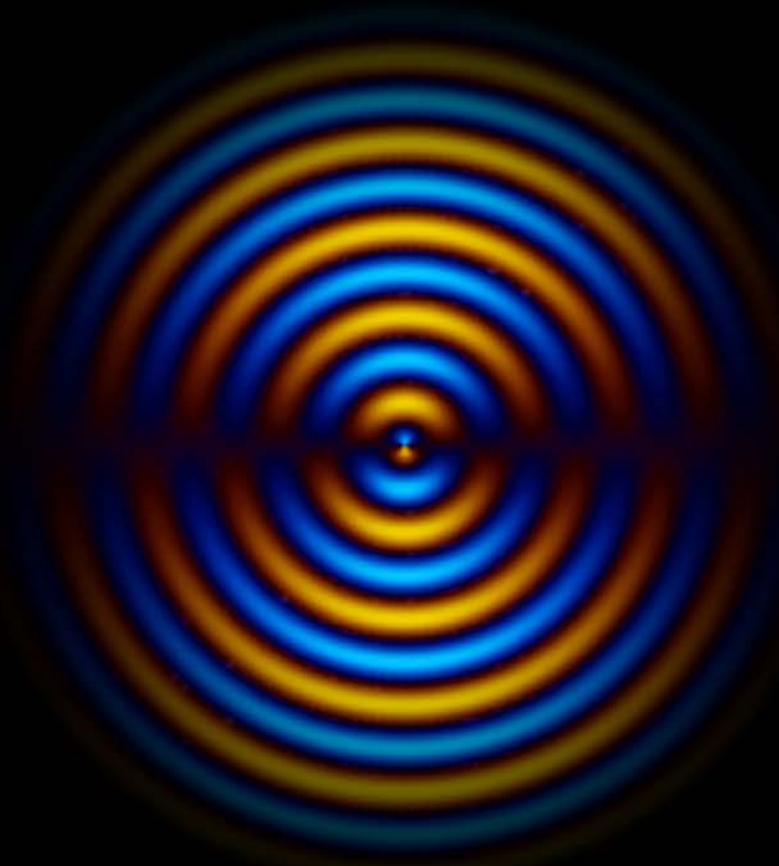

The Universe Is Only Spacetime

Particles, Fields and Forces
Derived from the Simplest
Starting Assumption



John A. Macken

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**Particles, Fields and Forces
Derived from the Simplest
Starting Assumption**

John A. Macken

Santa Rosa, California

john@onlyspacetime.com

Original Draft – February 2010

Revision 8.0 – July 2015

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Dedication: I dedicate this book to my wife, Enid, who has encouraged me and tolerated my idiosyncrasies over the years.

Acknowledgments: I wish to thank my friend, Dr. Nikolai Yatsenko, for volunteering to spend many hours teaching me aspects of quantum mechanics and general relativity. During these lessons I began the first steps of formulating a conceptually understandable model of the universe. Also Dr. Chris Ray has provided helpful comments on the text and my son, Jim Macken, provided many of the computer generated figures Finally, I would like to thank Francis William Browne for editing the book.

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Introduction

In most introductory classes on quantum mechanics, the physics professor starts out by explaining to the students that they are going to learn about certain properties of subatomic particles that are simply not conceptually understandable. For example, subatomic particles can discontinuously jump from one point to another without passing through the surrounding space. Fundamental particles exhibit “spin” which is an “intrinsic” form of angular momentum that cannot be explained by classical concepts of rotation. An isolated molecule can only rotate at specific frequencies. Two entangled photons can communicate faster than the speed of light over large distances – etc. Even special and general relativity have their share of incomprehensible mysteries. How is it possible for observers moving at different velocities to all observe the exact same speed of light? How does matter cause a distant volume of spacetime to curve?

Students are told that they should accept the fact that modern physics has many properties which are simply not able to comprehend by the human intellect. Classical physics gave conceptually understandable explanations, but now the students must learn to become comfortable that modern physics cannot be understood in the same way. Quantum mechanics is the most successful scientific theory ever developed, so “shut up and calculate”. A quote popularly attributed to physicist Richard Feynman is: “If you think you understand quantum mechanics, then you don’t”.

To be fair, a strict application of the principles of quantum mechanics does not strive to give a physically understandable explanation of these phenomena. Instead, the objective of quantum mechanics is to describe rules of each quantum mechanical operation and mathematical equations which describe these operations. For example, an electron is described as a point particle because this mathematical simplification is adequate to obtain useful equations. As Paul Dirac said, the aim is “not so much to get a model of an electron as to get a simple scheme of equations which can be used to calculate all the results that can be obtained from experiment”¹.

Today, physicists have learned to suppress their innate desire for conceptual understanding. The explanation given for our inability to conceptually understand quantum mechanical phenomena ultimately implies that the human brain evolved to understand the macroscopic world. Therefore, we simply should not expect to conceptually understand the properties of subatomic particles or photons. These concepts are just too far removed from our hunter gatherer roots. Over time we reluctantly learn to accept abstract quantum mechanical concepts and regard the desire for conceptual understanding as a remnant of classical physics. However, the importance of a model that gives conceptual understanding should not be minimized. If there really is an underlying simplicity to all of physics, then understanding this most basic model not only simplifies the teaching of physics, but also makes it easier to extend this model and make testable predictions which advance science. Such a model would be a powerful new tool that would greatly accelerate the rate of new discoveries.

¹ P. A. M. Dirac, “Classical Theory of Radiating Electrons,” Proc. Royal Soc., vol. 168, (1939)

There is clear evidence that the current starting assumptions for quantum mechanical calculations are either incomplete or contain at least one error. When calculations fall apart and yield an impossible answer such as infinity, these equations are screaming that a rigorous extension of the starting assumptions gives nonsense. Renormalization might seem to fix the problem, but this is merely artificially adjusted the answer so that it is no longer logically derived from the starting assumptions. Instead the unreasonable answer should be taken as an indication that the model being analyzed either contains at least one erroneous assumption or is missing an essential assumption. Every time an incorrect assumption is utilized or the missing assumption is not used, the mathematical analysis must yield an incorrect answer (garbage in, garbage out). Our inability to conceptually understand parts of quantum mechanics is a further indication that we are using an inadequate model. The approach taken in this book is to explore the possibility that there really is an underlying simplicity beneath the counter intuitive complexity of quantum mechanics. This is equivalent to saying that we are looking for the fabled "Theory of Everything". A logical starting point for this search should be to start with the simplest possible starting assumption which is: **The universe is only spacetime**. Another way of saying this is that spacetime is the single energetic field responsible for everything in the universe. Obviously, this model of spacetime goes far beyond the general relativity model of spacetime.

This simplest possible starting assumption implies that there is only one fundamental force, only one fundamental field and only one fundamental building block of all particles. Furthermore, even though forces, fields and particles appear to be very different, the starting assumption implies that on a deeper level they are all just different aspects of 4 dimensional spacetime. If this starting assumption is wrong, it should quickly become obvious because the properties of 4 dimensional spacetime are very limiting. Unlike the current state of physics which is free to postulate any number of dimensions, multiple universes, vibrating strings, messenger particles, etc., this starting assumption is very restrictive. All particles, fields and forces must be derived from only the properties of 4 dimensional spacetime.

Before the time of Galileo, the world was viewed as being full of mysterious occurrences which were either not questioned or attributed to the supernatural. With the dawn of the age of analytical science, it was realized that many of the mysteries were knowable and could be explained with laws of physics. The moon, planets and stars were not held above the earth by crystal spheres. The same gravity that caused a rock to fall here on earth also caused the moon to have a predictable orbit around the earth. What was previously considered an unknowable mystery was explained through deductive reasoning, mathematics and the application of the scientific method.

We have come a long way since the time of Galileo, but even today we have many mysteries that are considered beyond human understanding. For example, we have a multitude of mysterious effects that we attribute to different types of "fields". We can write equations that describe the effects of these "fields", but we really do not attempt to understand the fields in terms of

something more basic. I see an analogy to the time before Galileo and our present day attitude towards fields being physically unknowable. For example, how and why does matter cause a curved spacetime field? What is the physical difference between the field produced by a positively charged particle and a negatively charged particle? Do electric and magnetic fields produce a distortion of spacetime?

If the universe is only spacetime, then all other “fields” should be knowable in terms of effects on the most basic field: spacetime. For example, a new constant of nature will be proposed that quantifies the distortion of spacetime produced by an electric field. Also the concept that the universe is only spacetime has profound implications for science. This book makes the case that all particles, fields and forces are made of the single building block of 4 dimensional spacetime. However, this is not the quiet, smoothly curving spacetime envisioned by Einstein. His model of spacetime only describes spacetime on the macroscopic scale. All the action (energy) is on the quantum mechanical scale where spacetime is full of activity. This quantum mechanical model of spacetime is analyzed and found to possess the properties that allow it to be the single building block of everything in the universe.

Gravity is very well understood on one level, but it also has many mysteries. Why is the force of gravity vastly weaker than the other 3 fundamental forces? Why does gravity have only one polarity (always attracts)? Is gravity even a true force or merely the result of the geometry of spacetime? Can gravity be unified with the other forces? If we assume that the universe is only spacetime, then we bring a new perspective to explaining the mysteries of gravity. Both fundamental particles and the force of gravity can be derived from this starting assumption. There is no need to make an analogy to acceleration to explain the force of gravity. Furthermore, this approach makes a prediction about a previously unknown relationship between the gravitational force and the electromagnetic force. This prediction is easily proven correct. This book shows how these two forces plus the strong force are all closely related.

The standard model of particle physics has passed many tests. However, many mysteries still remain. The conventional models say that fundamental particles are either point particles or Planck length vibrating strings that are virtually point particles. Neither of these models explains numerous quantum mechanical properties of fundamental particles. For example, how do fundamental particles discontinuously move from point to point without passing through the intermediate space? How do they possess angular momentum of $\frac{1}{2} \hbar$ when they are virtually points? How much of an electron’s energy is stored in its electric/magnetic field? How does it exhibit both wave and particle properties? Is a fundamental particle made of some even more fundamental building block? This book shows that when fundamental particles are assumed to be made of spacetime (the quantum mechanical model of spacetime), then these counter intuitive properties can be explained. They become conceptually understandable and mathematically quantifiable. Furthermore, this model gives predictions about gravity and electric fields.

To most scientists this starting assumption (the universe is only spacetime) will initially seem impossible. How can matter, light, galaxies and the forces of nature be obtained from what appears to be the empty vacuum of spacetime? Well, the quantum mechanical model of spacetime proposed here is far from being a featureless void. Besides having well known properties such a speed of light and a gravitational constant, it also has impedance and a bulk modulus. Most important, the quantum mechanical version of spacetime is full of activity. Vacuum fluctuations (zero point energy) imply that vacuum has a vast energy density. Yet experiments and analysis seem to indicate an empty void. The measurable energy density of space from cosmology is about 10^{120} times less than the energy density implied by the quantum mechanical model of a vacuum. The common assumption is that something must cancel out the implied tremendous energy density of vacuum. The alternative proposed here is that the vacuum really does have this tremendous energy density, but there is a key difference between the energy that we can detect and the energy that we cannot detect. It is not necessary to assume energy cancelation, it is only necessary to understand the difference between the two types of energy (fermions/bosons versus vacuum energy).

This book attempts to show that the biggest mysteries of quantum mechanics become conceptually understandable when we adopt the model that builds particles and forces from the quantum mechanical properties of spacetime. Limitations of the human intellect have nothing to do with our inability to conceptually understand the mysteries of quantum mechanics and general relativity. We have been using the wrong models! The human intellect can understand anything in nature provided that we are using the correct model.

The model of the universe described here is shown to be compatible with existing laws and equations of physics. The concepts are checked to confirm plausibility by numerous calculations. Most of these are algebraic calculations so that the book is accessible to a wide audience of readers that are scientifically knowledgeable but not necessarily specialists. The few calculations that go beyond this basic level are handled in a way that the reader can grasp the result without necessarily following the mathematics.

The content of this book was not first presented in technical papers because the subject is just too large. It is necessary to lay out a series of introductory ideas, and then weave these concepts into a single coherent theory. A large part of the appeal of this approach is how a single starting assumption can answer so many diverse questions in physics.

(Note: The first three chapters lay important groundwork that prepares the reader to understand the proposed model. These chapters have a strong emphasis on physical interpretation and definitions. To establish a common base of physical interpretation, it is necessary to sometimes present explanations about quantum mechanics or general relativity that experts will find elementary. The objective of introducing these elementary concepts is to provide a shared explanation for the physical interpretations that are being used in the remainder of the book. Development of the wave based model of the universe starts in earnest in chapter #4.

References cited in the book are shown as footnotes at the bottom of the page that cites the reference.

Chapter 1

Confined Light Has Inertia

At the end of this chapter there is Appendix A that gives a more rigorous mathematical analysis of the concepts first presented using only algebraic equations. It is therefore possible to read this chapter on two levels.

Light in a Reflecting Box: The concepts presented in this book started with a single insight. I realized that if it was possible to confine light in a hypothetical 100% reflecting box, the confined light would exhibit many of the properties of a fundamental particle. In particular, a confined photon would possess the same inertia (rest mass) and same weight as a particle with equal internal energy ($E = mc^2$). If the box is moving, a confined photon also exhibits the same kinetic energy, same de Broglie waves, same relativistic length contraction and same time dilation as an equal energy particle.

It is an axiom of physics that a photon is a massless particle. Massless particles do not have a rest frame of reference. They are moving at the speed of light in any frame of reference. However, if light is confined in a box, it is forced to have a specific frame of reference. This “confined light” then exhibits properties normally associated with a rest mass of equivalent energy ($m = E/c^2$) in the frame of reference of the box. This will first be analyzed using the following special relativity equation:

$$m^2 = \left(\frac{E}{c^2}\right)^2 - \left(\frac{p}{c}\right)^2 \quad \text{where: } p \text{ is momentum and } E \text{ is energy} \quad (\text{equation 1})$$

Note to the reader: The first time symbols are used, they will be identified in the text. All the symbols used in the book and the important equations are also available in Chapter 15. It is recommended that you take a moment and look at chapter 15. If you are reading this book online, it is recommended that you print out Chapter 15 (10 pages) as an essential quick reference.

If a “particle” has energy of $E = pc$, then substituting this into the above equation gives:

$$m^2 = \left(\frac{p^2 c^2}{c^4}\right) - \left(\frac{p^2}{c^2}\right) = 0$$

In other words, when $E = pc$, then a “particle” has no rest mass. Now, momentum is a vector, so a very interesting thing happens when we apply equation #1 to confined light. For example,

a single photon confined between two reflectors is a wave traveling both directions simultaneously. The total momentum of this photon is zero because the two opposite momentum vectors nullify each other. Substituting $p = 0$ into the equation #1 yields: ($m = E/c^2$). In other words, confined light satisfies the definition of rest mass.

Another example of a photon gaining rest mass is a photon propagating through glass. If the glass has an index of refraction of 1.5, then the photon propagates at only 2/3 the speed of light in a vacuum and the momentum of the photon is reduced. The photon does not change energy when it enters the glass, but some of its momentum is imparted to the glass upon entrance and this momentum is returned to the photon upon exit. While the photon is propagating in the glass, it can be thought of as possessing some rest mass because $E \neq pc$. In other words, glass that has light propagating through it has more total mass (more inertia) than the same glass without any light propagation. It is also possible to analyze this more deeply and get into forward scatter and phase shifts introduced by the atoms of the glass. This analysis implies that the light has undergone partial confinement as it propagates through the glass at less than the speed of light in a vacuum. This partial confinement adds a small amount of "rest mass" to the glass.

The following example gives a deeper physical insight into how it is possible for confined light to exhibit mass. Suppose that a laser cavity has a 1 meter separation between two highly reflective mirrors. This is a 2 m (6.67 ns) round trip for light reflecting within this cavity. Light exerts photon pressure on absorbing or reflecting surfaces. The force exerted on an absorbing surface is $F = P/c$ or twice this force is exerted on a reflecting surface $F = 2P/c$ where $F =$ force and $P =$ power. If the laser in this example had 1.5×10^8 watts circulating between the two mirrors (reflecting surfaces), the energy confined between the two mirrors would be equal to 1 Joule and a force exerted by the light on each mirror would be one Newton in an inertial frame of reference.

Suppose that the laser is accelerated in a direction parallel to the optical axis of the laser. In the accelerating frame of reference, there would be a slight difference in the frequency of the light striking the two mirrors because of the mirror acceleration that occurs during the time required for the light to travel the distance between the two mirrors. The front mirror in the acceleration direction would be reflecting light that has Doppler shifted to a lower frequency compared to the light that is striking the rear mirror. If we return to the example of 1.5×10^8 watts of light circulating between two mirrors separated by one meter, then the force exerted against the front mirror would be slightly less than one Newton and the force exerted against the rear mirror would be slightly more than one Newton because of the difference in Doppler shifts. This force difference can be interpreted as the force exerted by the inertia of 1 Joule of confined light. The inertia of 1 Joule of confined light exactly equals the inertia of a mass with 1 Joule of internal energy (1.11×10^{-17} kg). For comparison, this mass is equal to about 6.6 billion hydrogen atoms.

While general relativity treats energy in any form the same, particle physics does not. The Standard Model of particle physics suggests that leptons and quarks require the hypothetical Higgs field to create the inertia of these particles. Therefore, in this example 6.6 billion hydrogen atoms require a Higgs field for inertia but an equal energy of confined light exhibits equal inertia without the need of a Higgs field. In fact, the inertia exhibited by the confined light is ultimately traceable to the constancy of the speed of light.

If we place the laser with 1 Joule of confined light stationary in a gravitational field, the confined light will exert a net force on the two mirrors equivalent to the weight expected from 6.6 billion hydrogen atoms. If the laser is oriented with its optical axis vertical, then the net force difference comes from what is commonly called the gravitational red/blue shift. This name is a misinterpretation that will be discussed later. The point is that more force is exerted on the lower mirror than the upper mirror because of the gravitational gradient between these two mirrors. If the laser is oriented horizontally, there will be gravitational bending of the light. The mirror curvature normally incorporated into laser mirrors easily accommodates this slight misalignment. However, the bending of light introduces a downward vector component into the force being exerted against both mirrors. This vector component is the weight of the light. It is true that general relativity teaches that energy in any form exhibits the same gravity. Therefore the gravitational similarity is expected. However, this does not automatically translate into giving inertia to quarks and leptons. The concept that confined light has weight and inertia has been explained differently in the article "Light Is Heavy"¹

Confined light also exhibits kinetic energy when it is confined in a moving frame of reference. Suppose that the laser with 1 Joule of confined light travels at a constant velocity relative to a "stationary" observer. Also suppose that the observer sees the motion as traveling with the optic axis of the laser parallel to the direction of motion. The stationary observer will perceive that light propagation in the direction of motion is shifted up in frequency and light propagating in the opposite direction is shifted down in frequency. Combining these perceived changes in frequency result in a net increase in the total energy of the confined light. (Appendix A) This energy increase is equal to the kinetic energy which would be expected from the relative motion of a mass of equal internal energy. Appendix A also shows that the energy increase (kinetic energy) is correct even for relativistic velocities. The kinetic energy of the confined light is ultimately traceable to the constancy of the speed of light.

Confined Black Body Radiation: Thus far, the example of confined light has used a laser with highly reflecting mirrors. An alternative example could use an ordinary cardboard box at a temperature of 300°K with an internal volume of 1 m³. The blackbody radiation within this box would have infrared light being emitted and reabsorbed by the internal walls. For the stated conditions, the blackbody radiation within the box would be about 6.1×10^{-6} J of

¹ <http://www.tardyon.de/mirror/hooft/hooft.htm>

radiation in flight within the volume of the box at any instant. This energy is equivalent to the annihilation energy of about 40,000 hydrogen atoms. Even though the black body radiation example is slightly harder to see, the result is similar to having reflecting walls. The confined black body radiation exhibits inertia, weight and relative motion exhibits kinetic energy. Carrying this blackbody radiation example further, let's consider the sun with a core temperature of about 15,000,000°K. At this temperature, the radiation is primarily at x-ray wavelengths. This confined x-ray radiation has inertia equivalent to about a gram per cubic meter. At a higher temperature where a star can burn carbon, the inertia of the confined x-rays is equivalent to the inertia of an equal volume of water (density = 1000 kg/m³). Once again, no Higgs field is required for confined radiation to exhibit inertia.

The examples used above had bidirectional light traveling in a laser or multi directional light traveling within a black body cavity. It would also be possible to confine light by having the light traveling in a single direction around a closed loop. For example, light could be confined by traveling around a loop made of a traveling wave tube or fiber optics. Also, it is not necessary to limit the discussion to light. Gravitational waves are also massless because they propagate energy at the speed of light. There are no known reflectors for gravitational waves, but it is hypothetically possible to imagine confined gravitational waves. If there were confined gravitational waves, they would also exhibit the rest mass property of inertia and exhibit kinetic energy when the confining volume exhibits relative motion.

A photon is often described as a "massless particle". We now see that a qualification should be added because only a freely propagating photon is massless. A confined photon possesses rest mass (possesses inertia). Both photons and gravitational waves are examples of energy propagating at the speed of light. In chapter 4 another form of energy propagating at the speed of light will be introduced (waves in spacetime). This also exhibits inertia when confined. From these considerations, the following statement can be made:

Energy propagating at the speed of light exhibits rest mass (inertia) when it is confined to a specific frame of reference.

Constraint on Higgs Mechanism: Imagine what it would be like if confined light (or confined gravitational waves) exhibited a different amount of inertia than a particle of equal energy. For example, suppose an electron and positron are confined in the 100% reflecting box. After some time the electron and positron interact to form two gamma ray photons of equal energy. Would the total inertia of the box be any different when it contained the electron and positron compared to containing confined photons of equal energy? If there was any difference, (even at relativistic velocity), then this would be a violation of the conservation of momentum. The equal energy confined photons must have **exactly** the same inertia as the confined particles under all conditions.

The standard model of particle physics explains the inertia of a fundamental particle (a fermion) results from an interaction with the hypothetical Higgs field. This explanation says that a muon interacts more strongly than an electron, therefore a muon has more inertia. However, the inertia imparted by the Higgs field does not have a precise requirement for exactly how much inertia a muon or an electron should possess. Now we learn that the inertia of an electron with 511 KeV of internal energy must exactly match the inertia of 511 KeV of confined photons. Similarly, a muon with internal energy of 106 MeV must exactly match the inertia of 106 MeV of confined photons. Matching the inertia of a fundamental particle to the inertia of an equal amount of energy propagating at the speed of light but confined to a specific volume adds an additional constraint to any particle model. The particle model proposed later in this book perfectly matches the required inertia constraint. The Higgs mechanism does not currently satisfy this requirement.

de Broglie Waves: The similarity between confined light and particles does not end with the confined light possessing rest mass, weight and kinetic energy when there is relative motion. Next we will examine the similarity between the wave characteristics of confined light and the de Broglie wave patterns of fundamental particles. For example, particles with mass m and velocity v that pass through a double slit produce an interference pattern which can be interpreted as having a de Broglie wavelength λ_d given by the equation:

$$\lambda_d = h/p \quad \text{where } \lambda_d = \text{de Broglie wavelength; } h = \text{Planck's constant; } p = \text{momentum}$$

$$\lambda_d = h/\gamma m_o v \quad \text{where } \gamma = \frac{1}{\sqrt{1-v^2/c^2}} \quad m_o = \text{particle's rest mass}$$

$$v_d = E/h \quad \text{where } v_d = \text{de Broglie frequency } E = \text{total energy}$$

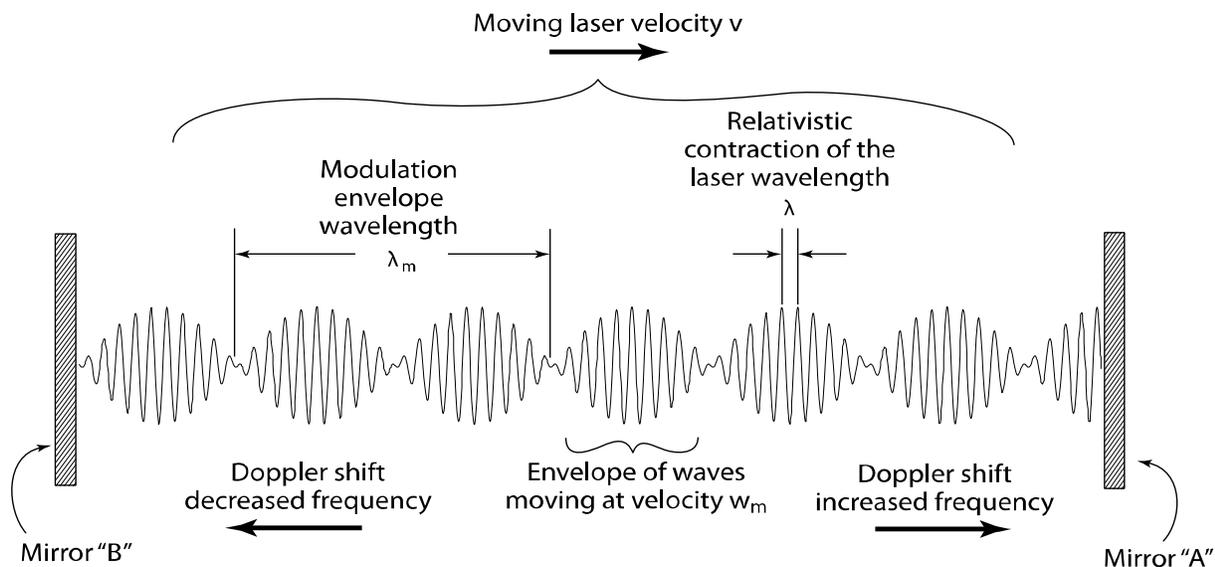


FIGURE 1-1 Wave pattern present in a moving laser due to Doppler shifts on the bi-directional light waves

The de Broglie waves have a phase velocity $w_d = c^2/v$ and a group velocity $u_d = v$. The phase velocity w_d is faster than the speed of light and the group velocity, u_d , equals the velocity of the particle, v .

There is a striking similarity between the de Broglie wave characteristics of a moving particle and the wave characteristics of confined light in a moving laser. Figure 1-1 shows a moving laser with mirrors A and B reflecting the light waves of a laser beam. Figure 1-1 is a composite because the light wave depicts electric field strength in the Y axis while the mirrors are shown in cross section. If the laser is stationary, the standing waves between the mirrors would have maximum electric field amplitude that is uniform at any instant. However, the laser in Figure 1-1 is moving in the direction of the arrow shown at velocity v . From the perspective of a "stationary" observer, light waves propagating in the direction of velocity v are Doppler shifted up in frequency, and light waves moving in the opposite direction are shifted down in frequency. When these electric field amplitudes are added, this produces the modulation envelope on the Doppler shifted bidirectional light in the laser as perceived by a stationary observer. This modulation envelope propagates in the direction of the translation direction but the modulation envelope has a velocity (w_m) which is faster than the speed of light ($w_m = c^2/v$) (calculated in appendix A). This is just an interference pattern and it can propagate faster than the speed of light without violating the special relativity prohibition against superluminal travel. No message can be sent faster than the speed of light on this interference pattern. The modulation envelope has a wavelength λ_m where:

$$\lambda_m = \frac{\lambda_\gamma c}{v} \quad \lambda_m = \text{modulation envelope wavelength}; \lambda_\gamma = \text{wavelength of confined light}$$

As seen in figure 1-1, one complete modulation envelope wavelength encompasses two nulls or two lobes. It will be shown later that there is a 180 degree phase shift at each null, so to return to the original phase requires two reversals (two lobes per wavelength).

The similarity to de Broglie waves can be seen if we equate the energy of a single photon of wavelength λ_γ to the energy of a particle of equivalent mass m . This will assume the non-relativistic approximation. Appendix A will address the more general relativistic case.

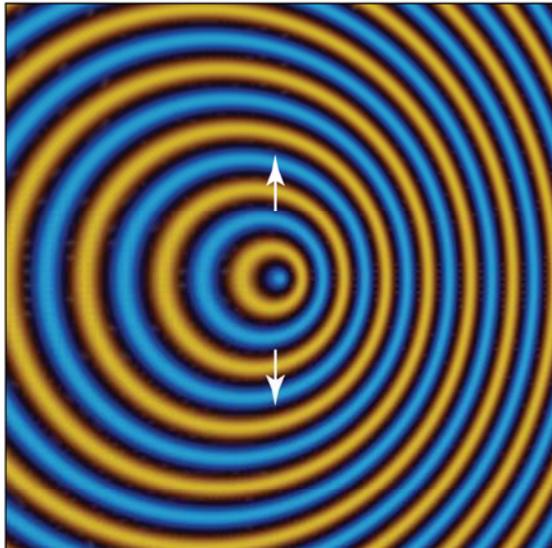
$$E = \frac{hc}{\lambda_\gamma} = mc^2 \quad \text{equating photon energy to mass energy therefore } m = \frac{h}{c\lambda_\gamma}$$

$$\lambda_d = \frac{h}{mv} \quad \lambda_d = \text{de Broglie wavelength};$$

$$\lambda_d = \frac{\lambda_\gamma c}{v} = \lambda_m \quad \text{de Broglie wavelength } \lambda_d = \text{modulation envelope wavelength } \lambda_m$$

The modulation envelope not only has the correct wavelength, it also has the correct phase velocity ($w_d = w_m = c^2/v$). The “standing” optical waves also have a group velocity of v . Therefore these waves move with the velocity of the mirrors and appear to be standing relative to the mirrors.

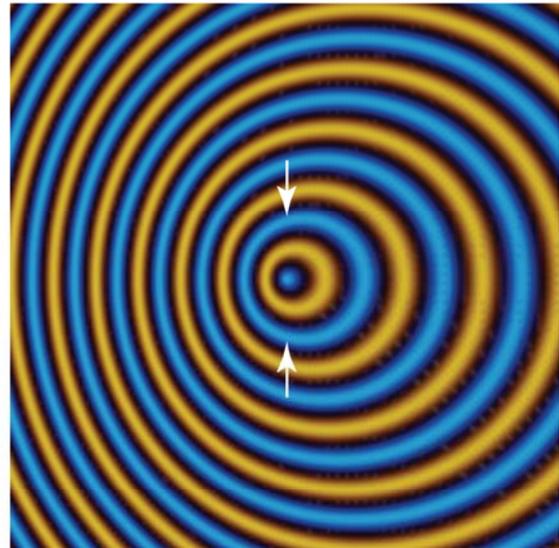
Outward propagating waves



Direction of motion

FIGURE 1-2 Doppler shift on outward propagating waves

Inward propagating waves



Direction of motion

FIGURE 1-3 Doppler shift on inward propagating waves

de Broglie Waves in Radial Propagation: It is easy to see how the optical equivalent of de Broglie waves can form in the example above with propagation along the axis of translation. However, it is not as obvious what would happen if we translated the laser in a direction not aligned with the laser axis. We will take this to the limit and examine what happens when the waves propagate radially into a 360° plane that is parallel to the translation direction. To understand what happens, we will first look at figure 1-2 that shows the Doppler shifted wave pattern produced by waves propagating away from a point source in a moving frame of reference. The source is moving from left to right as indicated by the arrow. Waves moving in the direction of relative motion (to the right) are seen as shifted to a shorter wavelength and waves moving opposite to the direction of travel are shifted to a longer wavelength. Figure 1-3 is similar to figure 1-2 except that only waves propagating towards the source are shown.

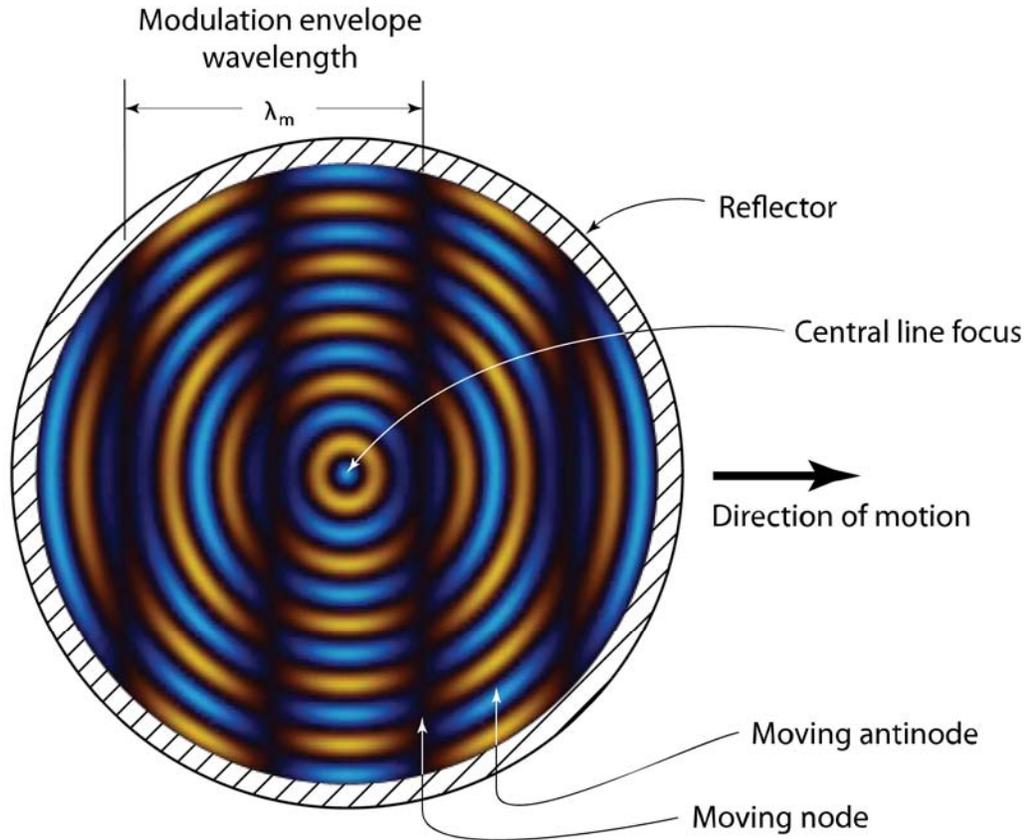


FIGURE 1-4 Wave pattern produced when radially propagating standing waves are observed in a moving frame of reference

Figure 1-4 shows what happens when we add together the outward and inward propagating waves shown in figures 1-2 and 1-3. Also a cross-sectioned cylindrical reflector has been added to figure 1-4. This reflector can be thought of as the reason that there are waves propagating towards the center. The central lobe of figure 1-4 can be thought of as a line focus that runs down the axis of the cylindrical reflector.

The vertical dark bands in figure 1-4 correspond to the null regions in the modulation envelope. These null regions can be seen in figure 1-1 as the periodic regions of minimum amplitude. There is a 180° phase shift at the nulls. This can be seen by following a particular fringe through the dark null region. If the wave is represented by a yellow color on one side of the null, this same wave is a blue color on the other side of the null. This color change indicates that a 180° phase shift occurs at the null. In figure 1-1, the reason that the wavelength of the modulation envelope λ_m is defined as including two lobes is because of this phase reversal that happens at every null. Therefore it takes two lobes to return to the original phase and form one complete wavelength.

The main purpose of this figure is to illustrate that de Broglie waves with a plane wavefront appear even in light that is propagating radially. This is a modulation envelope that is the equivalent of a plane wave moving in the same direction as the relative motion, but moving at a speed faster than the speed of light. Figure 1-4 represents an instant in a rapidly changing wave pattern.

There has also been an artistic license taken in this figure to help illustrate the point. Normally we would expect the electric field strength to be very large along the focal line at the center of the cylindrical reflector and decrease radially. However, accurately showing this radial amplitude variation would hide the wave pattern that is the purpose of this figure. Therefore the radial amplitude dependence has been eliminated to permit the other wave patterns to be shown. Another artistic license is the elimination of the Guoy effect at the line focus. The central lobe of a cylindrical focus should be enlarged by $\frac{1}{4}$ wavelength to accommodate the 90° phase shift produced when electromagnetic radiation passes through a line focus. Ultimately we will be transferring the concepts illustrated here to a different model that does not require this slight enlargement.

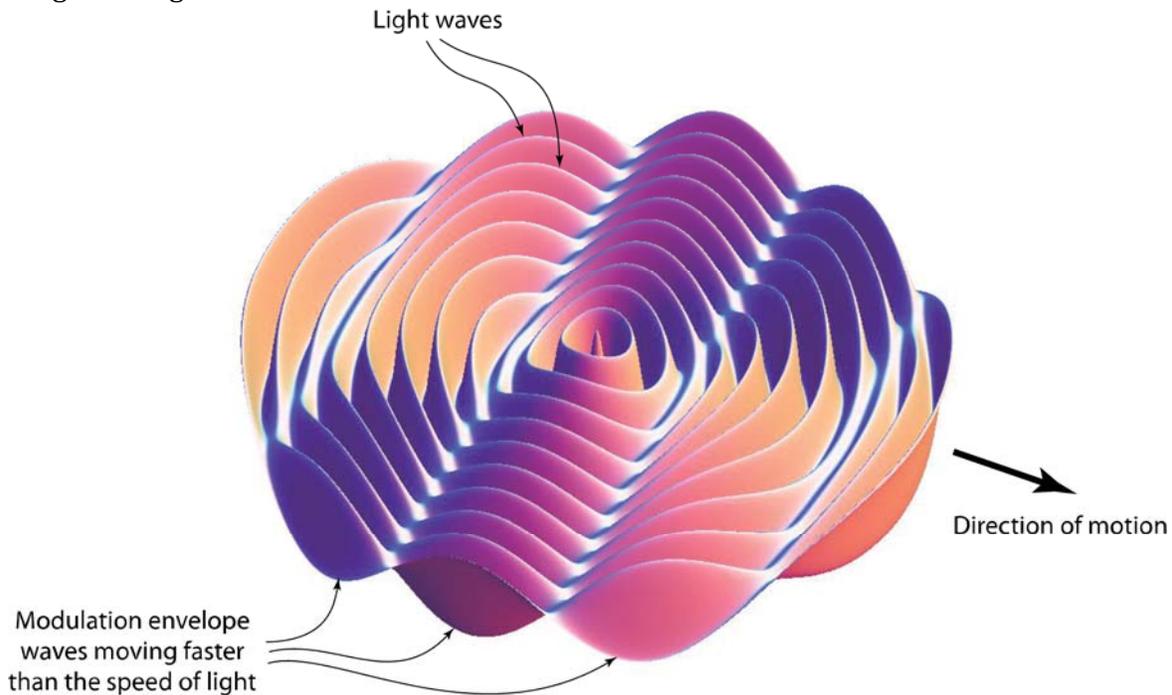


FIGURE 1-5 A three-dimensional representation of figure 1-4 where the Z axis is used to represent electric field

Figure 1-5 is a 3 dimensional representation of the wave pattern present in figure 1-4. In figure 1-5 the Z axis is used to represent the electric field. The cylindrical reflector has been removed from the illustration to permit the waves to be seen. Also as before, the radial amplitude dependence has been eliminated to permit the subtle modulation envelope to be seen. If figure 1-5 was set in motion, the concentric circular wave pattern would move as a unit. However,

superimposed on this is the moving envelope of waves that are moving through this wave structure (waves on waves). This moving envelope of waves is moving faster than the speed of light in the same direction as overall motion ($w_m = c^2/v$).

The surprising part of figure 1-4 and 1-5 is that we obtain a linear modulation envelope imposed on the radial propagating waves. It does not make any difference what the propagation angle is, the equivalent of de Broglie waves are produced for all angles. The only requirement is that the wave has bidirectional propagation. If later we are successful in establishing a model of fundamental particles that exhibits bidirectional wave motion, that model will also exhibit de Broglie waves.

Next we are going to talk about relativistic length contraction. For illustration, we will return to figure 1-1. This figure shows the wave frozen in time and designates the distance that approximately corresponds to the laser wavelength λ . Actually, this distance only precisely equals the laser wavelength when there is no relative motion. In the example illustrated in figure 1-1, there is relative motion. The wave illustrated is the result of adding together a wave that has been Doppler shifted up in frequency to a wave that has been Doppler shifted down in frequency. The combination produces a peak to peak distance that is equal to the relativistic contraction of the laser wavelength.

This is reasonable when you consider that there are a fixed number of standing waves between the two mirrors. If the distance between the two mirrors undergoes a relativistic contraction, the standing waves must also exhibit the same contraction to retain the fixed number of standing waves. However, it is possible to reverse this reasoning. Rather than saying that the standing waves must contract to fit between the relativistic contracted mirror separation, it is possible to say that we might be getting a fundamental insight into the mechanics of how nature accomplishes relativistic contraction of physical objects. If all fundamental particles and forces of nature can ultimately be reduced to bidirectional waves in spacetime, then these bidirectional waves, will automatically exhibit relativistic contraction and the mechanism of relativistic contraction of even the nucleus of an atom would be conceptually understandable.

Similarly, the mechanism of relativistic time dilation would also become conceptually understandable. If we were to time the oscillation frequency of individual waves in the laser of figure 1-1, we would find that the oscillation frequency that results when we add these two Doppler shifted waves together slows exactly as we would expect for the relativistic time dilation of a moving object. Again this is traceable to the constant speed of light producing different Doppler shifts on the components of the bidirectional light. The sum of these two frequencies exhibits a net slowing that corresponds to relativistic time dilation.

Therefore the analysis in this chapter and appendix A shows that a confined photon in a moving frame of reference has the following 8 similarities to a fundamental particle with the same energy and same frame of reference:

- 1) The confined photon has the same inertia (rest mass): $m = \hbar\omega_c/c^2$
- 2) The confined photon has the same kinetic energy: $k_e = \frac{1}{2}mv^2 = \frac{1}{2}(\hbar\omega_o/c^2)v^2$
- 3) The confined photon has the same weight as the particle.
- 4) The confined photon (bidirectional propagation) has the same momentum.
- 5) The confined photon's envelope wavelength λ_s is the same as the particle's de Broglie wavelength: $\lambda_s = \lambda_d$
- 6) The confined photon's modulation envelope phase velocity is the same as the particle's de Broglie phase velocity: $v_s = w = c^2/v$
- 7) The photon's group velocity is the same as the particle's group velocity: $v_d = u$
- 8) The confined photon has the same relativistic length contraction: $\lambda_{dd} = \lambda_o/\gamma$

It is hard to avoid the thought that perhaps a particle is actually a wave with components exhibiting bidirectional propagation at the speed of light but somehow confined to a specific volume. This confinement produces standing waves that are simultaneously moving both towards and away from a central region.

Do we have any truly fundamental particles? If I defined a fundamental particle by the ancient Greek standard of indivisibility and incorruptibility, then there are none. An electron and a positron can be turned into two photons (and vice versa). An isolated neutron (2 down quarks and 1 up quark) will decay into a proton (2 up quarks and 1 down quark) plus an electron and an antineutrino. In fact, all 12 "fundamental" fermions of the standard model can be converted into other fermions and into photons. The simplest explanation for this easy conversion between "fundamental" particles is that there is a wave structure to these fermions. The truly fundamental building block of all fermions is the underlying wave in spacetime that allows these easy transformations. It is on the level of this truly fundamental building block that there is a similarity between confined light and particles. This thought process will be continued in chapter 4.

Note:

Chapters 2 and 3 lay groundwork that prepares the reader to understand the proposed model. Development of the spacetime based model of particles and forces starts in earnest in chapter 4.

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Appendix A
Examination of the Similarities
Between Confined Light and a Particle
 Chris Ray

§ **Confined Light**

This appendix will investigate a photon confined in perfectly reflecting resonator. It will be shown that such a confined photon exhibits many particle-like properties including rest mass, relativistic contraction and a moving wave pattern that is similar to de Broglie waves.

We will begin by examining a standing wave in a resonator as viewed from a frame of reference in which the resonator is moving.

§ **First View: Counter Propagating Waves**

A 1-D standing wave can be modeled as a superposition of right and left moving plane waves.

$$\psi = e^{i(k_0x - \omega_0t)} + e^{i(-k_0x - \omega_0t)}$$

where $k_0 = \omega_0/c$.

In the frame of reference where the resonator is at rest there are standing waves in the resonator set up by the counter propagating waves.

$$\begin{aligned} \psi &= e^{i(k_0x - \omega_0t)} + e^{i(-k_0x - \omega_0t)} \\ &= (e^{ik_0x} + e^{-ik_0x})e^{-i\omega_0t} \\ &= 2 \cos(k_0x)e^{-i\omega_0t} \end{aligned}$$

In the frame of reference where the resonator is moving to the right with velocity v , we have counter propagating waves with different frequencies, because the waves have been doppler shifted: $\omega_R = \gamma(1+\beta)\omega_0$ and $\omega_L = \gamma(1-\beta)\omega_0$, where $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$. The wave then is given by

$$\psi = e^{i(k_Rx - \omega_Rt)} + e^{i(k_Lx - \omega_Lt)}$$

where $k_L = -\omega_L/c$ and $k_R = \omega_R/c$.

Define ω_+ and ω_- as follows

$$\begin{aligned} \omega_+ &\equiv \frac{1}{2}(\omega_R + \omega_L) \\ &= \frac{1}{2}(\gamma(1+\beta)\omega_0 + \gamma(1-\beta)\omega_0) \\ &= \gamma\omega_0 \\ \omega_- &\equiv \frac{1}{2}(\omega_R - \omega_L) \\ &= \frac{1}{2}(\gamma(1+\beta)\omega_0 - \gamma(1-\beta)\omega_0) \\ &= \gamma\beta\omega_0 \end{aligned}$$

Now define k_+ and k_- in a similar way.

$$\begin{aligned} k_+ &\equiv \frac{1}{2}(k_R + k_L) = \frac{1}{2c}(\omega_R - \omega_L) = \frac{\omega_-}{c} = \gamma\beta\frac{\omega_0}{c} \\ k_- &\equiv \frac{1}{2}(k_R - k_L) = \frac{1}{2c}(\omega_R + \omega_L) = \frac{\omega_+}{c} = \gamma\frac{\omega_0}{c} \end{aligned}$$

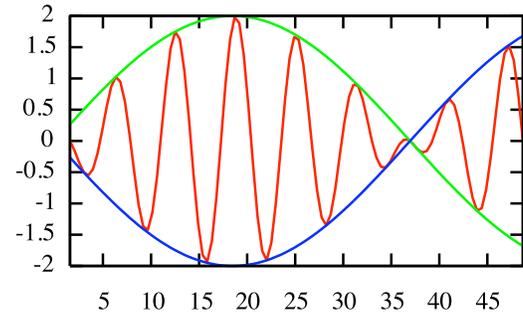
Note that

$$\begin{array}{lcl} k_L = k_+ - k_- & \text{AND} & \omega_L = \omega_+ - \omega_- \\ k_R = k_+ + k_- & & \omega_R = \omega_+ + \omega_- \end{array}$$

Now we can write the wave as

$$\begin{aligned} \psi &= e^{i(k_Lx - \omega_Lt)} + e^{i(k_Rx - \omega_Rt)} \\ &= e^{i((k_+ - k_-)x - (\omega_+ - \omega_-)t)} + e^{i((k_+ + k_-)x - (\omega_+ + \omega_-)t)} \\ &= \left[e^{-i(k_-x - \omega_-t)} + e^{i(k_+x - \omega_+t)} \right] e^{i(k_+x - \omega_+t)} \\ &= 2 \cos(k_-x - \omega_-t) e^{i(k_+x - \omega_+t)} \end{aligned}$$

The imaginary part of this is graphed below (in red) for $\beta = 0.085$ at $t = 0$.



This is a product of two traveling waves. We can compute wavelengths and velocities of these two parts.

$$\begin{aligned} v_+ &= \frac{\omega_+}{k_+} = \frac{\omega_+}{\omega_-/c} = \frac{c}{\beta} = \frac{c^2}{v} \\ v_- &= \frac{\omega_-}{k_-} = \frac{\omega_-}{\omega_+/c} = \beta c = v \\ \lambda_+ &= \frac{2\pi}{k_+} = \frac{2\pi c}{\gamma\beta\omega_0} = \frac{\lambda_0}{\gamma\beta} \\ \lambda_- &= \frac{2\pi}{k_-} = \frac{2\pi c}{\gamma\omega_0} = \frac{\lambda_0}{\gamma} \end{aligned}$$

where $\lambda_0 = \frac{2\pi c}{\omega_0}$ is the wavelength in the rest frame of the resonator.

First let us consider the “-” part of the wave. First we note that this part of the wave moves with the velocity of the resonator. Second we see that the wavelength has shrunk by a factor of γ relative to the wavelength in the rest frame. Thus the same number of wavelengths will fit in the similarly length-contracted resonator. Thus the $\cos()$ standing wave pattern has shrunk to fit the moving resonator and moves with the resonator.

Now consider the “+” part of the wave. This part of the wave moves with a velocity c^2/v . Which is the same as the phase velocity of a de Broglie plane wave for a massive particle: $\psi_d = e^{ipx/\hbar} e^{-iEt/\hbar}$.

$$\rightarrow v_{\text{phase}} = \frac{E/\hbar}{p/\hbar} = \frac{E}{p} = \frac{\gamma mc^2}{\gamma mv} = \frac{c^2}{v}$$

We can also see that the wavelength for the de Broglie plane wave: $\lambda_d = \frac{2\pi\hbar}{p} = \frac{2\pi\hbar}{E v/c^2} = \frac{2\pi\hbar c}{E\beta} = \frac{2\pi\hbar c}{\gamma E_0\beta}$ is also the same, if we assume that there is a single photon in the resonator and thus that the energy in the rest frame is $E_0 = \hbar\omega_0$. Since

$$\lambda_+ = \frac{2\pi}{k_+} = \frac{2\pi c}{\gamma\beta\omega_0} = \frac{2\pi\hbar c}{\gamma\beta E_0}$$

Thus we see that the “+” part of the resonator wave has the wavelength and phase velocity of a de Broglie plane wave of

a massive particle with a rest energy equal to the energy of the photon in the resonator.

§ **General From**

In the rest frame of a general standing wave the amplitude of the wave is given by

$$\psi'(x', y', z', t') = f(x', y', z')e^{-i\omega_0 t'}$$

Where it is understood that the physical wave is the real part of the complex wave ψ . Note that the amplitude function $f()$ is a real valued function.

We will assume that the energy of this wave is

$$E_0 = \hbar\omega_0.$$

We will also consider this energy in the rest frame of the wave, divided by c^2 , to be the mass of the system:

$$m \equiv \frac{E_0}{c^2} = \frac{\hbar\omega_0}{c^2}.$$

Since the wave is a standing wave the total momentum is zero: $p_0 = 0$.

In a General Frame

We want to know what the standing wave will look like in a frame in which the rest frame of the standing wave is moving in the positive x direction, with a velocity v . We can find this, if we assuming that the amplitude of the wave at a given space time point is the same in each frame, so that

$$\psi(x, y, z, t) = \psi'(x', y', z', t')$$

with x' and t' related to x and t via the following Lorentz transformation, while $y' = y$ and $z' = z$.

$$\begin{bmatrix} ct' \\ x' \end{bmatrix} = \begin{bmatrix} \gamma & -\gamma\beta \\ -\gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} ct \\ x \end{bmatrix} = \begin{bmatrix} \gamma(ct - \beta x) \\ \gamma(x - \beta ct) \end{bmatrix}$$

So that

$$\begin{aligned} \psi(x, y, z, t) &= \psi'(x', y', z', t') \\ &= \psi'(\gamma(x - \beta ct), y, z, \gamma(ct - \beta x)/c) \\ &= f(\gamma(x - \beta ct), y, z)e^{-i\omega_0\gamma(ct - \beta x)/c} \\ &= f(\gamma(x - vt), y, z)e^{i\omega_0\gamma\beta x/c}e^{-i\omega_0\gamma t} \\ &= f(\gamma(x - vt), y, z)e^{i(kx - \omega t)} \end{aligned}$$

In the last line we used the following definition.

$$\begin{aligned} \omega &\equiv \gamma\omega_0 \\ k &\equiv \gamma\beta\omega_0/c \end{aligned}$$

As was the case with the counter propagating plane waves, the wave function in the general frame is manifestly in the form of a plane wave ($e^{i(kx - \omega t)}$), with wavelength and velocity of a de Broglie wave, modulated with an standing wave pattern (f) that moves in the positive x direction with velocity v . In addition the characteristic length of the standing wave pattern has been length contracted in the x direction by the factor γ compared with the length in the rest frame. For examples suppose that there are two features in the standing wave, one at the position $x' = a$ and the other at the position $x' = b$. The distance between these features is $L = b - a$. The features could for example be two null points in the standing wave. These two features will also exist in the general frame,

though they are moving. Let x_a and x_b the location of these features, then we know that

$$\begin{aligned} \gamma(x_a - vt) &= a \\ \gamma(x_b - vt) &= b \end{aligned}$$

Solving these two equations for $x_b - x_a$ we find that

$$L' = x_b - x_a = \frac{b - a}{\gamma} = \frac{L}{\gamma}$$

So the distance between the features has been contracted by a factor γ .

We also see, as in the case of counter propagating waves, that one part of the wave moves with the velocity v and the other moves with the velocity

$$\frac{\omega}{k} = \frac{\gamma\omega_0}{\gamma\beta\omega_0/c} = \frac{c}{\beta} = \frac{c^2}{v}$$

Energy and Momentum

We can also find the energy and momentum in the new frame, using the relativistic transformation of energy and momentum.

$$\begin{aligned} \begin{bmatrix} E \\ pc \end{bmatrix} &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} E' \\ p'c \end{bmatrix} \\ &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} E_0 \\ p_0c \end{bmatrix} \\ &= \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} \hbar\omega_0 \\ 0 \end{bmatrix} \\ &= \begin{bmatrix} \gamma\hbar\omega_0 \\ \gamma\beta\hbar\omega_0 \end{bmatrix} \\ &= \begin{bmatrix} \hbar\omega \\ \hbar kc \end{bmatrix} \end{aligned}$$

We see that the frequency and wavenumber of the plane wave part of the wave are proportional to the energy and momentum of the wave.

$$E = \hbar\omega$$

and

$$p = \hbar k$$

in accordance with de Broglie waves.

Using the definition $m = \hbar\omega_0/c^2$, we consider the mass of the light in our resonator to be equal to the energy in the rest frame divided by c^2 . Thus we can rewrite the above as.

$$E = \gamma mc^2$$

and

$$p = \gamma mv$$

Chapter 2

Definitions and Concepts from General Relativity

The primary purpose of this book is to show how it is possible for the fundamental particles and the forces of nature to be conceptually explained using only 4 dimensional spacetime. This is nothing less than a new model of the universe. Presentation of this model would be an impossibly large task for a single person if every aspect of the model needs to be analyzed with the detail that might be expected from a technical paper covering a specific aspect of a mature subject. Therefore, the concepts will be introduced using simple equations that involve approximations and ignore dimensionless constants such as 2π or $1/2$. These simplifications permit the key concepts of this very large subject to be explained. Later, others can analyze and expand upon this large subject in more detail.

We will start by looking at the gravitational effects on spacetime in the limiting case of weak gravity. Much of the analysis to follow in subsequent chapters will deal with the gravity exhibited by a single fundamental particle such as an electron or a quark. Working with single particles or the interaction between two fundamental particles allows the proposed structure of such particles to be connected to the forces that are exhibited by these particles. At the same time, the extremely weak fields permit simplifications in the analysis.

In the following discussion, a distinction will be made between the words “length” and “distance”. Normally, these words are similar, but we will make the following distinction. Length is a spatial measurement standard. This is not just a standardized size such as a meter or inch, but it also can include a qualification such as proper length or coordinate length. A unit of length can be defined either by a ruler or by the speed of light and a time interval. The concept of distance as used here is best illustrated by the phrase “the distance between two points”. A distance can be quantified as a specific number of length units.

This chapter starts off with a discussion of the Schwarzschild solution to the Einstein field equation and physical examples of the effect of gravity on spacetime. This will seem elementary to many scientists, but new terminology and physical interpretations are introduced. Understanding this terminology and perspective is a requirement for subsequent chapters.

Schwarzschild Solution of the Field Equation: Einstein’s field equation has an exact solution for the simplified case of a static, nonrotating and uncharged spherically symmetric mass distribution in an empty universe. This mass distribution with total mass m is located at the origin of a spherical coordinate system. The standard (nonisotropic) Schwarzschild solution in this case takes the form:

$$dS^2 = c^2 d\tau^2 = (1/\Gamma^2)c^2 dt^2 - \Gamma^2 dR^2 - R^2 d\Omega^2$$

$$\Gamma \equiv dt/d\tau = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}} \quad (\text{explained below})$$

$dS = cd\tau$ The invariant quantity dS is the length of the world line between two events in 4 dimensional spacetime.

R = circumferential radius (circumference/ 2π) [explained below]

Ω = a solid angle in a spherical coordinate system ($d\Omega^2 = d\theta^2 + \sin^2\theta d\phi^2$)

c = the speed of light constant of nature

t = coordinate time (time infinitely far from the mass - effectively zero gravity)

τ = proper time - time interval on a local clock in gravity

Circumferential radius: Gravity warps the space around mass, so that the space around the test mass has a non-Euclidian geometry. The circumference of a circle around the mass does not equal 2π times the radial distance to the center of mass. To accommodate this warped space, the Schwarzschild equation uses a special definition of distance to specify the coordinate distance in the radial direction. Names like “R-coordinate” and “reduced circumference” are sometimes used to describe this radial coordinate that cannot be measured with a meter stick or a pulse of light. The name that will be used here is “circumferential radius” and designated with the symbol R . This is a distance that is calculated by measuring the circumference of a circle that surrounds a mass, and then dividing this circumference by 2π . If we measure the radius using a hypothetical meter stick or tape measure, then the “proper” radial distance will be designated by r . We can see from the Schwarzschild metric that if we set $dt = 0$, $dS = cd\tau = dr$ and $d\Omega = 0$ then:

$$dr = \Gamma dR$$

Gravitational Gamma Γ : The metric has been written in terms of the quantity Γ which this book will refer to as the “gravitational gamma Γ ”. The basic definition of Γ is:

$$\Gamma \equiv dt/d\tau = \frac{1}{\sqrt{1 + \left(\frac{2\varphi}{c^2}\right)}} = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}} = \frac{1}{\sqrt{g_{00}}}$$

where Γ = gravitational gamma and $\varphi = -Gm/R$ gravitational potential

$\Gamma = dt/d\tau$ in the static case when $dR = 0$ and $d\Omega = 0$.

g_{00} is a metric coefficient commonly used in general relativity

The symbol of upper case gamma Γ was chosen because this equation can also be written as follows:

$$\Gamma = \frac{1}{\sqrt{1 - \left(\frac{V_e^2}{c^2}\right)}} \quad \text{where } V_e \equiv \sqrt{\frac{2Gm}{R}} = \text{escape velocity}$$

The similarity between Γ and γ of special relativity is obvious since: $\gamma = \frac{1}{\sqrt{1 - \left(\frac{V^2}{c^2}\right)}}$

This analogy between the escape velocity in general relativity and the relative velocity in special relativity extends further in the weak gravity approximation. The time dilation due to gravity approximately equals the time dilation due to relative motion when the relative motion is equal to the gravitational escape velocity (weak gravity).

The Schwarzschild universe with only one mass has effectively “zero gravity” at any location infinitely far from the mass. At such a location $\Gamma = 1$. The opposite extreme of the maximum possible value of Γ is the event horizon of a black hole where $\Gamma = \infty$. If the earth was in an empty universe, then the surface of the earth would have a gravitational gamma of: $\Gamma \approx 1 + 7 \times 10^{-10}$. It is important to remember that Γ is always larger than 1 when gravity is present.

A stationary clock infinitely far away from the mass in Schwarzschild’s universe is designated the “coordinate clock” with a rate of time designated dt . In the same stationary frame of reference, the local rate of time in gravity (near the mass) is designated $d\tau$. The relationship is: $\Gamma = dt/d\tau$

There is a useful approximation of Γ that is valid for weak gravity.

$$\Gamma \approx 1 + \frac{Gm}{c^2 R} \quad \text{weak gravity approximation of } \Gamma$$

Gravitational Magnitude β : The gravitational gamma Γ has a range of possible values that extends from 1 to infinity. There is another related concept where the strength of the gravitational effect on spacetime ranges from 0 to 1 where 0 is a location in zero gravity and 1 is the event horizon of a black hole. This dimensionless number will be called the “gravitational magnitude β ” and is defined as:

$$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2 R}} = 1 - \frac{1}{\Gamma} \quad \beta = \text{gravitational magnitude}$$

In weak gravity the following approximation is accurate:

$$\beta \approx \frac{Gm}{c^2 r} \quad \text{and} \quad \Gamma \approx 1 + \beta \quad \text{weak gravity approximations}$$

For example, the earth's gravity, in the absence of any other gravity is $\beta \approx 7 \times 10^{-10}$. The sun's surface has $\beta \approx 2 \times 10^{-6}$ and the surface of a hypothetical neutron star with escape velocity equal to half the speed of light would have $\beta \approx 0.13$.

In common usage, the strength of a gravitational field is normally associated with the acceleration of gravity. However, the acceleration of gravity depends on the gradient of gravitational potential. In contrast, the gravitational magnitude β and the gravitational gamma Γ are measurements of the effect of gravity on time and distance without regard for the gravitational gradient. For example, there is an elevation in Neptune's atmosphere where Neptune has approximately the same gravitational acceleration as the earth. However, Neptune has roughly 16 times the earth's mass and roughly 4 times the earth's radius. This means that Neptune's gravitational magnitude β is roughly 4 times larger than earth's at locations where the gravitational acceleration is about the same.

The gravitational magnitude approximation $\beta \approx Gm/c^2r$ will be used frequently with weak gravity. For example, this approximation is accurate to better than one part in 10^{36} for examples that will be presented later involving the gravity of a single fundamental particle at an important radial distance. Therefore, this approximation will be considered exact when dealing with fundamental particles. Note that this approximation includes the substitution of proper radial distance r for the circumferential radius R . ($r \approx R$). Using the approximation $\beta \approx Gm/c^2r$ we also obtain the following equalities for β in weak gravity:

$$\beta \approx \frac{-\varphi}{c^2} \approx \frac{R_s}{r} \quad \varphi = -Gm/R \quad \text{and} \quad R_s = Gm/c^2 = \text{Schwarzschild radius* (see note below)}$$

$$\beta \approx \frac{dt-d\tau}{dt} \quad \text{the rate of time approximation for weak gravity}$$

All of these approximations will be considered exact when dealing with the extremely weak gravity of single fundamental particles in subsequent chapters.

- **Note:** The Schwarzschild radius of a nonrotating black hole is $r_s = 2Gm/c^2$ and the Schwarzschild radius of maximally rotating black hole, such as a photon black hole, is $R_s = Gm/c^2$. This book will often ignore numerical constants near 1, but there is another reason for using $R_s = Gm/c^2$ for particles. The particle model proposed later in this book has energy rotating at the speed of light which would have gravitational effects scale with R_s rather than r_s .

Zero Gravity: Schwarzschild assumed an empty universe with only a single mass. Such a universe approaches zero gravity as the distance from the mass approaches infinity. However, is there anywhere in our observable universe that can truly be designated as a zero gravity location? There are vast volumes with virtually no gravitational acceleration compared to the cosmic microwave background. However, this is not the same as saying that these volumes have a gravitational gamma of $\Gamma = 1$ (a hypothetical empty universe). Everywhere in the real universe

there is gravitational influence from all the mass/energy in the observable universe. Later, in the chapters on cosmology, an attempt is made to estimate the background (omni-directional) gravitational gamma of our observable universe compared to a hypothetical empty universe. While the presence of a uniform background Γ for the universe has implications for cosmology, we can only measure differences in Γ . There is ample evidence that general relativity works well by simply ignoring the uniform background Γ of the universe. Effectively we are assigning $\Gamma = 1$ to the background gravitational gamma of the universe and proportionally scaling from this assumption.

Therefore, a distant location which we designate as having $\beta = 0$ or $\Gamma = 1$ will be referred to as a “zero gravity location” or simply “zero gravity”. The term “zero gravity” in common usage usually implies the absence of gravitational acceleration as might be experienced in free fall. However, in this book “zero gravity” literally means that we are using the Schwarzschild model of a distant location which has been assigned coordinate values of $\beta = 0$ and $\Gamma = 1$. The rate of time at this coordinate location will be designated dt and called “coordinate rate of time”. A clock at this location will be designated as the “coordinate clock”.

Gravitational Effect on the Rate of Time: The equation $dt = \Gamma d\tau$ is perhaps the most important and easiest to interpret result of the Schwarzschild equation. It says that the rate of time depends on the gravitational gamma Γ . This equation has been proven correct by numerous experiments. Today the atomic clocks in GPS satellites are routinely calibrated to account for the different rate of time between the lower gamma at the GPS satellite elevation and the higher gamma at the Earth’s surface. Without accounting for this gravitational relativistic effect, the GPS network would accumulate errors and cease to function accurately after about one day. (There is also time dilation caused by the relative motion of the satellite. This is a much smaller correction than the gravitational effect and in the opposite direction.)

The difference in the rate of time with respect to radial distance in gravity will be called the “gravitational rate of time gradient”. The gravitational rate of time gradient is not a tidal effect. An accelerating frame of reference has no tidal effects, yet it exhibits a rate of time gradient. Our objective is to provide an equation that relates the acceleration of gravity “ g ” to the rate of time gradient and utilizes proper length in the expression of the rate of time gradient. For example, inside a closed room it is possible to measure the gravitational acceleration. If we cannot measure any tidal effects, there is no information about the mass and distance of the object producing the gravity. Is it possible to determine the local rate of time gradient (expressed using proper length and proper time) from just the gravitational acceleration?

It has been shown¹ that a uniform gravitational field with proper acceleration g (measured locally), has the following relationship between redshift and gravitational acceleration:

¹ Edward A. Desloge, “The Gravitational Redshift in a Uniform Field” Am. J. Phys. 58 (9), 856-858 (1990)

$$\nu/\nu_o = 1 - g\hbar/c^2 \quad \text{where:}$$

ν_o = frequency as measured at the source location with rate of time $d\tau_o$

ν = frequency as measured at the detector location with rate of time $d\tau$

\hbar = vertical distance using proper length between the source and detector

g = acceleration of gravity

Reference [1] shows that this equation is exact if the following qualifications are placed on the above definitions. These qualifications are: 1) the source location (subscript o) should be at a lower elevation than the detector location. 2) the separation distance \hbar should be the proper length as measured by a time of flight measurement (radar length) measured from the source location. A slightly different radar length would be obtained if this distance was measured from the detector elevation or measured with a ruler. However, in the limit of a gradient (infinitely small \hbar), this discrepancy disappears. Therefore with these qualifications:

$\nu/\nu_o = 1 - g\hbar/c^2$ is exact. It should be noted that the height difference \hbar is a proper distance (radar length measured from the source) and not circumferential radius.

As will be show in the next chapter, the gravitational redshift is really caused by a difference in the rate of time at different elevations. There is no accumulation of wavelengths, so $\nu_o = 1/d\tau_o$ and $\nu = 1/d\tau$. After making these substitutions, this equation becomes:

$$g = c^2 \frac{d\tau - d\tau_o}{d\tau d\hbar}$$

This is also an exact equation if the above qualifications are observed. Here the ratio $(d\tau - d\tau_o)/d\tau d\hbar$ will be referred to as the gradient in the rate of time. There are two points to be noticed. First, the gradient in the rate if time is able to be determined from the acceleration of gravity with no knowledge about the mass or distance of the body producing the gravity. For example, a gravitational acceleration of $g = 1 \text{ m/s}^2$ is produced by a rate of time gradient of 1.113×10^{-17} seconds/second per meter. The earth's gravitational acceleration of 9.8 m/s^2 near the earth's surface is caused by a rate of time gradient of about 10^{-16} seconds/second per meter of elevation difference in the earth's gravity. The most accurate clock presently available (2015) is an ^{87}Sr optical lattice clock² which has an accuracy of 2.1×10^{-18} . A clock with this accuracy has a resolution comparable to 2 cm elevation change in the earth's gravity.

The second important point is that the rate of time gradient is a function of proper length in the radial direction. Even though $dt/d\tau$ is a function of circumferential radius, the relationship between rate of time gradient and gravitational acceleration is not a function of circumferential radius. This fact will become important in the next chapter when we examine how nature keeps the laws of physics constant when there is an elevation change. The connection between

² <http://www.nature.com/ncomms/2015/150421/ncomms7896/full/ncomms7896.html>

gravitational acceleration and rate of time gradient will also be an important consideration when we examine the cosmological model of the universe (chapters 13 & 14).

Previously, we defined the concept of “gravitational magnitude β ” as: $\beta = 1 - d\tau/dt$. It is also possible to relate the acceleration of gravity to the gradient in the gravitational magnitude.

$$g = c^2 \left(\frac{d\beta}{dh} \right)$$

Inertial Frame of Reference: The concept that gravity can be simulated by an accelerating frame of reference sometimes leads to the erroneous interpretation that an inertial frame of reference eliminates all effects of gravity. Being in free fall eliminates the acceleration of gravity, but the gravitational effect on the rate of time and the spatial effects of the gravitational field remain. Another way of saying this is that the effects of the gravitational gamma Γ on spacetime are still present, even if a mass is in an inertial frame of reference. A clock in free fall still experiences the local gravitational time dilation.

A rigorous analysis from general relativity confirms this point, but two examples will be given to also illustrate the concept. Suppose that there was a hollow cavity at the center of the earth. A clock in this cavity would experience no gravitational acceleration and would be in an inertial frame of reference. The gravitational magnitude β in this cavity is about 50% larger than the gravitational magnitude on the surface of the earth ($\sim 10.5 \times 10^{-10}$ compared to 7×10^{-10}). For example, ignoring air friction, the escape velocity starting from this cavity is higher than starting from the surface of the earth. The clock in the cavity has a slower rate of time than a clock on the surface. The inertial frame of reference does not eliminate the other gravitational effects on the rate of time and the gravitational effect on volume.

A second example is interesting and illustrates a slightly different point. The Andromeda galaxy is 2.5 million light years ($\sim 2.4 \times 10^{22}$ m) away from Earth and has an estimated mass of about 2.4×10^{42} kg (including dark matter). The gravitational acceleration exerted by this galaxy at the distance of the Earth is only about 2.8×10^{-13} m/s². To put this minute acceleration in perspective, a 10,000 kg spacecraft would accelerate at about this rate from the “thrust” of the light leaving a 1 watt flashlight. In spite of the minute gravitational acceleration, the distant presence of Andromeda slows down the rate of time on the surface of the earth about 100 times more than the Earth’s own gravity. This is possible because the gravitational magnitude ($\beta \approx Gm/c^2r$ for weak gravity) decreases at a rate of $1/r$ while the gravitational acceleration decreases with $1/r^2$. At the earth’s surface, Andromeda’s gravitational magnitude is about:

$$\beta \approx Gm/c^2r = (G/c^2) (2.4 \times 10^{42} \text{ kg}/2.4 \times 10^{22} \text{ m}) \approx 7 \times 10^{-8} \text{ Andromeda's } \beta \text{ at earth}$$

Since the earth’s gravity produces $\beta \approx 7 \times 10^{-10}$ at the surface, Andromeda’s effect on the rate of time at the earth’s surface is about 100 times greater than the effect of the earth’s gravity. It does

not matter whether a clock is in free fall relative to Andromeda or whether the clock is stationary relative to Andromeda and experiences the minute gravitational acceleration. In both cases the gravitational effect on time and volume exist. This example also hints that mass/energy in other parts of the universe can have a substantial cumulative effect on our local rate of time and our local volume. This concept will be developed later in the chapters dealing with cosmology.

Schwarzschild Coordinate System: The standard Schwarzschild solution uses coordinates that simplify gravitational calculations. This spherical coordinate system uses circumferential radius R as coordinate length in the radial direction and uses circumferential radius times an angle Ω for the tangential direction. While there is no distinction in proper length for the radial and tangential directions, we will temporarily make a distinction by designating proper length in the radial direction as L_R and designating proper length in the tangential direction as L_T . This distinction does not exist in reality since: $cd\tau = dL = dL_T = dL_R$. However, using these designations, the relationship between proper length and Schwarzschild's coordinate length is:

$$dL_R = \Gamma dR \quad \text{radial length } L_R \text{ conversion to Schwarzschild radial coordinate } R$$

$$dL_T = R d\Omega \quad \text{tangential length } L_T \text{ to Schwarzschild tangential coordinate length}$$

The equation $dL_R = \Gamma dR$ is obtained by setting $dt = 0$. If we are using the proper distance between two points as measured by a ruler, or the calculated circumferential radius, then this zero time assumption is justified.

Next we will calculate the coordinate speed of light \mathcal{C} for the radial and tangential directions by starting with the standard Schwarzschild metric:

$$dS^2 = (1/\Gamma^2)c^2 dt^2 - \Gamma^2 dR^2 - R^2 d\Omega^2 \quad \text{for light set } dS^2 = 0,$$

$$(1/\Gamma^2) c^2 dt^2 = \Gamma^2 dR^2 + R^2 d\Omega^2$$

$$c^2 = \Gamma^4 \frac{dR^2}{dt^2} + \Gamma^2 \frac{R^2 d\Omega^2}{dt^2}$$

If we separate this coordinate speed of light into its radial component (\mathcal{C}_R) and its tangential component (\mathcal{C}_T), we obtain:

$$\mathcal{C}_R = dR/dt = c/\Gamma^2 \quad \mathcal{C}_R = \text{coordinate speed of light in the radial direction } (d\Omega = 0)$$

$$\mathcal{C}_T = R d\Omega/dt = c/\Gamma \quad \mathcal{C}_T = \text{coordinate speed of light in the tangential direction } (dR = 0)$$

This apparent difference in the coordinate speed of light for the radial and tangential directions is not expressing a physically measurable difference in the proper speed of light. The difference follows from the standard (nonisotropic form) of the Schwarzschild metric. If we choose the isotropic form of the Schwarzschild metric the difference will disappear and $\mathcal{C}_R = \mathcal{C}_T \approx c/\Gamma^2$.

However, the isotropic form has its own set of complexities, so we will be using the standard Schwarzschild metric.

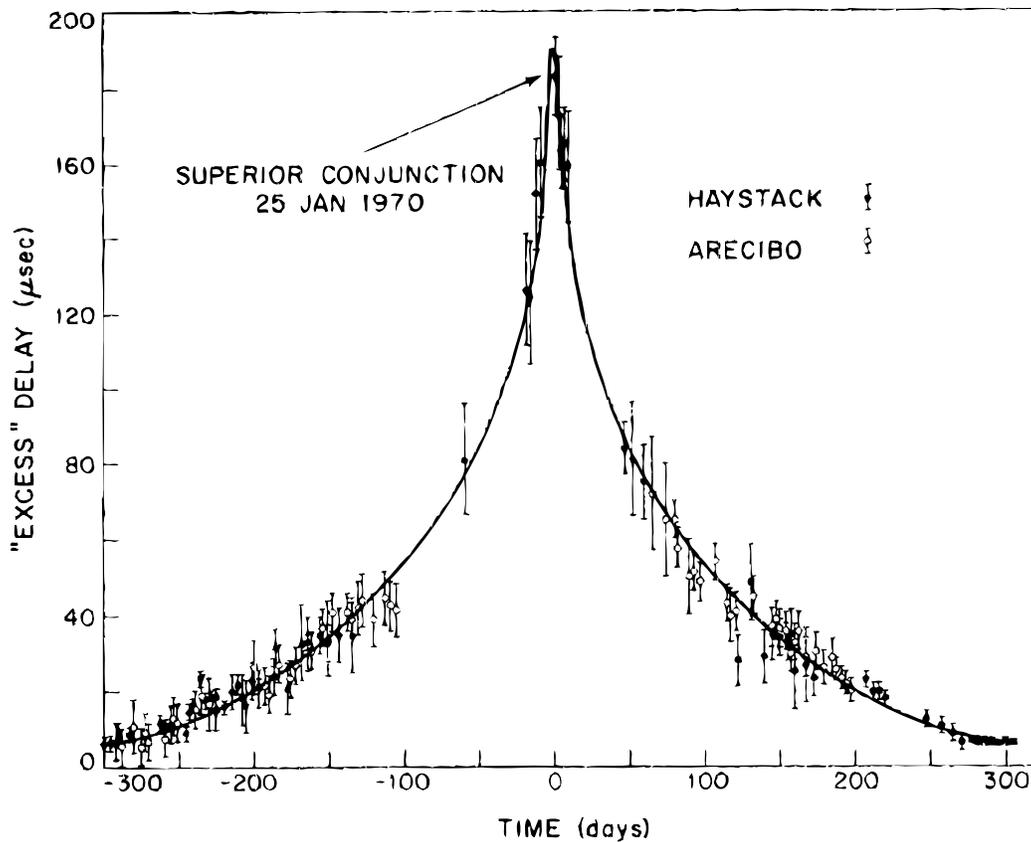


FIGURE 2-1 This is Irwin Shapiro's figure showing the relativistic time delay caused by the sun's gravity on the round trip time for radar to travel from the earth to Venus and back. The x axis is time in days before and after superior conjunction of Venus passing behind the sun.

The Shapiro Experiment: Next, we are going to switch to a discussion about the gravitational effect on proper length, proper volume and the coordinate speed of light. In 1964, Irwin Shapiro proposed an experiment to measure the relativistic distortion of spacetime caused by the Sun's gravity. This non-Newtonian time delay is obtained from the Schwarzschild solution to Einstein's field equation. The Sun is a good approximation of an isolated mass addressed by the Schwarzschild solution. The implication is that gravity affects spacetime so that it takes more time for light to make the round trip between two points in space when the mass (gravity) is present than when the mass (gravity) is absent. Shapiro and his colleagues used radar to track the planet Venus for about two years as Venus and the Earth orbited the Sun. During this time, Venus passed behind the Sun as seen from the Earth (nearly superior conjunction). The orbits of Venus and the Earth are known accurately, so it was possible to measure the additional time

delay in the round trip time from the earth to Venus and back. The effect of the sun's gravity on this round trip time could be calculated from multiple measurements made over the two year time period. Figure 2-1 shows Shapiro's graph of the excess time delay over the two year period. The peak delay at superior conjunction was 190 μ s on a half hour round trip transit time.

Variations of this experiment have been repeated numerous times in the normal course of the space program. Spacecraft on their way to the outer planets often start with an orbital path that at some point results in nearly superior conjunction relative to the Earth. The most accurate measurement to date was with the Cassini spacecraft. It was equipped with transponders at two different radar frequencies, therefore it was possible to determine and remove the effect of the Sun's corona on the time delay. The result was an agreement with the time delay predicted by general relativity accurate to 1 part in 50,000. With this type of agreement, it would seem as if there are no remaining mysteries about this effect and the physical interpretation should be obvious.

How exactly do length, time and the speed of light combine to produce the observed time delay in the Shapiro effect? For simplicity, we would like to look at the time delay associated with a radar beam traveling only in the radial direction. In the limit, we can imagine reflecting a radar beam off the surface of the Sun. This path would be purely radial. To make a measurement we need to have a round trip, but for simplicity of discussion, we will talk about the time delay for a one way trip. For light $dS = 0$, so the metric equation gives us that for light moving in the radial direction:

$$\left(\frac{1}{\Gamma}\right) c dt = \Gamma dR \rightarrow dt = \left(\frac{\Gamma^2}{c}\right) dR$$

We can compute the time Δt it takes to move between two different radii: r_1 and r_2 (where $r_2 > r_1$).

$$c \Delta t = \int c dt = \int_{r_1}^{r_2} \Gamma^2 dR$$

$$c \Delta t = \left(\frac{2Gm}{c^2}\right) \ln\left(\frac{r_2}{r_1}\right) + \left(\frac{2Gm}{c^2}\right) \ln\left(\frac{\Gamma_1^2}{\Gamma_2^2}\right) \quad \text{weak gravity: } \ln\left(\frac{\Gamma_1^2}{\Gamma_2^2}\right) \approx 0$$

$$\Delta t \approx \left(\frac{2Gm}{c^3}\right) \ln\left(\frac{r_2}{r_1}\right)$$

Substituting the Sun's mass, radius and distance gives $\Delta t \approx 50 \mu$ s. Therefore, in addition to a non-relativistic time delay (about 8 minutes), the one way relativistic time delay would be about an additional 50 μ s. The 190 μ s delay observed by Shapiro is roughly 4 times the one way 50 μ s delay from the earth to the sun because of the additional leg to Venus and then the round trip doubling of the time.

Normally, on Earth we would interpret a 50 μs delay in a radar beam as indicating an additional distance of about 15 km. How much does the sun's gravity distort space and increase the radial distance between the earth and the sun's surface compared to the distance that would exist if we had Euclidian flat space? The additional non Euclidian path length will be designated (ΔL). Starting from: $dL_R = \Gamma dR$

$$\Delta L = \int_{r_1}^{r_2} \Gamma dR$$

$$\Delta L \approx \left(\frac{Gm}{c^2}\right) \ln\left(\frac{r_2}{r_1}\right) \quad \text{set } r_2 = 1.5 \times 10^{11} \text{ m, } r_1 = 7 \times 10^8 \text{ m and } m = 2 \times 10^{30} \text{ kg}$$

$$\Delta L \approx 7.5 \text{ km} \quad \text{non-Euclidian additional proper distance between the Earth and Sun}$$

Suppose that it was possible to stretch a tape measure from the earth to the surface of the sun. The distance measured by the tape measure (proper distance) would be about 7.5 km greater than a distance obtained from an assumption of flat space and a Euclidian geometry calculation. The use of a tape measure means that we are using proper length as a standard.

Gravity Increases Volume: If we use proper length as our standard of length rather than circumferential radius, then we must adopt the perspective that gravity increases the volume of the universe. However, an interpretation based on proper volume is often ignored since the use of circumferential radius as coordinate length eliminates this volume change caused by gravity.

In the Shapiro experiment, we calculated that there was a non-Euclidian increase in distance between the earth and the sun of 7.5 km. Suppose that we imagine a spherical shell with a radius equal to the average radius of the earth's orbit. This is a radial distance equal to one astronomical unit ($\text{AU} \approx 1.5 \times 10^{11} \text{ m}$). The sun's mass is $\approx 2 \times 10^{30} \text{ kg}$ and the sun's Schwarzschild radius is $r_s \approx 2950 \text{ meters}$. What is the change in volume (ΔV) inside this spherical shell if we compare the Euclidian volume of the shell (V_o) and the non-Euclidian volume of the shell (V) when the Sun is at the center of the shell?

$$V = \int dV = \int 4\pi R^2 \Gamma dR$$

After integration, the difference $\Delta V = V - V_o$ is approximately:

$$\Delta V \approx (5\pi/3)r_s(r_2^2 - r_1^2) \quad \text{set } r_2 = 1.5 \times 10^{11} \text{ m, } r_1 = 7 \times 10^8 \text{ m and } r_s = 2950 \text{ meters}$$

$$\Delta V \approx 3.46 \times 10^{26} \text{ m}^3 \quad \text{non Euclidian volume increase}$$

To put this non Euclidian volume increase in perspective, the sun's gravity has increased the proper volume within a radius of 1 AU by about $3.5 \times 10^{26} \text{ m}^3$ which is more than 300,000 times larger than the volume of the earth (earth's volume is $\approx 1.08 \times 10^{21} \text{ m}^3$). Stated another way, the volume increase is about 20% smaller than the volume obtained by multiplying the non-Euclidian radial length increase ($\sim 7,500 \text{ m}$) times the surface area of the spherical shell

with a radius of 1 AU. Obviously this non Euclidian volume increase would be much larger if we had chosen a larger shell radius (for example, the size of the observable universe). The implications of this will be explored in the chapters on cosmology.

Concentric Shells Thought Experiment: The concept that gravity increases the volume of the universe is important enough that another example will be given. Suppose that there are two concentric spherical shells around an origin point in space. The inside spherical shell is 4.4×10^9 m in circumference (about the circumference of the Sun). The outside shell is 2π meters larger circumference. With no mass at the origin and infinitely thin shells, this means that there is exactly a 1 meter gap between the shells. We could confirm the 1 meter spacing with a meter stick or a pulse of light and a clock.

Next we introduce the Sun's mass at the origin. This introduces gravity into the volume between the two shells with an average value of about $\Gamma \approx 1 + 2 \times 10^{-6}$. The circumference of each shell (proper length) does not change after we introduce gravity. However, the distance between the two shells would now be about $1 + 2 \times 10^{-6}$ meters. This is 2 microns larger than the zero gravity distance. This 2 micron increase in separation increases the proper volume between the two shells by roughly 10^{13} m³.

In this example of two concentric shells we accepted the proper length of the circumference of the shells (tangential proper length). The question is whether there was also a decrease of this tangential length (relative to a "flat" coordinate system) when the sun's mass was introduced at the origin. It is possible to consider both radial and tangential directions affected equally. This results in gravity producing an even larger increase in proper volume than previously calculated. This will be discussed further in the chapters on cosmology.

Connection Between the Rate of Time and Volume: We are going to compute the effect of the gravitational gamma Γ on proper volume using the standard Schwarzschild metric. The use of this metric means that the standard Schwarzschild conditions apply: a static nonrotating and uncharged spherically symmetric mass distribution in an empty universe. This calculation involves terminology from general relativity that is not explained here. Readers unfamiliar with general relativity should skip the shaded calculation section below and move on to the conclusion.

If we know metric equations, we can compute the 3-dimensional volume and the 4-dimensional volume (includes time). The easiest way to do it is to use the following diagonal metric:

$$dS^2 = -g_{00}(dx^0)^2 + g_{11}(dx^1)^2 + g_{22}(dx^2)^2 + g_{33}(dx^3)^2$$

Then the 3-dimensional volume $dV(3)$ is:

$$dV(3) = (g_{11} \cdot g_{22} \cdot g_{33})^{1/2} dx^1 dx^2 dx^3$$

And for 4-dimensional volume $dV(4)$

$$dV(4) = (-g_{00} \cdot g_{11} \cdot g_{22} \cdot g_{33})^{1/2} dx^0 dx^1 dx^2 dx^3$$

In the particular case of the standard Schwarzschild metric:

$$g_{00} = -1/\Gamma^2; \quad g_{11} = \Gamma^2; \quad g_{22} = R^2, \quad g_{33} = R^2 \sin^2 \theta$$

The differentials of 4 dimensional coordinates in this case are:

$$(dx^0) = cdt; \quad (dx^1) = dR; \quad (dx^2) = d\theta; \quad (dx^3) = d\Phi \quad \text{So:}$$

$$dV(3) = (\Gamma^2 \cdot R^2 \cdot R^2 \sin^2 \theta)^{1/2} dR \cdot d\theta \cdot d\Phi$$

$$dV(3) = \Gamma R^2 \sin \theta dR d\theta d\Phi \quad \text{note that volume (3) scales with } \Gamma$$

$$V(4) = (-(-1/\Gamma^2) \cdot \Gamma^2 \cdot R^2 \cdot R^2 \sin^2 \theta)^{1/2} \cdot cdt \cdot dR \cdot d\theta \cdot d\Phi$$

$$dV(4) = R^2 c \sin \theta dt dR d\theta d\Phi \quad \text{note that this is independent of } \Gamma$$

The above calculation shows that proper volume (3 spatial dimensions) scales with the gravitational gamma Γ . This supports the previous examples involving the volume increase interpretation of the Shapiro experiment and also the volume increase that occurs in the thought experiment with two concentric shells. When we include the time dimension and calculate the effect of the gravity generated by a single mass on the surrounding spacetime, we obtain the answer that the 4 dimensional spacetime volume is independent of gravitational gamma Γ . The radial dimension increases ($\Gamma = dL_R/dR$) and the temporal dimension decreases ($\Gamma = dt/d\tau$). These offset each other resulting in the 4 dimensional volume remaining constant.

There is a simpler way of expressing this concept. Since $\Gamma = \left(\frac{dt}{d\tau}\right) = \left(\frac{dL_R}{dR}\right)$ therefore:

$$d\tau dL_R = dt dR$$

This concept will be developed further when we develop particles out of 4 dimensional spacetime and it also has application to cosmology.

Chapter 3

Gravitational Transformations of the Units of Physics

Covariance of the Laws of Physics: From the event horizon of a black hole to the most isolated volume in the universe, there are big differences in the rates of time throughout the universe. How do the laws of physics remain the same when the rate of time is different between locations? Why does a rate of time gradient also not affect the laws of physics? It is an oversimplification to imagine that changing the rate of time is similar to running a movie in slow motion while keeping the laws of physics unchanged.

We are going to be looking at how nature maintains the laws of physics when the rate of time changes with gravitational gamma. This is not just an academic question. Gravity produces a rate of time gradient and a gradient in the coordinate speed of light. Therefore, even in earth's gravity, the simple act of lifting an object to a different elevation means that the object is moved to a location where there is a different rate of time and a different coordinate speed of light. Acknowledging that there are changes in the rate of time leads to surprising new physical insights.

When the rate of time is different between two locations, but the laws of physics are the same, there must also be other changes in the units of physics to offset the difference in the rate of time. For example, momentum scales proportional to $1/t$, force scales proportional to $1/t^2$, power scales proportional to $1/t^3$ and the fine structure constant is independent of time ($1/t^0$). This is time raised to four different powers, yet the laws of physics are constant even with this difference in time dependence. What additional changes are required to offset the change in the rate of time and preserve the laws of physics unchanged in different gravitational potentials?

If there is a coordinate rate of time in a zero gravity location that is different from the rate of time in a location with gravity, and if the coordinate speed of light is different in the two locations, shouldn't there also be a difference in at least some of the other units of physics? For example, is one Joule of energy or one Newton of force also different in the zero gravity location compared to the gravity location? To make a meaningful comparison of the units of physics between locations with different gravitational potentials, it would be necessary to use a single rate of time. This point is easy to see. The more difficult question is: How do we treat length in this exercise?

It is impossible to directly compare length between two locations with a different gravitational potential. Also vectors are ambiguous when compared between locations with different gravitational potential. For example, the direction of a vector can be different depending on the path chosen to transport a vector between two locations with different gravitational potentials.

Therefore adopting the locally measured proper length as a standard of length for that location eliminates ambiguity, but is it the length standard we are seeking?

To be clear, this exercise is not interested in calculating the general relativistic effects on space and time. We will obtain this information from standard general relativity calculations. We will presume that we already know the gravitational gamma ($\Gamma = dt/d\tau$) for each location of interest. Instead we are interested in understanding how the laws of physics accommodate the spatial and temporal differences associated with these different values of Γ . The laws of physics always scale in a way that keeps the speed of light constant ($c = dL/d\tau$). For example, a zero gravity observer might perceive that that a location in gravity has a slow rate of time. However, the zero gravity observer also perceives that this location in gravity also has a proportionately slow coordinate speed of light. A speed of light experiment performed in gravity always results in the universal constant c because a zero gravity observer perceives a slow coordinate speed of light being timed by a slow clock. This results in not only a constant proper speed of light (c) but also the zero gravity observer can consider proper length as constant (independent of Γ). In other words, when the zero gravity observer applies his/her rate of time and adjusts for the different coordinate speed of light, then the unit of length (L) can be considered constant.

All the forces scale with proper length. This is true for not only the electromagnetic force, but even gravitational acceleration scales with proper length. In the last chapter we showed that $g = c^2 \Delta T / \Delta \ell d\tau$. In this equation $\Delta \ell$ is an increment of proper length in the elevation direction. General relativity tells us that there is a difference between circumferential radius R and proper length L . There is also one perspective where the tangential proper length decreases relative to coordinate tangential length when gravity is introduced into a volume of spacetime. However, fermions, bosons and forces know nothing about the general relativistic effects involving circumferential radius or coordinate tangential length. These particles and forces all scale with proper length. If gravity produces non Euclidian spatial geometry, these particles and forces merely accept the proper volume at a particular location and scale with proper length. Therefore since fundamental particles and forces scale with proper length and proper volume, for this exercise we need to adopt a coordinate system that recognizes proper length as a standard.

Normalized Coordinate System: The conclusion of this is that the analysis we wish to perform on the covariance of the laws of physics is best accomplished by adopting a coordinate system that uses coordinate rate of time from general relativity as the time standard and proper length as our length standard. This is an unconventional coordinate system that is a hybrid between the Schwarzschild coordinate system (coordinate time and circumferential radius) and the standard coordinates that use proper time and proper length. This coordinate system will be used to analyze the covariance of the laws of physics when two locations have different gravitational potentials and different rates of time. In this analysis we always assume both a constant distance between locations and static gravity. Further support for the use of this

coordinate system will be offered by actually performing this analysis using this hybrid coordinate system and seeing if the results are reasonable.

The hybrid coordinate system that uses proper length and coordinate rate of time will be called the “normalized” coordinate system. The speed of light utilizing this coordinate system will be called the “normalized” speed of light. We will also be referring to the “normalized” unit of energy, force, etc. All of these units use proper length and zero gravity rate of time. The normalized coordinates cannot be used for general relativity calculations to determine spacetime curvature. The equations become so simplified that important information is lost. Instead, the normalized coordinate system accepts the value of Γ obtained from general relativity and utilizes this information to analyze other aspects of physics. By adopting proper length as our coordinate length and zero gravity rate of time we achieve a coordinate system that works well with quantum mechanics and gives insights into the forces of nature.

Length and Time Transformations: The following analysis will use dimensional analysis and therefore we will be using the symbols of dimensional analysis. These are: M , L , T , Q , and θ to represent mass, length, time, charge and temperature respectively. For example, the units of energy are: $\text{kg m}^2/\text{s}^2$. The conversion to dimensional analysis terminology is:

$$\text{kg m}^2/\text{s}^2 \rightarrow ML^2/T^2.$$

Also, the calculations to follow will be making transformations between the various units of physics when Γ changes. For example, to understand how the laws of physics are maintained going from a hypothetical location in zero gravity ($\Gamma = 1$) to a location with strong gravity ($\Gamma > 1$), we will be working with discrete units such as a Joule or a Newton. This means that the transformation of our coordinates also requires the use of discrete units of length and time rather than the differential form.

For example, $dt = \Gamma d\tau$ relates the rate of coordinate time (dt) to the rate of proper time in gravity ($d\tau$). In this case $dt > d\tau$. However, suppose we compare a unit of time, such as one second in a location with zero gravity to one second in a location with gravity. If each location sent out a light pulse lasting 1 second (according to a local clock), then any observer (independent of Γ) would agree that the light pulse from the location in gravity lasted longer than the light pulse from the zero gravity location. This will be represented as $T_g > T_o$. The subscript “g” represents a location in gravity and “o” represents a location with zero gravity. Therefore, $T_g > T_o$ represents that a unit of time in gravity is larger (longer) than a unit of time in zero gravity. When we convert $dt = \Gamma d\tau$ to express a relationship between units of time it becomes:

$$T_o = T_g/\Gamma \quad \text{unit of time transformation from zero gravity to gravity}$$

There is no new physics being expressed here. The difference is comparable to comparing a rate of pulses expressed as pulse per second compared to the time between pulses expressed as seconds per pulse.

Since proper length is adopted as our standard of length, this means that we are not making a distinction between proper length in any location or orientation. The way that this is expressed is:

$$L_o = L_g \quad \text{unit of length transformation from zero gravity to gravity}$$

Normalized Speed of Light: When the normalized coordinate system uses proper length and the zero gravity rate of time, then the normalized speed of light (designated with a capital “C”) becomes: $C = dL/dt$. In other words, the normalized speed of light in the normalized coordinate system is the change in proper length divided by the rate of coordinate time dt.

$$C \equiv dL/dt = cdt/dt = c/\Gamma \quad C = \text{normalized speed of light}$$

$$C_o = c \quad C_o = \text{normalized speed of light in zero gravity (when } \Gamma = 1)$$

$$C_g = c/\Gamma \quad C_g = \text{normalized speed of light in a location with gravity (when } \Gamma > 1)$$

$$C_o = \Gamma C_g \quad \text{relationship between } C_o \text{ and } C_g$$

If there are two locations (1 and 2) that have gravitational gammas Γ_1 and Γ_2 respectively, then they will have normalized speed of light of C_1 and C_2 . The relation between these two different normalized speeds of light is: $\Gamma_1 C_1 = \Gamma_2 C_2 = c$.

In the equation $C_o = \Gamma C_g$ we have eliminated the need for Γ_1 because in zero gravity $\Gamma = 1$ and the need to mention Γ_1 disappears. It is informative to give an example of $C_o = \Gamma C_g$. The gravitational gamma Γ at the surface of the sun is: $\Gamma \approx 1.000002$. If we set the normalized speed of light in zero gravity to $C_o = 1$, then the surface of the sun has $C_g \approx 0.999998$. Since proper length is coordinate length in the normalized coordinate system, the non-Euclidian properties of space are interpreted as gravity creating additional proper volume in the space surrounding a mass. Therefore the non-Euclidian volume surrounding the sun is merely accepted by the normalized coordinate system. If a beam of light passes through this non Euclidian volume of space, then the difference in optical path length across the width of the beam is taken into account. This difference in path length contributes to bending of the light.

Comparison of Coordinate Speed of Light: We previously designated the coordinate speed of light using Schwarzschild coordinates as \mathcal{C}_R and \mathcal{C}_T . The comparison of the normalized speed of light in gravity C_g to the Schwarzschild coordinate speed of light is:

Length Transformation	Coordinate Speed of Light	Speed of Light Conversion	Coordinates
$L_o = L_g$	$C_g = dL/dt$	$c = \Gamma C_g$	Normalized speed of light conversion
$dR = (1/\Gamma) dL_R$	$\mathcal{C}_R = dR/dt$	$c = \Gamma^2 \mathcal{C}_R$	Schwarzschild coordinates (radial)
$Rd\Omega = dL_T$	$\mathcal{C}_T = Rd\Omega/dt$	$c = \Gamma \mathcal{C}_T$	Schwarzschild coordinates (tangential)

The normalized speed of light is similar to the proper speed of light c in the sense that both are independent of orientation (radial or tangential). The only difference is that the normalized speed of light uses coordinate time which is an absolute standard for the rate of time and also is a faster rate of time compared to the proper rate of time in gravity (stationary frame of reference).

Internally Self Consistent: Another important similarity between the normalized speed of light and proper speed of light is:

$$dL = Cdt = c d\tau$$

The above relationship indicates that the normalized coordinate system is internally self consistent. By definition, the following is always true: $cd\tau = dL$ (any orientation or gravitational Γ). So also the following is always true: $Cdt = dL$ (any orientation or gravitational Γ).

In gravity, the normalized speed of light is slow ($C_g = c/\Gamma$). However, a unit of time in gravity T_g is longer than the same unit of time in zero gravity ($T_g = \Gamma T_o$). The combination of these two factors offset each other, thereby producing a constant length: $C_g T_g = (c/\Gamma) (\Gamma T_o) = L_o$. The combination of these two factors achieves the same length in any Γ or orientation. Therefore it is possible to say that $L_o = L_g$ and have a coordinate system that is internally consistent.

Energy Transformation: We know the transformation of units of length ($L_o = L_g$) and time ($T_o = T_g/\Gamma$), but we need to determine the transformation for units of mass before all other transformations can be easily calculated. It is not obvious what transformation mass would be if we used a standard unit of mass in zero gravity (M_o) to quantify the same proper unit of mass in gravity (M_g). Mass is not synonymous with matter. For example, one electron in zero gravity transforms into one electron in gravity. However, do they have the same inertia? Mass is a quantification of inertia which implies force and acceleration. Both of these involve time, so it should be expected that mass (inertia) may have some dependence on the rate of time. Since we cannot directly reason to the mass transformation, it is necessary to determine some other transformation between zero gravity and gravity that can be determined by physical reasoning. Then we will use that transformation to deduce the mass transformation indirectly. Fortunately, there are two additional transformations that can be determined by physical reasoning. The conservation of momentum implies that a unit of momentum in zero gravity equals a unit of momentum in gravity. This will be written as $p_o = p_g$. The second transformation that can be determined from physical reasoning involves energy. It will be shown that $E_o = \Gamma E_g$.

Before actually deriving this, I just want to review the meaning of $E_o = \Gamma E_g$. The term E_o represents a unit of energy (such as 1 Joule or 1 eV) in a location with zero gravity ($\Gamma = 1$). Similarly, E_g represents the same unit of energy in a location with gravity ($\Gamma > 1$). Furthermore,

we assume that both sources of energy can be considered essentially stationary relative to each other. Therefore since gamma is greater than one ($\Gamma > 1$) the equation $E_o = \Gamma E_g$ says that 1 Joule in zero gravity represents more energy than 1 Joule in a location with gravity ($\Gamma > 1$). The ratio of these two energies is $E_o/E_g = \Gamma$.

The simplified energy transformation involves an approximation while the momentum transformation does not. However, we will start with the energy transformation anyway because it better illustrates the meaning of terms. To make a comparison of energy in different gravitational potentials, both E_o and E_g must be measured using the same standard of energy which implies using the same rate of time for both measurements. Perhaps it is convenient to imagine using the zero gravity (coordinate) rate of time for both energy measurements, but the only requirement is that the same rate of time be used. For example, it will be shown that an electron in gravity has less energy than an electron in zero gravity when the energies are compared using the same rate of time. Both electrons have 511,000 eV measured locally, but the energy standard (1 eV) changes. The proportionality constant is the gravitational gamma:

$$\Gamma = \frac{1}{\sqrt{\left(1 - \frac{2Gm}{c^2 R}\right)}} = \frac{dt}{d\tau}$$

This concept is best explained with a thought experiment. Suppose that there is a planet that is in a highly elliptical orbit around a star. The planet's kinetic energy changes from a minimum kinetic energy at the orbital apogee to a maximum kinetic energy at the perigee. Does this change in kinetic energy produce any change in the gravity produced by the combination of the planet and star as the planet orbits the star? (Assume the measurement is made far from the star/planet). We know from general relativity that the total gravity produced by a closed system remains constant when there is no transfer of energy into or out of the closed system. Since gravity scales with energy, the implication is that the planet's total energy remains constant in all parts of the highly elliptical orbit. It is obvious that the planet's kinetic energy changes from apogee to perigee. Since the gravity produced by the orbiting planet is constant, the implication is that the gain in kinetic energy equals the loss of internal energy as the planet enters a stronger gravitational field. The more general principle is that a body in free fall maintains a constant total energy (internal plus kinetic) as it falls. This can be expressed as: $E_o = E_g + E_k$ where:

E_o is the internal energy of a mass m in zero gravity ($E_o = m_o c^2$) measured using the zero gravity standard of energy.

E_g is the internal energy of a mass in gravity but measured using the zero gravity standard of energy (measured using the coordinate clock).

E_k is the kinetic energy of mass m in free fall from infinity to distance r in the gravity of larger mass M . Also E_k is measured using the zero gravity standard of energy.

Since the definition of E_k references zero gravity, then $E_k = Gm_oM/r = E_o(GM/c^2r)$. In the following calculation we will use the approximation: $E_o(GM/c^2r) \approx E_g(GM/c^2r)$. Normally this approximation would not be allowed since we are attempting to determine the relationship between E_o and E_g , however in this case it is acceptable because in weak gravity $(GM/c^2r) \ll 1$.

$$\begin{aligned} E_o &= E_g + E_k & E_k &\approx E_g(GM/c^2r) \quad \text{approximation from above} \\ E_o &\approx E_g(1 + GM/c^2r) & \text{set: } \Gamma &\approx 1 + GM/c^2r \\ E_o &\approx \Gamma E_g & &\text{this approximation is exact in a rigorous analysis} \end{aligned}$$

The gravitational red/blue shift can cause some confusion in the discussion of standards of energy and will be discussed later. Also, this equation can easily be misinterpreted if proper units of energy are used to measure E_g rather than always using normalized units of energy.

Mass Transformation from Energy: Next we will solve for the mass transformation using $E_o = \Gamma E_g$; $L_o = L_g$ and $T_o = T_g/\Gamma$. Energy has units of $\text{kg m}^2/\text{s}^2$ which in dimensional analysis terms will be expressed as: $E \rightarrow M L^2/T^2$

$$\begin{aligned} E_o &= \Gamma E_g & \text{set: } E_o &\rightarrow \frac{M_o L_o^2}{T_o^2} \quad \text{and} \quad E_g \rightarrow \frac{M_g L_g^2}{T_g^2} \\ \frac{M_o L_o^2}{T_o^2} &= \Gamma \left(\frac{M_g L_g^2}{T_g^2} \right) & \text{set: } L_g &= L_o \quad \text{and} \quad T_g = \Gamma T_o \\ \frac{M_o L_o^2}{T_o^2} &= \Gamma \left(\frac{M_g L_o^2}{\Gamma^2 T_o^2} \right) \end{aligned}$$

$$M_o = M_g/\Gamma \quad \text{units of mass transformation obtained from the energy transformation}$$

Again, both M_o and M_g represent the same units of stationary mass such as 1 kilogram. Furthermore, both units of mass are measured using a single rate of time. As suspected previously, the connection between mass and inertia means that the normalized unit of mass (inertia) has a dependence on the rate of time (Γ dependence).

The transformation $M_o = M_g/\Gamma$ looks strange because it says that the normalized mass unit increases as gravity increases (as Γ increases). This will be analyzed later, but it relates to the inertia measured by a zero gravity observer.

Mass Transformation from Momentum: Next we will check the mass transformation by also deriving the mass transformation by assuming the conservation of momentum ($p_o = p_g$). This becomes:

$$\frac{M_o L_o}{T_o} = \frac{M_g L_g}{T_g} \quad \text{set } L_o = L_g \text{ and } T_o = T_g/\Gamma$$

$$M_o = M_g/\Gamma$$

Now that we have established the mass transformation, we can combine this with the length and time transformations to generate all of the other transformations nature requires to maintain the laws of physics when the rate of time changes because of a change in gravitational potential. To summarize, here are the key transformations:

$$L_o = L_g \quad \text{unit of length transformation}$$

$$T_o = T_g/\Gamma \quad \text{unit of time transformation}$$

$$M_o = M_g/\Gamma \quad \text{unit of mass transformation}$$

Appendix B at the end of this chapter shows the details of derivation of the various transformations. Essentially this is just dimensional analysis where the dimensions of mass, length and time are transformed from zero gravity to gravity. The following transformation of force is typical of the other transformations.

$$\text{Force F: } F_o \rightarrow \frac{M_o L_o}{T_o^2} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g}{\frac{T_g^2}{\Gamma^2}} \rightarrow \Gamma F_g$$

$$F_o = \Gamma F_g \quad \text{force transformation}$$

The table on the following page gives all of the important transformations.

Gravitational Transformation of Units and Constants: The following are transformations of units of physics from zero gravity $\Gamma = 1$ to a location in gravity $\Gamma > 1$. The relationships are expressed assuming a single rate of time and proper length. The gravitational gamma Γ is defined as:

$$\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}} \approx 1 + Gm/c^2 R.$$

The symbols of dimensional analysis L, T, M, Q and θ are used to represent length, time, mass, charge and temperature respectively.

Normalized Transformations

$L_o = L_g$	unit of length transformation
$T_o = T_g/\Gamma$	unit of time transformation
$M_o = M_g/\Gamma$	unit of mass transformation
$Q_o = Q_g$	unit of charge expressed in coulombs – not stat coulombs
$\theta_o = \theta_g$	unit of temperature transformation
$C_o = \Gamma C_g$	normalized speed of light transformation
$dL = \Gamma dR$	proper length and circumferential radius transformation

$E_o = \Gamma E_g$	energy
$v_o = \Gamma v_g$	velocity
$F_o = \Gamma F_g$	force
$P_o = \Gamma^2 P_g$	power
$G_o = \Gamma^3 G_g$	gravitational constant
$U_o = \Gamma U_g$	energy density
$P_o = \Gamma P_g$	pressure
$\omega_o = \Gamma \omega_g$	frequency
$\rho_o = \rho_g/\Gamma$	density
$k_o = \Gamma k_g$	Boltzmann's constant
$\sigma_o = \Gamma^2 \sigma_g$	Stefan-Boltzmann Constant
$I_o = \Gamma I_g$	electrical current
$V_o = \Gamma V_g$	voltage
$\epsilon_{oo} = \epsilon_{og}/\Gamma$	permittivity of vacuum
$\mu_{oo} = \mu_{og}/\Gamma$	permeability of vacuum

Units and Constants That Do Not Change in Gravity

$p_o = p_g$	momentum is conserved
$\mathcal{L}_o = \mathcal{L}_g$	angular momentum is conserved
$\hbar_o = \hbar_g$	Planck's constant (angular momentum is conserved)
$\alpha_o = \alpha_g$	fine structure constant (dimensionless constant is conserved)
$\Omega_o = \Omega_g$	electrical resistance
$\mathbb{B}_o = \mathbb{B}_g$	magnetic flux density
$Z_{oo} = Z_{og}$	impedance of free space
$Z_{so} = Z_{sg}$	impedance of spacetime

Fundamental Equations

$E_o = E_g + E_k$	relationship of internal energy and gravitational kinetic energy E_k
$E_o = E_g - E_{po}$	relationship of internal energy and gravitational potential energy E_{po}

Conversion to Normalized Perspective: When we calculate energy, velocity, force, mass, power, voltage, etc. using proper time, because of the covariance of the laws of physics, we obtain an answer that numerically equals the value in zero gravity. Therefore, to convert this proper value into normalized values, we merely substitute the proper value into the above transformations by replacing the zero gravity term (E_o , V_o , F_o , etc.) and solve for the normalized value (E_g , V_g , F_g , etc.). For example, an electron has energy of 8.187×10^{-14} Joules. In the normalized perspective, this is really the energy of an electron in zero gravity. However, the covariance of the laws of physics allows us to use this energy in locations with $\Gamma > 1$. To convert to normalized energy, we merely substitute the zero gravity energy (8.187×10^{-14} Joules) for E_o in the equation $E_g = E_o/\Gamma$ and solve for E_g . Since $\Gamma > 1$ for a location in gravity, this means that $E_g < E_o$. For example, at the surface of the sun $\Gamma \approx 1 + 2 \times 10^{-6}$. Therefore an electron at the surface of the sun has only 0.999998 the energy of an electron in zero gravity.

Insights from Transformations

Energy Transformation and Calculation: We normally closely associate mass and energy. However, the normalized transformations treat mass and energy differently. When an object is moved to a location with a larger gravitational gamma (and slower rate of time), the normalized energy of the object decreases and the normalized mass (inertia) of the object increases. The mass transformation is discussed below, but when we transform $E = mc^2$ into the normalized time perspective, the gravitational effect on the normalized speed of light is squared and the gravitational effect on mass is raised only to the first power. The result is: $E_o = \Gamma E_g$. This equation applies only to stationary objects because this was an assumption used in the derivation. The term “stationary” means no change as a function of time in the optical path length between two objects or points.

The equation $E_o = \Gamma E_g$ says that a unit of energy in zero gravity is larger than the same unit of energy in a location with gravity. This applies to all forms of energy such as: the annihilation energy of mass, the energy stored in capacitors, the energy of chemical reactions, thermal energy, or the energy of atomic transitions. In all cases the normalized energy of stationary objects in gravity is diminished by the gravitational gamma factor. The loss of energy when an object moves to stronger gravity is easy to see. A meteor striking the earth generates heat. This heat is the lost internal energy of the meteor. The atoms of the meteor that remain in the earth’s gravity have less internal energy than they had in space (once the heat is removed).

If we elevate a one kilogram mass by 1 meter in earth’s gravity, we say that we have given the mass potential energy of 9.8 Joules. Where is this energy stored? I want to see and understand this mysterious gravitational potential energy. If we ignore the change in time over the one

meter elevation, then the source of gravitational potential energy is a mystery. However, if we acknowledge that the rate of time is different when we change elevation, then we arrive at the conclusion that the energy expressed in normalized units of energy is also different at the two elevations. This insight allows us to obtain a partial insight into the storage of gravitational potential energy. The proposed particle model presented later will give a more complete explanation. Below, we will use the transformation $E_o = \Gamma E_g$ and compare E_g at two different elevations (1 and 2 where elevation 2 is higher than 1). We will use weak gravity approximations and the following symbols:

Normalized energy in gravity at elevation 1 and 2:	E_{g1} and E_{g2} ,
Large mass (planet) and small test mass	M and m
Radius from the center of the large mass to elevation 1 and 2:	r_1 and r_2
Gravitational gamma and beta for elevation 1 and 2:	$\Gamma_1, \Gamma_2, \beta_1,$ and β_2

$$E_{g2} = \frac{E_o}{\Gamma_2} \quad \text{and} \quad E_{g1} = \frac{E_o}{\Gamma_1} \quad \text{normalized energy transformations}$$

$$E_{g2} - E_{g1} = \frac{E_o}{\Gamma_2} - \frac{E_o}{\Gamma_1} = E_o \left(\frac{1}{\Gamma_2} - \frac{1}{\Gamma_1} \right) = E_o (\beta_1 - \beta_2) \quad \text{set: } \frac{1}{\Gamma} = 1 - \beta$$

$$E_{g2} - E_{g1} \approx \left[\left(\frac{GM}{c^2 r_1} \right) - \left(\frac{GM}{c^2 r_2} \right) \right] mc^2 \approx \left(\frac{1}{r_1} - \frac{1}{r_2} \right) (GMm)$$

$$\text{since } r_2 - r_1 \ll r_1 \text{ substitute: } \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \approx \frac{r_2 - r_1}{r_1^2}$$

$$E_{g2} - E_{g1} \approx (r_2 - r_1) \left(\frac{GM}{r_1^2} \right) m \quad \text{set } r_2 - r_1 = \Delta h \text{ and acceleration } \frac{GM}{r_1^2} = g$$

$$E_{g2} - E_{g1} \approx gm \Delta h \quad \text{gravitational potential energy}$$

Therefore, the change in the normalized energy between level 1 and 2 ($E_{g2} - E_{g1}$) equals the gravitational potential energy for mass m in gravitational acceleration g for a height change of $\Delta h = r_2 - r_1$. It is interesting to do a numerical example using a one kilogram mass being elevated by one meter in the earth's gravity.

$M = 5.976 \times 10^{24}$ kg	mass of the earth
$r_1 = 6.378 \times 10^6$ m	radius of the earth
$\Gamma_1 \approx 1 + GM/c^2 r_1 = 1 + 6.977 \times 10^{-10}$	gravitational gamma of the earth at sea level
$\Gamma_2 \approx \Gamma_1 + (\Gamma_1 - 1)[(r_2 - r_1)/r_1] \approx 1 + 6.977 \times 10^{-10} + 1.091 \times 10^{-16}$	
$\Gamma_2 - \Gamma_1 \approx 1.091 \times 10^{-16}$	difference in Γ when $\Delta h = r_2 - r_1 = 1$ meter
$E_2 - E_1 \approx (\Gamma_2 - \Gamma_1) E_1 \approx 1.091 \times 10^{-16} \times mc^2$	$mc^2 \approx 8.99 \times 10^{16}$ J for 1 kg mass
$E_2 - E_1 \approx 9.8$ J	difference in normalized energy of a 1 kg mass elevated 1 m

Therefore, when we use normalized units (coordinate time and proper length), we find that the internal energy of a mass changes with elevation by exactly the amount of gravitational potential energy. For example, a one kilogram mass has 9.8 Joules more energy when it is at an elevation

1 meter above sea level than it has when it is at an elevation of sea level when energy is expressed in normalized units of energy. There is also a change in the normalized speed of light and in the normalized mass. The combination of these factors results in a change in the normalized energy of a mass that is elevated or lowered in a gravitational field. The relationship between internal energy in zero gravity E_o , the normalized internal energy in gravity E_g and gravitational potential energy E_ϕ is:

$$E_o = E_g - E_\phi$$

The minus sign in front of E_ϕ is the result of considering potential energy to be a negative number. This equation leads to the equation $E_o = E_g + E_k$ discussed above. A body in free fall does not change its normalized energy. Previously, a star and planet in an elliptical orbit were used in an example. Sensing the gravity of the star/planet combination by the use of a distant probe mass is equivalent to sensing the zero gravity energy of the star/planet combination.

Mass Transformation: The normalized mass transformation $M_o = M_g/\Gamma$ looks counter intuitive because it indicates that normalized mass increases when gravitational gamma Γ increases. There is no additional matter being created, there is just a change in the perceived inertia when we convert to a single rate of time and quantify units of inertia in locations with different values of Γ . The inertia (mass) exhibited by a body is defined by the force generated when a body is accelerated. Both force and acceleration incorporate units of time therefore mass (inertia) also exhibits a dependence on the rate of time. A combination of factors results in a unit of mass (inertia) in gravity being larger than the same unit of mass (inertia) in zero gravity

Even though normalized mass increases in gravity, normalized energy decreases as explained above. Since it is easier to conceptually understand energy decreasing in gravity, perhaps it is easier to imagine energy being more fundamental than mass (inertia). It is only a historical accident that we use mass as one of the 5 dimensional units of physics. In particle physics, energy is considered more fundamental than mass and units of eV or MeV are common. If energy replaced mass as one of the 5 dimensional units, then the energy transformation would be the single factor that offsets the gravitational effect on time.

The weak equivalence principle says that there is no difference between gravitational mass and inertial mass. This is true because they both scale proportionately to the gravitational gamma when a constant rate of time is used. Merely elevating a mass in the earth's gravitational field changes both the normalized gravitational mass and the normalized inertial mass. The gravitational field produced by the one kilogram mass scales with total energy, so elevating this mass increases the energy of the elevated mass. This energy increase exactly offsets the decrease in energy of whatever means was used to elevate the mass. The total normalized energy and total gravitational field of the earth is unchanged.

Gravitational Redshift: The gravitational red/blue shift is often misinterpreted^{1 2}. Above it was shown that the internal energy of an atom changes with elevation by exactly the difference in the gravitational potential energy. Not only is there a change in the internal energy of an atom when it changes elevation, there is also a proportional change in the energy of the atom's energy levels when there is a change in elevation. Therefore, from the perspective of someone in zero gravity (normalized time), a particular atomic transition in gravity is less energetic and this transition emits a comparatively low energy and low frequency photon. This low energy is not detectable locally because all energy comparisons (such as 1 eV) have been similarly shifted to a lower energy by the gravitational effect on time and mass.

Now we will address the gravitational redshift. The formula for the red/blue shift is:

$\lambda_o = \Gamma \lambda_g$ where:

λ_g = wavelength in gravity and λ_o = wavelength in zero gravity

Suppose a photon in gravity starts at a lower elevation (level 1) and ends at a higher elevation (level 2). If the photon's energy is measured at level 1 and 2 with local instruments, then a loss of energy is observed at level 2. This redshift appears to be a decrease in frequency, a decrease in energy and an increase in wavelength. If it was possible to measure wavelength, frequency and energy from a single elevation (single rate of time), then it would appear as if there was no change in energy, no change in frequency, but the same increase in wavelength that was observed with a local measurement. The energy and frequency disagreement occurs because different rate of time and energy scales are being used at different elevations. The agreement in wavelength occurs because the transformation $L_o = L_g$ says that all observers are using the same length standard to measure wavelength.

If we look only at wavelength, then there is such a thing as gravitational redshift. This is because from all gravitational potentials, the same change in wavelength is observed. However, if we look at either energy or frequency using zero gravity rate of time, then there is no such thing as gravitational redshift. The apparent change in frequency and energy occurs because we measure energy and frequency using local standards of the beginning and ending elevations. At these different elevations (different values of Γ), it is our local standards of energy and time that have changed, not the photon's energy and frequency.

There is an interesting question that I would like to propose. We know that there appears to be a gravitational blue shift when a photon is generated at a high elevation (height 2) and is analyzed at a lower elevation (height 1). In other words, the photon seems to have gained energy. The question is: What would happen if we trapped a photon in a reflecting box at height

¹ L. B. Okun, K.G. Selivanov and V.L. Telegdi, "On the Interpretation of the Redshift in a Static Gravitational Field", Am.J.Phys.68:115,2000; arXiv:physics/9907017.

² L. B. Okun, "Photons and static gravity, Mod.Phys",Lett.A15:1941,2000; arXiv:hep-ph/0010120

2, then lowered the box to height 1? Would the photon in a box have the same energy as a freely propagating photon when it reached height 1?

I contend that the photon lowered in a box would appear to have less energy than the freely propagating photon. From a local perspective, the freely propagating photon appears to gain energy (blue shifted) and the photon in a box would appear to have the same energy as the energy at height 1. From the perspective of a zero gravity observer, the freely propagating photon retained its original energy when it propagated from heights 2 to 1 and the photon in a box lost energy. This lost energy was removed from the photon in the lowering process. As previously explained, a confined photon exhibits weight. Lowering a box containing a confined photon transfers energy from the photon to the apparatus used to lower the box. There are numerous ways to analyze this problem and I contend that they all give the answer described here. However, this is a little off the subject, so I will not elaborate further.

Another question is: How is it possible for the wavelength to change with elevation if there is no change in the normalized frequency? The answer is that the normalized speed of light changes with elevation ($C_o = \Gamma C_g$). If a photon propagates from a lower elevation to a higher elevation, there is no change in frequency, but the normalized speed of light C_g increases with elevation. This increase in the normalized speed of light increases the distance traveled per cycle time (increases the wavelength). This change in wavelength is obvious from any location, but the constant frequency is only observable when all measurements are made from a single elevation (a single rate of time).

Finally, a word of caution about not using the redshift formula ($\lambda_o = \Gamma \lambda_g$) in transformations as a substitute for length. It is not correct to equate wavelength with the unit of length when there is a change in Γ . A photon generated from a local atom has a wavelength that is a good standard of length. However, a photon generated at another gravitational potential has a wavelength that changes with Γ . Therefore, a photon that is not generated locally cannot be used as a standard of length.

Electrical Charge Transformation: The transformation of electric charge needs special explanation. The transformations of $Q_o = Q_g$ is only correct if charge is expressed in coulombs rather than stat coulombs. Coulombs and stat coulombs are fundamentally different. The MKS unit of coulomb is 6.24×10^{18} electrons but the CGS unit of stat coulomb is related to electrostatic force and has units of $\sqrt{ML^3}/T$. The result is that charge is conserved in gravitational transformations if charge is expressed as a number of electrons (coulombs), but it is not conserved if charge is expressed in stat coulombs with units of $\sqrt{ML^3}/T$. If an electrostatic force equation is written in CGS units, then ϵ_o is missing and there is no normalization of permittivity. The following transformation must be used for charge expressed in stat coulombs:

$$Q_o = \sqrt{\Gamma} Q_g \text{ (charge in stat coulombs)}$$

Testing: The objective of these transformations is to offset the gravitational effect on the rate of time and keep the laws of physics covariant in any gravitational potential. It is interesting to make substitutions into various equations of physics and see that the transformations do indeed keep the same equations of physics when there is a transformation of gravitational gamma. This is saying that these transformations exhibit internal self consistency. However, it is also possible to see the implied physics behind these transformations upon close examination.

Shapiro Revisited: In the last chapter we talked about the Shapiro experiment detecting a relativistic increase in the time required for radar to travel radially in the sun's gravity. The delay was equivalent to about a 50 μs delay in the time required for light to travel one way from the earth to the sun's surface. If we use Schwarzschild coordinates, then the 50 μs delay is due entirely to the slowing of the coordinate speed of light which scales according to the local value of Γ^2 along the radial path between the earth and the sun ($c = \Gamma^2 \mathcal{C}_R = \Gamma^2 dR/d\hat{t}$).

How do we interpret the 50 μs delay using the normalized coordinates? If a tape measure could be used to measure the distance between the earth and the surface of the sun, the distance measured by a tape measured would be about 7.5 km longer than the circumferential radius distance calculated by dividing the circumference by 2π . The normalized coordinate system uses proper length (tape measure length) as coordinate length. Therefore, the normalized coordinates gives the radar pulse credit for having traveled the additional 7.5 km of non-Euclidian distance between the earth and the sun. It takes about 25 μs for speed of light travel to cover 7.5 km, so the normalized coordinates attributes half the 50 μs delay to the time required to travel the non-Euclidian distance generated by the sun's gravity. The other half is due to the normalized speed of light being slowed according to $c = \Gamma \mathcal{C}_g = dL_R/dt$. Integrating over the changing Γ along the optical path gives the additional 25 μs due to this slowing. Therefore, the 50 μs total delay is the same, but the interpretation is different.

The following chapters will primarily use the standard definition for the speed of light. This standard definition will be designated by lower case "c". Occasionally we will switch into using normalized speed of light to give another perspective. In this case we will use an upper case "C". Attention will be called to this change.

Appendix B

This appendix gives the details of the derivation of some of the additional transformations enumerated in the table titled “Gravitational Transformations of Units and Constants”. This appendix can be skipped without the loss of any important information to the main points of this book if this backup information is not of interest to the reader.

Velocity v : $v_o \rightarrow \frac{L_o}{T_o} = L_g \frac{\Gamma}{T_g} \rightarrow \Gamma v_g$

$v_o = \Gamma v_g$ normalized velocity v_g decreases in gravity (just like C)

Gravitational Constant G : $G_o \rightarrow \frac{L_o^3}{M_o T_o^2} = \frac{L_g^3}{\left(\frac{M_g}{\Gamma}\right) \left(\frac{T_g^2}{\Gamma^2}\right)} \rightarrow \Gamma^3 G_g$

$G_o = \Gamma^3 G_g$ normalized gravitational constant (see comment below)

Energy Density U : $U_o \rightarrow \frac{M_o}{L_o T_o^2} = \frac{\frac{M_g}{\Gamma}}{L_g \left(\frac{T_g^2}{\Gamma^2}\right)} \rightarrow \Gamma U_g$

$U_o = \Gamma U_g$ normalized energy density

Electrical Charge: Next we come to transformations that have dimensions that include electrical charge in Coulombs. These include permittivity ϵ_o , permeability μ_o , current I , Voltage V and the impedance of free space Z_o . For this exercise, the symbol ϵ_{oo} will represent ϵ_o in zero gravity and ϵ_{og} will represent ϵ_o in gravity. Similarly we will use the symbols μ_{oo} , μ_{og} , Z_{oo} , and Z_{og} . A unit of charge will be represented by Q_o and Q_g .

It is not possible to use the above substitutions to determine the transformation of a unit of electrical charge when comparing change between zero gravity Q_o and a unit of charge in gravity Q_g using a single rate of time. It is true that the dimension of charge (expressed in Coulombs) does not contain either time or mass, so the two dimensions known to have Γ dependence are missing (stat Coulombs will be discussed later). So superficially it seems as if there should be no change in a unit of charge when the rate of time changes due to a change in Γ . However, we need to supplement this with some additional physical reasoning using the laws of physics.

From the conservation of charge and the Faraday law we know that charge is conserved when there is a change in elevation. This indicates that $Q_o = Q_g$. There is additional support for this contention because the impedance of free space Z_o has units that scale with $1/Q^2$ (dimensional analysis symbol Q). If there was a gravitational dependence on charge, then the impedance of

free space would have a gravitational dependence. There would be a slight impedance mismatch when light changes elevation in gravity. This impedance mismatch would cause scattering of electromagnetic radiation from gravitational fields. For all these reasons we will assume that:

$$Q_o = Q_g$$

A unit of electrical charge in gravity (Coulombs) equals a unit of electrical charge in zero gravity. We will now use this transformation to generate additional electrical transformations.

$$\text{Permittivity } \epsilon_o: \epsilon_{oo} \rightarrow \frac{Q_o^2 T_o^2}{L_o^3 M_o} = \frac{Q_g^2 \left(\frac{T_g^2}{\Gamma^2}\right)}{L_g^3 \left(\frac{M_g}{\Gamma}\right)} \rightarrow \epsilon_{og}/\Gamma$$

$$\epsilon_{oo} = \epsilon_{og}/\Gamma \quad \text{normalized permittivity}$$

$$\text{Impedance of Free Space } Z_o: Z_{oo} \rightarrow \frac{M_o L_o^2}{T_o Q_o^2} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g}{\Gamma}\right) Q_g^2} \rightarrow Z_{og}$$

$$Z_{oo} = Z_{og} \quad \text{impedance of free space}$$

$$\text{Voltage } \mathcal{V}: V_o \rightarrow \frac{M_o L_o^2}{T_o^2 Q_o} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g}{\Gamma}\right) Q_g} \rightarrow \Gamma V_g$$

Temperature Θ : Finally we come to the transformation of Boltzmann's constant k and temperature. Boltzmann's constant is typically described as: $k = 1.38 \cdot 10^{-23}$ Joule/molecule $^{\circ}$ Kelvin. This number, measured locally, does not change when gravitational gamma is changed. However, the standard of what constitutes a unit of energy (Joule) changes according to the previously derived transformation: $E_g = E_o/\Gamma$. Therefore, to an observer using normalized time, the energy per molecule per degree Kelvin decreases in gravity. Therefore, an acceptable interpretation for the zero gravity observer is that temperature in gravity equals the same temperature in zero gravity, but the Boltzmann "constant" depends on Γ .

$$\Theta_o = \Theta_g \quad \text{temperature is unaffected by an change in gravity}$$

$$\text{Boltzmann Constant: } k_B \rightarrow ML^2/T^2\Theta$$

$$k_B = 1.38 \cdot 10^{-23} \text{ Joule/molecule } ^{\circ}\text{Kelvin} \rightarrow ML^2/T^2\Theta \text{ molecule}$$

$$k_{Bo} \rightarrow \frac{M_o L_o^2}{T_o^2 \Theta_o} \text{ molecule} = \frac{\left(\frac{M_g}{\Gamma}\right) L_g^2}{\left(\frac{T_g}{\Gamma}\right) \Theta_g} \text{ molecule} \rightarrow \Gamma k_{Bg}$$

$$k_{Bo} = \Gamma k_{Bg} \quad \text{normalized Boltzmann's "constant"}$$

Stefan-Boltzmann Constant: $\sigma_o \rightarrow \frac{M_o}{T_o^3 \theta_o^4} = \frac{\frac{M_g}{\Gamma}}{\left(\frac{T_g^3}{\Gamma^3}\right) \theta_g^4} \rightarrow \sigma_g / \Gamma^2$

$\sigma_o = \Gamma^2 \sigma_g$ normalized Stefan-Boltzmann "constant"

The Stefan-Boltzmann constant is the constant associated with the intensity of a black body emission $\mathcal{J} = \sigma \varepsilon T^4$ where σ = Stefan-Boltzmann Constant, ε = emissivity, T is temperature and θ is the dimension of temperature. The equation $\mathcal{J} = \sigma \varepsilon T^4$ supports the idea that $\theta_g = \theta_o$ because temperature is raised to the fourth power. If there was a temperature dependence on Γ , we would have a Γ^4 dependence.

Chapter 4

Assumptions

*“There has never been a law of physics that did not demand
'space' and 'time' for its statement.”*

John Archibald Wheeler

Starting Assumption: Physics today has a large body of experimental observations and mathematical equations that correspond to the experimental observations. Therefore, on a superficial level it would appear that we have a good theoretical understanding of nature up to a limit that will be called the frontier of knowledge. However, there are many counter intuitive physical interpretations of the mathematical equations and experimental observations. This book proposes alternative physical interpretations that not only fit the equations and experiments, but also offer improved conceptual understanding and new insights.

If we are looking for the fabled “theory of everything”, it is best to start the quest with the simplest possible starting assumption. Only if the simplest assumption is proven to be inadequate, should we reluctantly move on to a more complex assumption. When I examined the similarities between light confined in a reflecting box and particles, I was struck by a big idea. This idea is:

Basic Assumption: **The universe is only spacetime.**

This idea will be taken as a basic assumption for the remainder of this book. If this simple starting assumption is correct, it should be possible to invent a model of the universe that uses only the properties of 4 dimensional spacetime. Ultimately, all matter, energy, forces, fields and laws of physics should logically be obtainable from just 4 dimensional spacetime. This is a large project that encompasses all of physics. It grew into this book length explanation rather than a few technical papers.

Initially, this might seem impossible because spacetime appears to be just a quiet vacuum that possesses three spatial dimensions plus time. However, the quantum mechanical model of the vacuum has a vast energy density also known as vacuum energy, quantum fluctuations, zero point energy, etc. As John Archibald Wheeler said “Empty space is not empty... The density of field fluctuation energy in the vacuum argues that elementary particles represent percentage-wise almost completely negligible change in the locally violent conditions that characterize the vacuum.” The spacetime model that is capable of forming matter, energy, forces and fields is a composite of the quantum mechanical vacuum on the microscopic scale and general relativistic characteristics of spacetime on the macroscopic scale. Besides a specific speed of light and a gravitational constant, spacetime also possesses impedance, bulk modulus, energy density etc.

The combination of these properties permits spacetime to become the basic building block for all matter and forces.

Spacetime does have some real advantages as the basic building block of everything in the universe. Spacetime is the stiffest of all possible mediums that support wave propagation. A disturbance in spacetime propagates at the speed of light. The characteristics of spacetime permit it to support any frequency wave up to Planck frequency ($\sim 10^{43}$ Hz). This is a tremendous advantage if we are attempting to find a medium that can hypothetically support the large energy density required to build a proton, for example. Some waves in spacetime will be shown to be capable of modulating the spatial and temporal properties of spacetime. This can serve as the basic building block of matter, forces and fields.

The simplicity of the starting assumption does have one advantage. It should be relatively easy to prove or disprove. Unlike string theory, this starting assumption hardly provides any “wobble room”. If the assumption is wrong, the error should be quickly evident. If the assumption is correct, the extreme limitations define a narrow path that should lead to both confirmations and new insights. I will summarize the conclusions of chapter #1.

A confined photon in a moving frame of reference has the following 8 similarities to a fundamental particle with the same energy and same frame of reference:

1) the same inertia, 2) the same weight, 3) the same kinetic energy when moving 4) the same de Broglie wavelength 5) the same de Broglie phase velocity, 6) the same de Broglie group velocity, 7) the same relativistic length contraction, 8) the same relativistic time dilation. It is hard to avoid the thought that perhaps a particle is actually a wave with components exhibiting bidirectional propagation at the speed of light but somehow confined to a specific volume. This confinement produces standing waves that are simultaneously moving both towards and away from a central region.

The assumption that the universe is only spacetime causes us to explore the possibility that waves in spacetime (dynamically curved spacetime) are the basic building blocks of particles, forces and fields. It also offers the opportunity to give a physical description of quantum mechanical operations such as the collapse of the wave function or making a measurement of a quantum mechanical state. The ultimate test is whether this assumption logically leads to gravity and compatibility with quantum mechanics.

The starting assumption that the universe is only spacetime requires that the reader change perspective about what is a cause and what is an effect. The standard physical interpretation of general relativity is that matter causes curved spacetime. The reverse perspective would be that curved spacetime causes matter. In this perspective spacetime is the single universal field responsible for everything in the universe including matter. Waves in spacetime can be

thought of as dynamically curved spacetime. Static curved spacetime and particles will both be shown to be the result of dynamically curved spacetime.

Creative Challenge: I started with two positions that are currently not connected. On the one hand, there is the current understanding of the fundamental particles, forces and physical laws. On the other hand, there is the basic assumption that the universe is only spacetime. An attempt to bring these two disconnected positions together requires a creative look at both the properties of spacetime and the properties of particles, forces and physical laws. The experimentally verified physical facts and equations are assumed to be correct, but it is not necessary to adopt the physical interpretations currently used to explain these facts and equations. For example, the equations of general relativity accurately describe gravity and the universe. However, the accuracy of these equations does not guarantee the accuracy of the physical interpretations currently associated with these equations. The idea that gravity is not a force, but the result of the geometry of spacetime is a physical interpretation of the equations of general relativity. Rather than focusing on explaining gravity or uniting quantum mechanics and general relativity, I merely start with what I believe is the simplest possible starting assumption (the universe is only spacetime) and attempt to reconcile this assumption with everything known to exist in the universe.

Planck Units: In 1899 Max Planck proposed a system of units based only on constants of nature. He used the reduced Planck constant $\hbar = 1.055 \times 10^{-34}$ kg m²/s, the Newtonian gravitational constant $G = 6.672 \times 10^{-11}$ m³/s²kg, the speed of light $c = 2.998 \times 10^8$ m/s and the Coulomb constant $1/4\pi\epsilon_0 = 8.987 \times 10^9$ m³kg/s²C². This combination of constants can be used to make units of length, time, mass, and charge. Extrapolating further, it is possible to make all other units such as units of force, energy, momentum, power, electric field, etc.

It was immediately recognized that Planck units were fundamental because they were derived from constants of nature. However, it later became recognized that Planck units held an even more special place in physics. Planck units were actually based on the properties of spacetime and they represented the limiting values (maximum or minimum) for a single fermion or boson. For example, a group of particles can have mass in excess of Planck mass ($m_p = 2.176 \times 10^{-8}$ kg). However, the theoretical limit for a single fundamental particle (a single fermion) is Planck mass. If there was a fermion with Planck mass it would form a black hole. The inverse of Planck time is the maximum possible frequency for a photon. Planck length $l_p = 1.616 \times 10^{-35}$ m represents the theoretical limiting value (device independent) of any length measurement. Similarly, Planck time $t_p = 5.301 \times 10^{-44}$ s represents the limiting accuracy of any time measurement. When we are attempting to build the universe out of only spacetime, Planck units become the natural units for this analysis.

Spacetime Models

Spacetime: The Quantum Mechanical Model: Quantum mechanics does not specifically have a model of spacetime. However, quantum mechanics does describe the properties of the energetic vacuum which we will be defining as the properties of spacetime on the microscopic scale. For comparison, the general relativity description of spacetime will be characterized as the macroscopic properties of spacetime. The quantum mechanical view of the vacuum (including QED and QCD) is a locally violent medium filled with vacuum fluctuations. At the basis of the uncertainty principle there is energetic spacetime that is in a continuous state of flux. The distance between two points can only be specified to a limited accuracy (Planck length) because of the effect of these fluctuations on spatial measurement. Similarly the energy at a point undergoes wild fluctuations. This is usually considered as justification for the formation and annihilation of virtual particle pairs, but this energy fluctuation can also be considered merely an energetic distortion of spacetime. Even the rate of time at adjacent points in “flat” spacetime (no gravitational acceleration) can fluctuate slightly producing variations (differences between clocks) that can differ by Planck time.

These fluctuations produce measurable results. For example, the Casimir effect produces a force on two closely spaced metal plates which have been measured to an accuracy of 5% of the theoretical prediction. In a hydrogen atom there is an interaction between the electron and the vacuum fluctuations that produces a small shift in the energy of the $2S_{1/2}$ energy level. This “Lamb shift” has been accurately predicted and experimentally measured. In QED, the vacuum fluctuations can mix with the excited states of an atom resulting in the initiation of spontaneous emission of a photon from the atom^{1 2}. Also, these vacuum fluctuations can produce vacuum polarization which changes Coulomb’s law near an electrically charged particle.

An electron has a magnetic moment which would be precisely equal to 2 except for the anomalous magnetic dipole moment caused by vacuum fluctuations. This electron spin g-factor (g_s) has been predicted by QED calculations and experimentally verified to better than 10 significant figures for the anomalous contribution. The result is: $g_s \approx 2.00231930436$. This means that the magnetic moment of an electron is the most accurate prediction in all of physics. This accuracy depends on the accuracy of the quantum mechanical model of the fluctuations in spacetime. All of these examples are meant to illustrate that quantum mechanics requires that vacuum has vacuum fluctuations at a very large energy density.

¹ Hiroyuki Yokoyama & Ujihara K (1995). *Spontaneous emission and laser oscillation in microcavities*. Boca Raton: CRC Press. p. 6. ISBN 0-8493-3786-0.

² Marian O Scully & M. Suhail Zubairy (1997). *Quantum optics*. Cambridge UK: Cambridge University Press. p. §1.5.2 pp. 22–23. ISBN 0-521-43595-1

One way of quantifying these fluctuations is to visualize a vacuum as being filled with harmonic oscillators at a temperature of absolute zero. From field theory, the lowest quantum mechanical energy of each oscillator³ is $E = \frac{1}{2} \hbar \omega = \frac{1}{2} \hbar c / \lambda$ (where $c = \omega \lambda$ and λ is pronounced lambda bar). This is the famous zero point energy. Each oscillator can be visualized as occupying a volume of $V = k \lambda^3$ where k is a numerical factor near 1. For example, a wave can be confined in a reflecting cavity that is $\frac{1}{2}$ wavelength on a side. The wave amplitude is zero at the walls and maximum in the center for this size cavity. Since we are standardizing on the use of ω for frequency and λ for wavelength, it is possible to say that the wave has been confined to a volume of λ^3 if we ignore numerical factors near 1. Using this volume designation, this means that the energy density U at frequency ω is: $U_\omega = \hbar \omega / \lambda^3 = \hbar c / \lambda^4 = \hbar \omega^4 / c^3$.

What is the total energy density of zero point energy at all frequencies up to a cutoff frequency of ω ? When all frequencies are present with the characteristics of the harmonic oscillators of spacetime, Milonni (previous reference) has shown that there are interactions which result on the total energy density is equal to $U_t = \hbar \omega / \lambda^3 = \hbar \omega^4 / c^3$. This is the same as before except that now the frequency ranges from zero to a maximum of ω . If ω is assumed to have no limit (infinite frequency) then the implied energy density would also be infinite. If we assume that zero point energy is associated with the properties of spacetime (proven later) then the maximum frequency that spacetime can support is Planck frequency ω_p which is the inverse of Planck time $\omega_p = 1 / T_p = (c^5 / \hbar G)^{1/2} \approx 1.85 \times 10^{43} \text{ s}^{-1}$. Assuming Planck frequency ω_p , the implied energy density of the quantum mechanical model of spacetime is approximately equal to Planck energy density $U_p = \hbar \omega_p^4 / c^3 \approx 4 \times 10^{113} \text{ J/m}^3$. (a numerical constant is being ignored). This shocking large number will be extensively analyzed several different places later in this book. For now we will merely recognize that this is part of the quantum mechanical model of spacetime.

Spectral Energy Density: The normal way of treating energy density at a particular frequency is to designate the “spectral energy density” which is energy density per unit frequency interval. We will designate this spectral energy density as: $U(\omega)d\omega$. Every point in spacetime is treated like it is a quantized harmonic oscillator with energy $E = \frac{1}{2} \hbar \omega$. This concept leads to a spectral energy density $U(\omega)d\omega$ that is:

$$U(\omega)d\omega = k \left(\frac{\hbar \omega^3}{c^3} \right) d\omega$$

“This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. All inertial observers are equivalent. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift. Therefore this spectral energy distribution satisfies the

³ Milonni, P. W.: *The quantum vacuum: an introduction to quantum electrodynamics*. p. 49 Academic Press Inc., San Diego (1994)

requirement that it should not be possible to detect any difference in the laws of physics in any frame of reference (at least up to the cut off at Planck frequency). It should also be noted that neither cosmological expansion nor gravity alters this spectrum"⁴. The implications of having a finite cut off frequency are discussed as part of the cosmological analysis in chapter 14.

Quantum Foam: In 1955, John Wheeler proposed that spacetime is highly turbulent at the scale of Planck length. He proposed that as the scale of time and length approaches Planck time and Planck length, the energy fluctuations in spacetime increase. These fluctuations on the smallest scale possible cause spacetime to depart from its smooth macroscopic characteristic. John Wheeler suggested the term "quantum foam" to describe spacetime on this smallest scale. In the book "Einstein's Vision", John Wheeler proposed that elementary particles were excited energy states (resonances) of the vacuum energy fluctuations. He pointed out that the density of a nucleus was $\sim 10^{18}$ kg/m³ and this density is negligibly small compared to the equivalent density of spacetime ($\sim 10^{97}$ kg/m³ or an energy density of $\sim 10^{113}$ J/m³). While John Wheeler's description of spacetime has the same basic components as the spacetime model proposed in this book, his concept of how spacetime forms particles and forces is different.

To summarize, the quantum mechanical model of vacuum, spacetime is a sea of energetic activity that can be visualized several different ways. The uncertainty principle has distance, momentum, time and energy undergoing fluctuations. Field theory has a sea of harmonic oscillators, each with zero point energy of $E = \frac{1}{2} \hbar \omega$. Particle physics has virtual particle pairs and virtual photons coming into existence and going out of existence. QCD has virtual particles with both color charge and electrical charge producing vacuum polarization. The quantum mechanical model of vacuum requires a minimum vacuum energy density of at least 10^{50} J/m³ for many QCD calculations and some variations require the full Planck energy density of $\sim 10^{113}$ J/m³.

Spacetime: The General Relativity Model: We will be viewing the general relativity description of spacetime as describing only the macroscopic properties of spacetime. General relativity visualizes spacetime as a smooth, well behaved medium consisting of 3 spatial dimensions plus time. Spacetime can be curved by energy in any form but it is not subject to the random fluctuations of the quantum mechanical model. General relativity is a classical theory that does not recognize Planck's constant, Planck length or Planck time. The distance between two closely spaced points is not considered to fluctuate but there is a limit as to the precision of the measurement. This precision limit is set by the possibility of forming a black hole if too much energy is required to make the measurement. However, even this limit is a mixture of quantum mechanics and general relativity. In general relativity there are no quantized operations.

⁴ Puthoff, H.E. Phys. Rev. A Volume 40, p.4857, 1989 Errata in Phys. Rev A volume 44, p. 3385, 1991 See also New Scientist, volume 124, p.36, Dec. 2, 1989

General relativity (GR) teaches that energy in any form generates gravity. According to general relativity the universe would collapse into a black hole if the energy density of the universe exceeds the “critical” energy density. According to cosmological observation, spacetime is “flat” on the large scale exceeding about ½ billion light years. The observed energy density of the universe (about 10^{-9} J/m³) appears to be within the margin of error (within 1%) of equaling the critical energy density of the universe. Therefore, according to general relativity the quantum mechanical model of vacuum must be wrong because the quantum mechanical model requires energy density vastly exceeding the critical density of about 10^{-9} J/m³. According to general relativity, an energy density of 10^{113} J/m³ is ridiculous. This energy density would form a black hole even for a sphere that is Planck length in radius.

General relativity does have its share of predictions not shared by quantum mechanics. For example, the rate of time depends on gravity in GR while quantum mechanics considers the rate of time to be constant. Also, GR predicts that proper volume also is affected by gravity. Quantum mechanics does not recognize a gravitational effect on volume.

Reconciling the QM and GR Models: The discrepancy between the quantum mechanical energy density of vacuum ($\sim 10^{113}$ J/m³) and the cosmologically observed energy density of the universe ($\sim 10^{-9}$ J/m³) is the largest numerical discrepancy in all of physics. The difference is a factor of about 10^{122} but this is usually rounded off to “merely” a factor of 10^{120} . The standard interpretation is that there must be some other effect that cancels out what appears to be a ridiculously large quantum mechanical energy density. However, there is good evidence that the vacuum fluctuations exist. They are required for many current quantum mechanical effects. They cannot simply be canceled by another effect that somehow eliminates all the effects of these fluctuations. Furthermore, canceling out 10^{113} J/m³ would require an equally large effect in the opposite direction. No effect that cancels 10^{113} J/m³ has been proposed.

On close examination we really do not need a true cancelation of energy. We merely need one or more mechanisms that allow the quantum mechanical vacuum energy to exist but not interact with us or our observable universe except through the quantum mechanical interactions mentioned. It will be proposed later that the quantum mechanical model of spacetime is correct regarding the energy density of spacetime at the quantum scale of Planck length and Planck time. Also, the general relativity model is correct regarding the energy density of spacetime on the macroscopic scale that does not recognize fluctuations at the scale of Planck length and Planck time. Since the GR predictions are virtually universally accepted, we will concentrate on the energy density predictions of quantum mechanics which are generally presumed to be eliminated by some unknown offsetting property of spacetime. This seems obvious since we do not macroscopically interact with this tremendous energy density nor has it caused the universe to collapse as implied by general relativity.

It is proposed here that spacetime is a composite of the quantum mechanical model and the general relativity model. The quantum mechanical model of spacetime has quantum fluctuations and tremendous energy density. It is describing undetectable waves in spacetime that lack quantized angular momentum and are as homogeneous as quantum mechanics allows. Usually we ignore this by renormalization because it is a uniform background energy density of the vacuum. The general relativity model only recognizes the small portion of the energy in the universe that possesses quantized angular momentum (fermions and bosons). This portion is capable of forming energy concentrations such as massive bodies which distort the macroscopic homogeneity of the quantum mechanical model to form curved spacetime.

The rest of this book is devoted to explaining various aspects of the above statement.

The factor of 10^{120} discrepancy between the two models is the difference between the minute fraction of energy (particles, photons, etc.) that possesses quantized angular momentum and the vastly larger vacuum energy density that does not possess quantized angular momentum. This vacuum energy will later be shown to be a homogeneous superfluid and have other properties that prevent gravitational collapse. These statements are only made to alert the reader that the obvious objections will be addressed later.

Another objection addressed later is the contention that the large energy density of vacuum fluctuations is impossible because the volume of the universe is expanding yet the vacuum energy density is perceived to remain constant. This seems to imply that a vast amount of new energy is being added to the universe each second to accompany the new volume being created. This answer requires two chapters (13 & 14) for a complete explanation, but a key point in this explanation is that spacetime is undergoing a transformation that started at the Big Bang and continues today. The expansion of the proper volume of the universe is one result of this transformation. Another result is that our standard of a unit of energy is shrinking. A decreasing standard will make a constant amount of energy on an absolute scale to appear to grow on our shrinking scale. New energy is not being added to the universe but the properties of the vacuum fluctuations are changing. This will be explained in more detail in chapters 13 and 14.

Vacuum Fluctuations and Vacuum Energy: In the remainder of this book the terms “vacuum energy” and “vacuum fluctuations” will be used interchangeably. In both cases they refer to the quantum mechanical model of spacetime with energy density of about 10^{113} J/m³. For example, “vacuum fluctuations” implies quantum mechanical fluctuations of the vacuum (fluctuations of spacetime) which will be described in the next section of this book. Such fluctuations also can be described as “vacuum energy”. The reason for using two different terms is because sometimes it is desirable to emphasize the energy characteristics and sometimes it is desirable to emphasize the fluctuation characteristic.

In this book the terms “vacuum energy” and “vacuum fluctuations” will never imply dark energy or the cosmological constant. These are concepts from cosmology that imply a vastly lower energy density and a different explanation. Dark energy will be discussed in chapters 13 and 14. A model of the universe will be presented that is based on spacetime undergoing a transformation that produces the observed increase in proper volume and other observations without the need of dark energy.

Dipole Waves in Spacetime

Thus far we have talked about vacuum fluctuations and inferred that these can be considered waves in spacetime. Now it is time to be more specific about the properties of these waves in spacetime. Since the starting assumption of this book is that the universe is only spacetime, the goal is to see if it is possible to prove that all particles, fields and forces are formed out of 4 dimensional spacetime. A critical step is to “invent” a model of waves in spacetime that could possibly be the universal building block of all particles and forces. Once such a model is postulated, it must be tested to see if it actually corresponds to reality.

If fundamental particles are ultimately confined waves in spacetime, it is necessary to look for an explanation that incorporates waves in spacetime with characteristics that can be the basic building block for all matter and forces. Gravitational waves do not have the necessary properties to be both vacuum fluctuations and the basic building block of all particles and forces. We are looking for a wave in spacetime that changes both the rate of time (distorts the time dimension) and changes the distance between points in a way that changes proper volume. We know from general relativity that mass affects both the rate of time and proper volume (mass curves spacetime). **Therefore, if we are trying to build matter out of waves in spacetime, we must use waves in spacetime that possess the ability to affect both the rate of time and the distance between two points.** We must use waves that have the ability to dynamically curve spacetime. The only wave in spacetime that can affect the rate of time and proper volume is a hypothetical dipole wave in spacetime.

The immediate problem is that dipole waves in spacetime are forbidden on the macroscopic scale addressed by general relativity. In standard texts on general relativity the subject of dipole waves warrants just a brief mention because they are considered impossible. For example, perhaps the most authoritative text on general relativity is the 1300 page tome titled “Gravitation” by Charles Misner, Kip Thorne and John Archibald Wheeler. On page 975 of the 24th printing, dipole waves in spacetime receive a three line mention to the effect that *there can be no mass dipole radiation because the second time derivative of the mass dipole is zero* ($\ddot{d} = \dot{p} = 0$). This conclusion ultimately follows from the conservation of momentum. The generation of dipole waves in spacetime would require the center of mass of a closed system to accelerate in violation of the conservation of momentum. Furthermore, if a dipole wave in spacetime somehow existed, the passage of this wave past an electrically neutral, isolated mass would cause

the center of mass to undergo an oscillating displacement which is also a violation of the conservation of momentum. Clearly, dipole waves in spacetime cannot exist on the macroscopic scale governed by general relativity.

However, if we are exploring the possibility of constructing the entire universe out of 4 dimensional spacetime, dipole waves in spacetime have a lot of appeal and deserve a closer look. Matter affects both the rate of time and proper volume (matter curves spacetime). Therefore, dipole waves in spacetime need to be considered as the spacetime wave building block for matter. Are there any conditions where dipole waves in spacetime would be permitted? The answer is yes provided that the dipole waves conform to a severe limitation. The following is the second key assumption of this book:

***Second Assumption:* Dipole waves in spacetime are permitted by the uncertainty principle provided that the displacement of spacetime caused by the dipole wave does not exceed Planck length or Planck time. This restriction will be called the “Planck length/time limitation”.**

The spacetime based model proposes that dipole waves in spacetime can exist on the scale governed by quantum mechanics. This is to say that there are displacements of spacetime that are so small that the displacements are below the quantum mechanical detectable limit set by the uncertainty principle. This is analogous to the reasoning that permits virtual particle pairs to temporarily exist provided that they are permitted by the uncertainty principle. It is proposed that dipole waves in spacetime can exist indefinitely provided that the spatial displacement of spacetime does not exceed Planck length and the temporal displacement of spacetime does not exceed Planck time. These small displacements would be undetectable even with an infinitely long observation time. These dipole waves are the background “noise” of the vacuum. They actually are the cause of the uncertainty principle.

A superficial analysis of the minimum detectable change in length measured over a long time would use the uncertainty principle equation: $\Delta x \Delta p \geq \frac{1}{2} \hbar$ and substitute for Δp the largest possible value of momentum uncertainty for a single quantized unit. This would be Planck momentum which is the momentum of a hypothetical photon with Planck energy. Using this maximum momentum for a single quantized unit, the minimum value of Δx is: $\Delta x = L_p$ (Planck length).

However, this question of the minimum length measurement has been given a more rigorous examination that includes both quantum mechanics and general relativity. The conclusion of all

these articles^{5,6,7,8,9,10} is that there is a fundamental limit to length measurement (device independent) on the order of Planck length ($L_p \approx 1.6 \times 10^{-35}$ m). A similar analysis of time^{2,3} has concluded that there is a fundamental minimum detectable unit of time (difference between clocks) which is on the order of Planck time ($T_p \approx 5.4 \times 10^{-44}$ s). Like all Planck unit definitions, the Planck length/time limitation ignores numerical factors near 1. Therefore, a more precise statement of this limitation might include a numerical factor near 1 that is being ignored here. Since we cannot be sure if there is a numerical factor near 1 that is being ignored in any discussion of Planck length or Planck time, this offers justification for ignoring numerical factors near 1 in the plausibility calculations made in the remainder of the book. Presumably, subsequent analysis by others can insert the ignored factors near 1 if they are needed. However, it will be shown throughout the remainder of the book that the plausibility calculations give the correct answers by ignoring numerical factors near 1. Only in the cosmology chapters (13 and 14) will we need to use a well-known numerical factor near 1.

We will accept the Planck length/time limitation and proceed assuming that dipole waves in spacetime can have this displacement and yet have the wave properties fundamentally undetectable. This limitation is conceptually understandable if it is viewed as a signal to noise limitation. If the very nature of spacetime is that there are quantum fluctuations of Planck length and Planck time, then it is quite reasonable that it is impossible to make physical measurements below this noise limit. Therefore, quantum mechanics permits a dipole wave in spacetime to displace a particle's center of mass by Planck length without violating the conservation of momentum. Similarly, a dipole wave can displace time (the difference between clocks) at a specific location by Planck time compared to the surrounding volume without violating any conservation requirement. Even though the wave properties of spacetime dipole waves are undetectable, this does not imply that spacetime dipole waves are inconsequential. It will be shown that any dipole wave that possesses quantized angular momentum (any fermion or boson) will produce detectable interactions without permitting an experimental measurement of the Planck length and Planck time displacements of spacetime which constitute some of its wave properties.

Another characteristic of dipole waves in spacetime is that they are not strictly longitudinal waves or transverse waves because they are really 4 dimensional waves. A wave that modulates the rate of time such that perfect clocks can differ by $\pm T_p$ is present in all 3 spacial dimensions of a physical volume. Therefore it has both a transverse and longitudinal quality. Similarly, a

⁵ Padmanabhan, T.: *Limitations on the operational definition of spacetime events and quantum gravity*. Class. Quantum Grav. 4 L107 (1987)

⁶ Garay, L. J.: *Quantum gravity and minimum length*. Int. J. Mod. Phys. A 10, 145-166 (1995), [arXiv:gr-qc/9403008](https://arxiv.org/abs/gr-qc/9403008)

⁷ Baez, J. C., Olson, S. J.: *Uncertainty in measurements of distance*. Class. Quantum Grav. 19:14, L121-L125 (2002)

⁸ Calmet, X., Graesser, M., Hsu, S. D.: *Minimum length from quantum mechanics and general relativity*. Phys. Rev. Lett. 93, 211101 (2004) [[arXiv:hep-th/0405033v2](https://arxiv.org/abs/hep-th/0405033v2)]

⁹ Calmet, X.: *Planck length and cosmology*. Mod. Phys. Lett. A 22, 2027-2034 (2007), [[arXiv:0704.1360v1](https://arxiv.org/abs/0704.1360v1)]

¹⁰ Calmet, X.: *On the precision of length measurement*. Eur. Phys. J. C 54: 501-505, (2008) [[arXiv:hep-th/0701073v1](https://arxiv.org/abs/hep-th/0701073v1)]

wave that modulates the 3 spatial dimensions by $\pm L_p$ is producing a volume change which is both transverse and longitudinal. Again all 4 dimensions are being modulated simultaneously because there is also a coordinated modulation of the rate of time. When the rate of time slows, the volume increases and vice versa.

It is proposed that vacuum fluctuations, quantum foam, zero point energy, vacuum energy, the uncertainty principle etc. are all just different ways of describing dipole waves in spacetime with a spatial displacement amplitude in the range of Planck length ($\Delta L \approx L_p$) and a temporal displacement amplitude of Planck time ($\Delta T \approx T_p$). This says that the dimensionless strain wave amplitude (A_s) for a reduced wavelength of λ expressed using spatial properties and temporal properties would be:

$$A_s = \Delta L/L = L_p/\lambda \quad \text{strain amplitude expressed using Planck length and } \lambda$$

$$A_s = \Delta T/T = T_p\omega \quad \text{strain amplitude expressed using Planck time and } \omega$$

Figures 5-3 and 5-4 in chapter 5 are drawn for a different purpose, but they can be used to illustrate strain amplitude. Figure 5-3 has a displacement amplitude of $\pm L_p$. The X axis on this graph is designated in units of reduced wavelengths λ . The strain amplitude at any instant corresponds to the slope of the graph. For example, the maximum slope (maximum strain amplitude) is L_p/λ which occurs when the wave crosses the "X" axis ($y = 0$). Similarly, figure 5-4 relates to the temporal properties of a dipole wave in spacetime with a maximum and minimum temporal displacement of $\pm T_p$. Therefore, maximum temporal strain amplitude corresponds to $\pm T_p\omega$. The Planck length/time limitation implies the following corollary:

Corollary Assumption: The maximum strain amplitude (A_{max}) permitted for a dipole wave in spacetime is L_p/λ in the spatial domain and $T_p\omega$ in the temporal domain.

$$A_{max} = L_p/\lambda = T_p\omega$$

Static versus Dynamic Units: We are going to interrupt the discussion of dipole waves to insert a note about units. Many times in this book, Planck length will be representing a wave amplitude dimension (dynamic dimension) rather than a static distance as might be equated to ruler length. I will attempt to clearly specify when length represents a wave amplitude or a strain in spacetime with units of length but not to be confused with static length (distance). It is also possible to have a wave amplitude associated with Planck time. For example if a wave in spacetime caused perfect clocks to speed up and slow down by Planck time, then Planck time would be expressing a wave amplitude (a dynamic unit) rather than the conventional idea of a time interval such as 1 second.

What Are Dipole Waves In Spacetime? We will start the examination of dipole waves in spacetime by making an analogy to electromagnetic dipoles. For example, a carbon monoxide molecule has the carbon atom negatively charged and the oxygen atom positively charged. The

bond between these two atoms has similarities to a mechanical spring. When the carbon monoxide molecule is given energy, it will vibrate and rapidly rotate around a transverse axis. This is a rotating electromagnetic dipole which emits a photon into a characteristic emission pattern associated with dipoles. The CO molecule oscillating dipole emission is always combined with a change of one unit of angular momentum associated with a change in rotational energy level. The emission of a photon always removes \hbar of angular momentum.

Next, suppose that we had a diatomic molecule where both of the atoms were positively charged. Oscillating or rotating this molecule would also produce electromagnetic radiation, but at a much lower efficiency because both atoms have the same charge. This produces a different emission pattern known as a “quadrupole emission pattern”. Even though quadrupole emission is different than dipole emission, the photons produced by quadrupole emission have the same fundamental properties as photons produced by dipole emission. Both are electromagnetic radiation with transverse wave properties. This is where the electromagnetic analogy to dipole waves in spacetime breaks down because waves in spacetime have a fundamental difference between dipole waves compared to quadrupole waves (gravitational waves).

Mass has only one polarity. Therefore, it is impossible to generate dipole waves in spacetime by oscillating or rotating two connected masses. The lowest order wave obtainable by unsymmetrical acceleration of mass such as an oscillating ellipsoid or a rotating rod is quadrupole gravitational waves. Gravitational waves are transverse waves which propagate at the speed of light in the medium of spacetime. For example, a gravitational wave passing a spherical volume would convert the spherical volume into an oscillating ellipsoid. One dimension transverse to the propagation direction elongates while the orthogonal transverse dimension contracts. These offset each other so that the oscillating ellipsoid has the same volume as the spherical volume. Also, a gravitational wave does not change the rate of time as it passes a test volume.

To obtain dipole waves in spacetime by accelerating mass, it would be necessary to have the center of mass of a closed system accelerate in violation of the conservation of momentum. Another impossible alternative would require one mass of ordinary matter and another mass that exhibited negative energy. This “anti-gravity matter” would produce an inverse curvature of spacetime compared to ordinary matter. As distance to the anti-gravity matter decreased, the rate of time would increase and proper volume would decrease (the opposite of ordinary matter).

A mass with anti-gravity would be the equivalent of a negative gravitational charge and it would also have to be hypothetical negative energy. If a particle of ordinary matter was attached to a hypothetical antigravity particle and the combination rotated, the wave emitted would cause the rate of time at any point in the equatorial plane to speed up and slow down. Also proper volume would expand and contract at these locations. The hypothetical wave in spacetime that would be

generated would be a dipole wave in spacetime. The effect on spacetime would be the equivalent of a modulated gravitational field. Electrically neutral particles, no matter how massive, would undergo an oscillating acceleration towards and away from the hypothetical rotating object. This dipole wave in spacetime is the simplest type of hypothetical wave, but it would also be a violation of the conservation of momentum if it occurs on the macroscopic scale (larger than Planck length). There is no way of generating a dipole wave in spacetime with ordinary matter.

Envisioning a Dipole Wave in Flat Spacetime: Chapter 5 will give some figures to help quantify a dipole in spacetime including figures. There is no way of generating totally new dipole waves (new energy) in spacetime. Planck amplitude dipole waves in spacetime and quantized angular momentum are all part of the properties of spacetime and these fluctuations existed since the Big Bang. Imagine an empty void with no vacuum fluctuations at any scale. This void would have no physical properties – no speed of light, no impedance, no gravitation constant, no permittivity (ϵ_0), no field of any kind. This quiet void goes too far, so instead we will imagine perfectly flat spacetime with a perfectly uniform rate of time and perfectly uniform Euclidian geometry even at the smallest scale.

Next, we will imagine this volume filled with multiple small amplitude dipole waves in spacetime. The temporal part of a dipole wave causes the rate of time to speed up and slow down slightly. If there were perfect point clocks distributed throughout this volume, some clocks located in volumes of “fast time” would be running slightly faster than clocks located in the “slow time” volumes of spacetime. The dipole waves are oscillations, therefore a clock that is running slightly fast one instant would run slightly slow at a later time. There is also chaotic rearrangements of the dipole waves, so the distribution also changes. If it was possible to momentarily freeze the dipole waves in spacetime, we would find that the volume is not flat spacetime either. The locations that have slow rate of time, have a slightly larger volume than expected from Euclidian geometry. The locations that have fast rate of time have slightly less proper volume than expected from Euclidian geometry.

This connection between the rate of time and volume also occurs on the macroscopic scale. As was discussed in chapter 2, a volume that exhibits a fast rate of time also exhibits a non-Euclidian decrease in proper volume compared to the surrounding space. Similarly, a volume that exhibits a slow rate of time also exhibits non-Euclidian enlarged proper volume. Like all waves, dipole waves in spacetime always have equal amounts of wave maximums and wave minimums. For example, a fast rate of time can be considered a wave maximum and a slow rate of time can be considered a wave minimum. The point is that even though there is a random quality to the dipole waves, there is always a pairing of maximum and minimum spacetime distortions over a distance of one wavelength. If we were flipping coins to determine the distribution of fast and slow volumes of spacetime, it would be possible to find a few locations that by chance had a grouping of almost all fast or slow time distortions and this would be detectable. However, if there needs to be a pairing of fast and slow time components on the scale of perhaps two times

Planck length, then this dictates a different range of possibilities. All that is possible is a slight variation in the orientation of fast and slow locations. This is a plausible mechanism that enforces the Planck length/time limitation over a time period long enough to make a measurement at the speed of light across a test volume of spacetime.

Dipole waves in spacetime represent the simplest type of wave distortion of spacetime. In contrast, a volume filled with chaotic gravitational waves (quadrupole waves) would have no oscillation of the rate of time and no oscillation in proper volume. There would be an effect on the distance between points, but an increase in distance in one dimension is offset by a decrease in distance in an orthogonal dimension so that there is no net change in volume. The way that gravitational waves affect spacetime means that they can produce a measurable oscillation in the distance between two points. In other words, gravitational waves can produce changes in the distance between two points that is much greater than Planck length. This is a fundamental difference between dipole waves in spacetime and gravitational waves. The wave properties of gravitational waves are detectable, the wave properties of dipole waves in spacetime are not detectable as discrete waves. However, it will be shown that there are many observable effects of these Planck amplitude waves in spacetime.

“Spacetime Field”: What is a field? John Gribbin¹¹ describes a field as a physical quantity that has a value for each point in space and time. John Archibald Wheeler says a field “occupies space - It contains energy. Its presence eliminates a true vacuum.”¹² Richard Feynman said, “A field has such familiar properties as energy content and momentum, just as particles can have”.¹³ Albert Einstein equated “field” to “physical space”.

The standard model is a field theory. Fundamental particles are described as “excitations” of their associated “fields”. Therefore, even the standard model has the vacuum filled with field energy. Since particles are excitations of fields, and fields exert forces, it might be said that all particles and forces are derived from fields. In other words, the standard model implies that “the universe is only fields.” It is a short jump from this to “the universe is only spacetime”.

The standard model currently has 17 named fundamental particles but this number could be increased if the “color” difference is counted as separate particles. This implies the unappealing prospect that the vacuum contains at least 17 overlapping fields. The standard model describes these particles, but it does not give a physical description of the fields themselves. Lacking this base, physics currently contains many mysteries which can be described mathematically but are not understood conceptually.

¹¹ John Gribbin (1998). *Q is for Quantum: Particle Physics from A to Z*. London: Weidenfeld & Nicolson. p. 138. ISBN 0-297-81752-3

¹² John Archibald Wheeler (1998). *Geons, Black Holes, and Quantum Foam: A Life in Physics*. London: Norton. p. 163.

¹³ Richard P. Feynman (1963). *Feynman's Lectures on Physics, Volume 1*. Caltech. pp. 2–4

The proposal presented in this book is that there is only one truly fundamental field which will be named the “spacetime field”. This is the sea of dipole waves in spacetime previously described (Planck frequency, displacement amplitude of $\pm L_p$, T_p and Planck energy density). Besides wave properties, the spacetime field will be shown to possess impedance, bulk modulus, pressure and superfluid characteristics which will be described. All the fundamental particles will be shown to be a few combinations of frequency, amplitude and spin which achieve a resonance within the spacetime field. There is only one universal field (the spacetime field) which has multiple resonances (stability conditions) corresponding to the fundamental particles. Rather than 17 separate fields which lack conceptually understandable physics and unification, a single field will be described in enough detail to eventually permit computer modeling of the quantum mechanical operations of physics.

Predominant Frequency of Dipole Waves in Spacetime: Zero point energy is described as harmonic oscillators, each with energy of $E = \frac{1}{2} \hbar \omega$. The usual description is that each harmonic oscillator occupies a volume of $V = k\lambda^3 = k(c/\omega)^3$ where k is a numerical factor near 1. This leads to the concept of the spectral energy density discussed previously in this chapter. The usual assumption is that all frequencies are continuously present up to a maximum frequency equal to Planck frequency. The “spectral energy density” of these waves scale with ω^3 , therefore the higher frequencies dominate the energy density.

I previously used this wave frequency and density description in earlier drafts of this book. However, I always knew that there was another alternative model of the frequency distribution which is slightly different. I cannot choose between these two alternatives, so I will mention the alternative also. In this alternative the spacetime field is dipole waves at Planck frequency when viewed from the rest frame of reference of the cosmic microwave background (CMB). Other frequencies can exist in spacetime as spatial and temporal modulations of this sea of Planck frequency dipole waves in spacetime. Therefore, the presence of these other frequencies broadens the spectrum around Planck frequency. In this alternative model, the Big Bang only initially generated Planck frequency ($\sim 10^{43} \text{ s}^{-1}$) dipole waves. These monochromatic waves then became the foundation of the spacetime field. All the lower frequency dipole waves that will be shown to be required to make particles and forces are wave distortions on this energetic background of Planck frequency waves. Both alternatives have low frequency waves on top of predominantly Planck frequency waves.

It should be mentioned that the spacetime field is a completely different concept than the granularity or pixelation proposed by “loop quantum gravity”. In loop quantum gravity, the predicted granularity of spacetime has dimensions on the order of Planck length. There is also a minimum unit of time equal to one unit of Planck time. Therefore, the loop quantum gravity model has spacetime broken into static pixels of volume and time. These pixels are not

oscillating dipole waves in spacetime and therefore do not represent the tremendous energy density of spacetime required to explain zero point energy.

Planck Scale: The mention of Planck length and Planck time does not necessarily imply “Planck scale”. The term “Planck scale” has come to imply the conditions that would exist if particles or photons had Planck energy ($E_p \approx 1.22 \times 10^{19}$ GeV or 1.96×10^9 Joule). For example, a hypothetical particle with Planck energy (Planck mass) would have the force of gravity be comparable to the strong force or the electromagnetic force. Such a particle would have a Compton frequency equal to Planck angular frequency which is the inverse of Planck time. The natural unit of length of such a hypothetical particle is Planck length. All of these properties are hypothetical because a Planck mass fundamental particle does not exist. It would be the smallest possible black hole.

Fermions will be shown to be a wave in the spacetime field that possesses quantized angular momentum which is confined to a specific volume. This is a rotating distortion of the spacetime field at frequencies in the range of 10^{20} Hz to 10^{26} Hz. The rotating distortion of the spacetime field has a displacement amplitude of Planck length and Planck time but the frequency is many orders of magnitude less than Planck frequency. Therefore the energy is much less than Planck energy and does not fit the definition of “Planck scale”.

Properties of Dipole Waves in Spacetime: It is important to also understand that dipole waves in the spacetime field travel at the speed of light but they do not freely propagate like photons or gravitational waves. Since dipole waves affect the rate of time and the proper volume, they interact with each other. Here are some other proposed properties of dipole waves in spacetime that are presented here in summary form and explained later.

- 1) Every part of a dipole wave in the spacetime field becomes the source of a new wave (called a wavelet).
- 2) These wavelets propagate in all directions.
- 3) The addition of wavelets tends to constructively interfere predominately in the forward and backward propagation directions of the previously existing wavefronts.
- 4) These wavelets explore an infinite number of possible trajectories to achieve an amplitude sum at any point (intensity is amplitude squared).
- 5) This is proposed to be the physical explanation that is being modeled by Richard Feynman’s path integral formulation. These properties will be explained later.

Force

If the universe is only spacetime, and if energy is a wave in spacetime (dynamic spacetime), then force must also be the result of a dynamic distortion of spacetime. The following assumption can be made:

Third Assumption: There is only one fundamental force: $F_r = P_r/c$. This is a repulsive force that occurs when waves in the spacetime field, traveling at the speed of light, are deflected.

This single fundamental force exerted by the deflection of waves in spacetime propagating at the speed of light will be called the “relativistic force F_r .” Also, P_r represents “relativistic power” which is power propagating at the speed of light. For example, light and gravitational waves are both power propagating at the speed of light. Dipole waves in spacetime will also be shown to be another form of energy propagating at the speed of light.

The relativistic force is the only force delivered by dipole waves in spacetime. This energy always propagates at the speed of light, even when it seems to be confined to a limited volume. The limited volume is the result of speed of light propagation in a closed loop and interacting with the surrounding vacuum energy (explained later). I propose that the relativistic force is the only truly fundamental force in the universe. All other forces of nature are just different manifestations of this truly fundamental force. The relativistic force is derived from the only fundamental form of energy in the universe, dipole waves in the spacetime field.

It is a common assumption among physicists that the forces of nature were all united at the high energy conditions that existed shortly after the Big Bang. It is true that a hypothetical particle with Planck mass would have a gravitational force roughly comparable to the electromagnetic force or even comparable to the strong force at short distances. According to the commonly held view, the forces of nature separated when the universe expanded and the energy density decreased. The implication is that today the forces of nature are fundamentally different. The fundamental forces are usually thought to be transferred by “messenger particles” such as virtual photons, virtual gluons and gravitons. Furthermore, gravity is not included in the standard model. A popular physical interpretation of general relativity considers gravity to be a geometric effect and not a true force.

Therefore, the above assumption is a radical departure from conventional thought. It is proposed that all forces, (the strong force, the electromagnetic force, the weak force and the gravitational force), are the result of the deflection of waves in the spacetime field traveling at the speed of light. The case will be made that even today the four forces of nature (including gravity) are still closely related because they are all derived from the relativistic force.

The force $F = P_r/c$ is well known as the force associated with photon pressure where P_r is the power of a beam of light. For example, the emission or absorption of 3×10^8 watts of light produces a force of 1 Newton. The word “deflection” is used to cover any change in propagation. For example, even the absorption of a photon by an electron in an atom is characterized here as an interaction between waves in the spacetime field that involves a “deflection”. In later chapters it will be shown that the electromagnetic force, the strong nuclear force and even the gravitational force are all the result of dipole waves in the spacetime field interacting and being deflected.

Energy Density Equals Pressure: Photon pressure is always repulsive. In fact, pressure in any form is always repulsive. Energy density U is fundamentally equivalent to pressure \mathcal{P} when we are dealing with energy propagating at the speed of light. Even though the units look different (J/m^3 versus N/m^2), in dimensional analysis notation the dimensions of both energy density and pressure are the same: $\text{M}/\text{L}\text{T}^2$ (mass/length time²). For example, black body radiation inside a uniform temperature closed container has radiation pressure being exerted on the walls and has a radiation energy density filling the container. The relationship between energy density and pressure for black body radiation (electromagnetic radiation) is $U = 3\mathcal{P}$. The factor of 3 in a container filled with blackbody radiation is traceable to 3 spatial dimensions. A laser with collimated electromagnetic radiation reflecting between 2 mirrors would eliminate the factor of 3 and have $U = \mathcal{P}$ where \mathcal{P} is the pressure exerted on the 2 mirrors. We are ignoring numerical factors near 1 in these conceptual equations therefore we will equate $U = \mathcal{P}$. The relationship between energy density and pressure is important in cosmology because radiation pressure inside a star prevents the star from undergoing a gravitational collapse. For example, the center of the sun is at a temperature of roughly 15 million degrees Kelvin. At this temperature, the photon energy density is about $3 \times 10^{13} \text{ J}/\text{m}^3$ and the photon pressure is about $10^{13} \text{ N}/\text{m}^2$. This internal pressure stabilizes the sun’s output and makes life on earth possible.

The relationship between pressure and energy density in a gas or liquid is more complex. The simplest example of the energy storage of the pressure component in a fluid can be illustrated by the following example. Imagine two helium atoms colliding in a vacuum. This collision is viewed from the frame of reference where the atoms are initially propagating at equal speed in opposite directions. The kinetic energy of each atom can be associated with a typical temperature using the Boltzmann constant. When the atoms collide, the speed momentarily drops to zero in this frame of reference and the absolute temperature of each atom also momentarily drops to zero. The kinetic energy (temperature) is temporarily converted to internal energy in each atom resulting in a distortion of the electron cloud of each helium atom. In a high pressure gas there are many such collisions per second. The energy associated with the pressure of the gas can be traced to the fact that atoms in the gas spend part of the time with a distorted electron cloud that has higher energy than an isolated atom with no distortion. A high pressure monatomic gas has 3 energy contributions to its total energy density; 1) the internal

energy ($E = mc^2$) of the individual atoms, 2) the kinetic energy of the temperature and 3) the pressure component resulting in a distorted electron cloud.

Now we will look at the much simpler case of confined light. Each photon has energy of $E = \hbar\omega$, and the total energy density of the confined light is $U = 3P$ for chaotic 3 dimensional propagation such as confined black body radiation. It is proposed that the equivalence between energy density and pressure applies in all cases because the units are the same (M/LT^2) and the physical interpretation of these units is the same. There are a few cases in physics where two dissimilar definitions can have the same units when expressed as length, time and mass. For example, torque and energy both have units of ML^2/T^2 . However, it is clear that torque is force applied through a radial length r without motion (no work). Energy is force applied through a distance $[(ML/T^2) L]$. The units of energy have to be interpreted as requiring motion through a distance (work). There is never an example where a unit of torque is equal to a unit of energy because the physical interpretation of the units is fundamentally different. In the case of energy density and pressure, the physical interpretation is the same. It is proposed that at the most fundamental level, energy density ALWAYS implies pressure.

It is proposed that even the energy density of a proton or electron implies pressure. It is not possible to casually ignore the energy density of a proton and assume that since there is no obvious container restraining the implied pressure that the equivalence between energy density and pressure has somehow been broken. The standard model assumes that fundamental particles have no internal structure and no volume (point particles). Even string theory has one dimensional strings with no volume. Therefore, both of these require infinite energy density which implies infinite pressure. The laws of physics “break down” – end of story! The alternative offered by the spacetime based model of particles and forces is that everything is understandable. The laws of physics never break down. Distortions of spacetime can appear to be point particles if the expectation is a classical object with a hard surface. However, we will show how it is possible for fundamental particles to be a reasonable finite volume distortion of spacetime which appears to be a point particle in experiments.

Attractive Forces: The previous assumption is surprising because it claims that there is only one fundamental force and because it claims that this single fundamental force is only repulsive. The obvious question is: How can attractive forces such as gravity, the strong force or the electromagnetic force be the result of a single force that is only repulsive? The detailed answer to this question requires additional information covered in subsequent chapters. However, it is possible to give a brief introductory explanation here.

It was previously explained that vacuum fluctuations have energy density equal to Planck energy density. From the equivalence of energy density and pressure, it follows that vacuum fluctuations are capable of exerting a maximum pressure equal to Planck pressure $\approx 10^{113}$ N/m². Later it will be shown that the proposed spacetime based model of fundamental particles has a

specific energy density and this requires that vacuum energy/pressure exert an offsetting pressure to achieve stability. For example, a proton has a known radius of about 10^{-15} m. This volume combined with the proton's energy implies that a proton has energy density of about 10^{34} J/m³. This energy density implies that the waves forming a proton generate an internal pressure of about 10^{34} N/m². Stated another way, an isolated proton is stabilized by the spacetime field exerting a repulsive force on all sides of the proton. An electric field is a distortion of the spacetime field that will be discussed in chapter 9. If the proton comes near an electron, the proton experiences what we consider to be a force of electrostatic attraction. It will be shown that this is actually an unbalanced repulsive force. The vacuum pressure required to stabilize a proton is unbalanced by the distortion of the spacetime field caused by the electron's electric field. This results in what appears to be a force of attraction.

In this model there are no exchange particles that somehow achieve attraction. All action at a distance is ultimately traceable to a localized imbalance in vacuum pressure. There are also no attractive forces. There is only an unbalanced repulsive force (unbalanced pressure) exerted on fundamental particles by the dipole waves that are the vacuum fluctuations of the spacetime field. This introductory explanation lacks many essential details that will be provided later.

Impedance of Spacetime

The first step in unraveling the 10^{120} discrepancy between the quantum mechanical model and the general relativity model is to see if there is anything in general relativity that actually supports the idea of a large vacuum energy density. It is proposed that an analysis of gravitational waves indeed gives support to the quantum mechanical model of the spacetime field. Gravitational waves are a form of energy that propagates at the speed of light as transverse waves IN spacetime. They produce a dynamic distortion of 2 of the 4 dimensions of the spacetime field. The distortion converts the spherical volume into an oscillating ellipsoid. One transverse axis of the ellipsoid elongates while the orthogonal transverse axis contracts. This oscillation of the ellipsoid produces no net change in volume from the original spherical volume and there is no change in the rate of time. Since gravitational waves (quadrupole waves) do not modulate volume or the rate of time, gravitational waves can have a displacement of spacetime much greater than the Planck length/time limitation that applies to dipole waves in spacetime.

Gravitational waves transfer energy and angular momentum. In 1993 the Nobel Prize was awarded to Russell Hulse and Joseph Taylor for the proof that a binary neutron star system was slowing down its rotation because it was emitting about 10^{25} watts of gravitational waves. The amount of slowing was within 0.2% of the amount predicted by general relativity. The emission of gravitational waves produces a retarding force on the rotating binary stars, thus producing an

observable slowing of the rotation (loss of energy and angular momentum). If it was possible to reverse the direction of these gravitational waves, the gravitational waves would return energy and angular momentum to the binary neutron star system.

The reason that gravitational waves are introduced into a discussion about the energy density of spacetime is that gravitational waves are propagating in the spacetime field. They are analogous to sound waves propagating in an acoustic medium. The same way that the equations for sound propagation give information about the acoustic medium, so also the gravitational wave equations can give information about the properties of the spacetime field.

Z_s – The Impedance of Spacetime: In acoustics, all materials offer opposition to acoustic flow when an oscillating acoustic pressure is applied. For example, tungsten has the highest acoustic impedance which is about 2.5×10^6 times greater than the acoustic impedance of air. Electromagnetic radiation also experiences a characteristic impedance as it propagates through space. The electric field \mathbb{E} and magnetic field \mathbb{H} are related by the “impedance of free space Z_o ”. The relationship is:

$$Z_o \equiv \mathbb{E}/\mathbb{H} = \frac{1}{\epsilon_o c} \approx 376.7 \Omega \quad \text{impedance of free space}$$

Gravitational waves also experience impedance as they propagate through spacetime. I identified the impedance experienced by gravitational waves when I first started working on this project. I was surprised that I initially could not find any other reference to this. After about 5 years, I discovered that the impedance of spacetime had been previously identified by Blair¹⁴ from an analysis of gravitational wave equations and reported in the 1991 book The Detection of Gravitational Waves. However, even in that book the impedance of spacetime is only casually mentioned and is not used in any calculations. Since then, the impedance of spacetime appears to be ignored by the scientific community. As will be seen, the impedance of spacetime is the key to quantifying the properties of the spacetime field. Most of the calculations in the remainder of this book depend on this impedance which is identified by Blair as:

$$Z_s = c^3/G = 4.038 \times 10^{35} \text{ kg/s} \quad Z_s = \text{impedance of spacetime}$$

The reasoning that led me to independently discover the impedance of spacetime started by comparing gravitational waves to acoustic waves. All propagating waves involve the movement of energy. In other words, propagating waves of any kind are a form of power. There is a general equation that applies to waves of any kind. The most common form of this equation relates intensity “ \mathcal{J} ”, the wave amplitude A , the wave angular frequency ω , the impedance of the medium Z and a dimensionless constant k . The intensity \mathcal{J} can be expressed in units of w/m^2 .

¹⁴ Blair, D. G. (ed.): *The Detection of Gravitational Waves*. p 45. Cambridge University Press, Cambridge New York Port Chester (1991)

$$J = k A^2 \omega^2 Z$$

We will first illustrate the use of this general equation using acoustic waves. The acoustic impedance is: $Z_a = \rho c_a$ where ρ is density and c_a is the speed of sound in the medium (acoustic speed). Acoustic impedance has units of kg/m²s using SI (dimensional analysis units of M/L^2T). The amplitude of an acoustic wave is defined by the displacement of particles oscillating in an acoustic wave. The amplitude term in acoustic equations has units of length such as meters.

When the equation $J = k A^2 \omega^2 Z$ is used for gravitational waves, the amplitude term is a dimensionless ratio which in its simplest form can be expressed as strain amplitude $A = \Delta L/L$. This ratio is expressing a strain in spacetime which can also be thought of as the maximum slope of a graph that plots displacement versus wavelength. When the amplitude term is dimensionless strain amplitude, then for compatibility the impedance of spacetime Z_s must have dimensions of mass/time (M/T).

Even though $J = k A^2 \omega^2 Z$ is a universal wave-amplitude equation, it can only be used if amplitude A and impedance Z are expressed in units compatible with intensity (watts/m²) in this equation. For example, electromagnetic radiation is usually expressed with amplitude in units of electric field strength and the impedance of free space Z_o in units of ohms. This way of stating wave amplitude and impedance does not have the correct units required for compatibility with the above intensity equation. As discussed in chapter 9, there are other ways of expressing these terms that make electromagnetic radiation compatible with this universal equation.

The intensity of gravitational waves can be complex because of nonlinearities and radiation patterns. However, this intensity can be expressed simply if we assume plane waves and the weak gravity limit.¹⁵ Using these assumptions, the gravitational wave intensity J is often expressed as:

$$J = \left(\frac{\pi c^3}{4G} \right) \nu^2 A^2 \quad \text{where: } J = \text{intensity of a gravitational plane wave and } \nu = \text{frequency}$$

However, this can be rearranged to yield the following equation:

$$J = k A^2 \omega^2 (c^3/G)$$

k = a dimensionless constant; ω = angular frequency

$A_s = \Delta L/L$ = strain amplitude where L is measurement length and ΔL is the change in length

¹⁵ D. G. Blair, *The Detection of Gravitational Waves*, Cambridge University Press, 1991, p. 34

It is obvious comparing this equation to the general equation $\mathcal{J} = kA^2\omega^2Z$ that the two equations have the same form and that the impedance term must be: $Z = Z_s = c^3/G$

5 Wave-Amplitude Equations: Now that we are armed with the impedance of spacetime, the equation for intensity (\mathcal{J}) can be converted into equations that express energy density (U), energy (E) and power (P). If we are restricted to waves propagating at the speed of light, then we can also convert the intensity equation into an expression of the force (F) exerted by the propagating wave. This conversion incorporates the equation $F = P/c$ where P is power propagating at the speed of light. These will be called the “5 wave-amplitude equations”. These equations also use the symbols of:

\mathcal{A} = area (m²), V = volume (m³) and k = dimensionless constant near 1

$\mathcal{J} = kA^2\omega^2Z$	\mathcal{J} = intensity (w/m ²)	
$U = kA^2\omega^2Z/c$	U = energy density (J/m ³)	$(U = \mathcal{J}/c)$ and $U = \mathcal{P}$ = pressure
$E = kA^2\omega^2ZV/c$	E = energy (J)	$(E = \mathcal{J}V/c)$
$P = kA^2\omega^2Z\mathcal{A}$	P = power (J/s)	$(P = \mathcal{J}\mathcal{A})$
$F = kA^2\omega^2Z\mathcal{A}/c$	F = force (N)	$(F = \mathcal{J}\mathcal{A}/c)$

These 5 equations will be used numerous times in the remainder of the book. It is proposed that all energy, force and matter is derived from waves in the spacetime field and these 5 equations will be used to support this contention. The amplitude term A needs further explanation. We are presuming waves propagating at the speed of light and we are temporarily excluding electromagnetic waves until chapter 9. This leaves gravitational waves and dipole waves in the spacetime field. We need to standardize how we designate the amplitude of these waves.

For gravitational wave experiments where the wavelength is much longer than the measurement path length ($\lambda \gg L$), it is acceptable to designate the strain amplitude as $A_s = \Delta L/L$. However, when we are dealing with an arbitrary wavelength which might be small, it is necessary to specify strain as the maximum slope of a graph that plots displacement versus wavelength. This maximum slope occurs when the displacement is zero and the strain is maximum (see figures 5-3 and 5-4 in chapter 5). If we designate the maximum displacement as ΔL , and the wavelength as λ , then the maximum strain (maximum slope) is $A_s = \Delta L/\lambda$ where $\lambda = \lambda/2\pi$. This example presumes that we are working with a displacement of length. Gravitational waves produce a length modulation with offsetting effects in orthogonal dimensions such that there is no modulation of volume and no modulation of the rate of time. Therefore, gravitational waves are not subject to the Planck length/time limitation that applies to dipole waves. As previously explained, dipole waves have a maximum spatial displacement amplitude of $\Delta L = L_p$ and a maximum temporal amplitude of $\Delta T = T_p$. Therefore, the maximum strain amplitude (A_{\max}) of a dipole wave is:

$$A_{\max} = L_p/\lambda = \omega/\omega_p = \sqrt{\hbar G \omega^2/c^5}$$

Impedance of Spacetime from the Quantum Mechanical Model: Now that we are equipped with the 5 wave-amplitude equations, the dipole wave hypothesis and $A_{\max} = L_p/\lambda$, it is possible to analyze zero point energy from a new perspective. If zero point energy is really dipole wave fluctuations in the medium of spacetime, then it should be possible to do a calculation which supports this idea. For review, the quantum mechanical model of the spacetime field has spacetime filled with zero point energy (quantum oscillators) with energy of $E = \frac{1}{2} \hbar\omega$. If we are ignoring numerical factors near 1, therefore we can consider each quantum oscillator as occupying a volume $V = \lambda^3$. This means that the energy density of the quantum mechanical model (of zero point energy) is $U = \hbar\omega/\lambda^3 = \hbar\omega^4/c^3$. Now we are ready to calculate the impedance of spacetime obtained from a combination of 1) zero point energy with energy density $U = \hbar\omega^4/c^3$; 2) dipole waves in spacetime with maximum amplitude of $A_{\max} = L_p/\lambda$, and 3) the previously obtained equation for energy density $U = A^2\omega^2 Z/c$. Rearranging terms we have:

$$Z = Uc/A^2\omega^2$$

$$\text{Set: } U = \hbar\omega^4/c^3 \text{ and } A = A_{\max} = \sqrt{\hbar G\omega^2/c^5}$$

$$Z = \left(\frac{\hbar\omega^4}{c^3}\right) \frac{c}{\omega^2} \left(\frac{c^5}{\hbar G\omega^2}\right) = \frac{c^3}{G} = Z_s \quad \text{Success!}$$

Link between QM and GR Models of Spacetime: This is a fantastic outcome! We took the energy density of zero point energy and combined that with the strain amplitude of a dipole wave in the spacetime field and an equation from acoustics. When we solved for impedance we obtained c^3/G . This is the same impedance of spacetime that gravitational waves experience as they propagate through spacetime. To me, this implies that the characteristics of spacetime obtained from general relativity agree with the quantum mechanical model of the spacetime field filled with zero point energy and exhibiting energy density of 10^{113} J/m^3 . How can this be? The general relativity model incorporates cosmological observation and sets the energy density of the universe at about 10^{-9} J/m^3 .

Actually this is an erroneous comparison. The quantum mechanical model of the spacetime field is giving the homogeneous internal energy density of spacetime itself. When gravitational waves propagate through the spacetime field, they are interacting with this internal structure of the spacetime field and the gravitational waves experience impedance of $Z_s = c^3/G$. The energy density of 10^{-9} J/m^3 obtained by cosmological observation is not seeing the internal structure of spacetime with its tremendous energy density of dipole waves. Instead, the cosmological observations are just looking at the energy density of the fermions, bosons and “dark energy” (discussed later). This is not the same thing as the internal structure of the spacetime field. Gravitational waves can propagate through the spacetime field that contains no fermions or bosons and still experience $Z_s = c^3/G$. Assuming that the total energy density of the universe is

10^{-9} J/m^3 is like looking only at the foam on the surface of the ocean and ignoring all the water that makes up the ocean.

The first part of reconciling the difference between the general relativity and quantum mechanical models of spacetime is to view the quantum mechanical model as describing the internal structure (the microscopic structure) of the spacetime field. Meanwhile, the general relativity model is describing the macroscopic characteristics of spacetime and the interactions with matter.

If the spacetime field can propagate waves such as gravitational waves (or dipole waves), it implies that the spacetime field must have elasticity. This elasticity requires the ability to store and return energy as the wave propagates. The medium itself must have energy density. The quantum mechanical model of space is filled with a sea of energetic fluctuations (dipole waves). If these are visualized as energetic waves in the spacetime field, then a new wave can be visualized as compressing and expanding these preexisting waves. If this new wave causes the preexisting waves to slightly change their frequency and dimensions (wavelength) as they are being compressed and expanded, then this picture provides the necessary elasticity and energy storage to the spacetime field.

This might sound like a circular argument since each wave contributes to the elasticity required by all other waves. What about the “first” wave? This subject will be discussed further in the two cosmology chapters 13 and 14. However, it will be proposed that there was no first wave. The spacetime field came into existence already filled with these vacuum fluctuations. Energetic waves are simply a fundamental property of the spacetime field that give the vacuum properties such as ϵ_0 , μ_0 , c , G , Z_s , etc.. In fact, the spacetime field does not have waves; the spacetime field IS the sea of vacuum fluctuations (waves) described by the quantum mechanical model. Spacetime never was the quiet and smooth medium assumed by general relativity. Therefore there never was a time when a first wave was introduced into a quiet spacetime. This wave structure with its Planck length/time limitation can be ignored on the macroscopic scale but spacetime has a quantum mechanical basis.

The task is not to find a mechanism that causes cancelation of this tremendous energy density. This energy density is really present in the spacetime field and is necessary to give the spacetime field the properties described by general relativity. Instead the focus needs to turn to finding the reason that this high energy density is not more obvious and why it does not itself generate gravity. Is there something about the energy in vacuum fluctuations that makes it different than the energy in matter and photons? This question will be answered later.

Energy Density of Spacetime Calculated from General Relativity: Previously we showed that it was possible to deduce the impedance of spacetime $Z_s = c^3/G$ from quantum mechanical considerations, zero point energy and an equation from acoustics. However, now we will show

that it is possible to calculate the energy density of the spacetime field using just equations from general relativity and acoustics. Since general relativity and quantum mechanics are often considered to be incompatible, it might seem unlikely that we would turn to general relativity to analyze the quantum mechanical energy density of spacetime. The reason for suspecting that this might be a fruitful approach is that gravitational waves are like sound waves propagating in the medium of spacetime. It is well known that analyzing the acoustic properties of a material can reveal some of its physical properties of the medium including its density. Gravitational waves are like sheer acoustic waves propagating in the medium of the spacetime field. Therefore, we will make analogies to acoustics and attempt to calculate the energy density of the spacetime field. The following equation from acoustics relates the density of the medium ρ to intensity J , particle displacement Δx , acoustic speed of sound c_a , and angular frequency ω .

$$J = k \rho \omega^2 c_a \Delta x^2.$$

The spacetime field does not have rest mass like fermions, but gravitational waves do possess momentum. As previously explained, if we could confine gravitational waves in a hypothetical 100% reflecting box, then the gravitational waves would exhibit rest mass. The box is merely turning traveling waves into standing waves. The waves themselves possess characteristics that can be associated with not only energy density but also mass density under specialized conditions. If we can calculate the energy density of the spacetime field using equations from acoustics and gravitational waves, then this will be important not only for establishing the quantum mechanical properties of spacetime, but also for making a connection between general relativity and quantum mechanics.

Earlier in this chapter, an equation was referenced which connects the intensity J of gravitational waves with the frequency ν and the strain amplitude A of the gravitational waves. This equation assumes the weak field limit where nonlinearities are eliminated and also assumes plane waves. That equation is repeated below. The amplitude A of the gravitational wave is given as the dimensionless strain amplitude (maximum slope) of $A = \Delta L/\lambda$ where ΔL is the maximum displacement of spacetime and the reduced wavelength is: $\lambda = \lambda/2\pi = c/\omega$.

$$J = \left(\frac{\pi c^3}{4G}\right) \nu^2 A^2 = k A^2 \omega^2 \left(\frac{c^3}{G}\right) = k \left(\frac{\Delta L}{\lambda}\right)^2 \omega^2 \frac{c^3}{G}$$

We will set the intensity of the above equation equal to the intensity of the acoustic equation $J = k \rho \omega^2 c_a \Delta x^2$ and solve for density ρ . To achieve this we will set the acoustic displacement Δx equal to the gravitational wave spatial displacement ΔL and set acoustic speed $c_a = c$.

$$k \rho \omega^2 c_a \Delta x^2 = k \left(\frac{\Delta L}{\lambda}\right)^2 \omega^2 \frac{c^3}{G} \quad \text{set } \Delta x = \Delta L, \quad c_a = c, \quad \lambda = c/\omega, \quad \text{solve for } \rho \text{ and } U$$

$$\rho_i = k \frac{\omega^2}{G} = k \frac{c^2}{\lambda^2 G}$$

$$U_i = k \frac{c^2 \omega^2}{G} = k \frac{F_p}{\lambda^2} = k \frac{\omega^2}{\omega_p^2} U_p = k \frac{L_p^2}{\lambda^2} U_p$$

set: $\lambda = r$ (radial distance) which is a required for physical interpretation

$$U_i = k \frac{F_p}{r^2} = k \frac{L_p^2}{r^2} U_p$$

Where: ρ_i is the interactive density of spacetime

U_i is the interactive energy density of spacetime

$U_p = c^7 / \hbar G^2 \approx 10^{113} \text{ J/m}^3 = \text{Planck energy density}$

$\omega_p = \sqrt{c^5 / \hbar G} \approx 1.85 \times 10^{43} \text{ s}^{-1} = \text{Planck angular frequency}$

The terms “interactive density” and “interactive energy density” are necessary because the spacetime field does not have density and energy density in the conventional use of the terms. When we think of the density of an acoustic medium such as water, this has the same density even if the acoustic frequency is equal to zero. The spacetime field only exhibits an “interactive density” when there is a wave in spacetime with a finite frequency. If the frequency is 0, then $\rho_i = 0$ and $U_i = 0$.

I want to briefly point out that the above equations derive the energy density of spacetime that must be there in order for gravitational waves to propagate. The presence of this energy density and the frequency dependence was obtained from a gravitational wave equation and an acoustic equation with no assumptions from quantum mechanics. Proceeding with the spacetime field interpretation of these equations, a gravitational wave is oscillating a part of the sea of dipole waves that forms the spacetime field. These dipole waves are slightly compressed and expanded by the gravitational wave, so they reveal the energy density that is actually interacting with the gravitational wave. The dipole waves in the spacetime field are primarily at Planck frequency $\omega_p \approx 2 \times 10^{43} \text{ s}^{-1}$.

If there was such a thing as a Planck frequency gravitational wave filling a specific volume, then this Planck frequency gravitational wave could efficiently interact with all the energy density in that specific volume of the spacetime. No known particles could generate this frequency, but this represents the theoretical limits of the properties of spacetime. For example, suppose we imagine two hypothetical Planck mass particles forming a rotating binary system. They would both be black holes with radius equal to Planck length L_p . As they rotated around their common center of mass, they would generate gravitational waves. If they were close to merging, then the frequency would be close to Planck frequency. To explore this limiting condition, we will assume a gravitational wave with Planck angular frequency and substitute $\omega = \omega_p = \sqrt{c^5 / \hbar G}$ into $U_i = c^2 \omega^2 / G$. This gives Planck energy density $U_p = c^7 / \hbar G^2 \approx 4.63 \times 10^{113} \text{ J/m}^3$.

Before proceeding, we should pause a moment and realize that this simple calculation has just proven that general relativity requires that spacetime must have Planck energy density for spacetime to be able to propagate gravitational waves at Planck frequency. General relativity also specifies how waves less than Planck frequency interact with the energy density of the

spacetime field. We normally think of general relativity as being incompatible with quantum mechanics. However, general relativity actually supports and helps to quantify the proposed quantum mechanical model of the spacetime field.

Interactive Energy Density from Wave-Amplitude Equation: It is possible to gain a different perspective on the interactive energy density of spacetime by finding the substitution into the equation $U = k A^2 \omega^2 Z/c$ required to yield $U_i = c^2 \omega^2 / G$.

$$\frac{A^2 \omega^2}{c} \left(\frac{c^3}{G} \right) = \frac{c^2 \omega^2}{G}$$

$$A = 1$$

Therefore, the interactive energy density is generated when we set the amplitude term A equal to the largest possible value which is $A = 1$. Planck energy density is obtained when we substitute both the largest amplitude $A = 1$ and the highest possible frequency $\omega = \omega_p$. At any frequency ω less than Planck frequency, the interactive energy density U_i represents the largest possible energy density at frequency ω assuming the medium has impedance equal to the impedance of spacetime: $Z_s = c^3/G$. To generalize the interactive energy density so that it applies to more than just gravitational waves, we have view the entire universe (even particles) as entirely wave-based. This will be proven in the rest of this book. The significance here is that we can extrapolate from the interactive energy density encountered by a gravitational wave over distance λ to the interactive energy density that exists over a spherical volume of spacetime with radius r . To calculate this, we can substitute $\lambda = r$ so that $U_i = F_p/\lambda^2$ becomes $U_i = F_p/r^2$.

Analysis of Waves Less than Planck Frequency: At frequencies lower than Planck frequency, a gravitational wave experiences a mismatch with the spacetime field that primarily has waves at Planck frequency. There is only a partial coupling to the energy density of the spacetime field. The scaling of the lower frequencies is given by the equation $U_i = (\omega^2/\omega_p^2)U_p$. A numerical example will be given which assumes a gravitational wave with an angular frequency of 1 s^{-1} and reduced wavelength of $3 \times 10^8 \text{ m}$. For this wave, the frequency mismatch factor is $(\omega^2/\omega_p^2) \approx 2.9 \times 10^{-87}$. Therefore, according to $U_i = (\omega^2/\omega_p^2)U_p$ the interactive energy density encountered by this frequency is: $U_i = 1.35 \times 10^{27} \text{ J/m}^3$ or $\rho_i = 1.5 \times 10^{10} \text{ kg/m}^3$. If a gravitational wave with angular frequency of 1 s^{-1} is assumed to have intensity $\mathcal{J} = 1 \text{ w/m}^2$, then using the previously stated gravitational wave equation, the oscillating spatial displacement produced over a distance equal to the reduced wavelength is: $\Delta L = 4.7 \times 10^{-10} \text{ m}$. I will not go through the entire numerical example, but a λ^3 volume has an interactive mass of $4 \times 10^{35} \text{ kg}$. Ignoring numerical constants, the energy deposited by the gravitational wave in this volume is $E = \mathcal{J}\lambda^2/\omega = 9 \times 10^{16} \text{ J}$. If you calculate the distance that this energy will move a $4 \times 10^{35} \text{ kg}$ mass in time $1/\omega$, it turns out to also be $4.7 \times 10^{-10} \text{ m}$ (ignoring numerical constants near 1). Therefore, the displacement of spacetime Δx obtained from general relativity corresponds to the distance ($4.7 \times 10^{-10} \text{ m}$) that the interactive mass (or interactive energy) can be moved in a time of $1/\omega$.

The dipole waves in spacetime contained in the gravitational wave volume cannot be physically moved because they are already propagating at the speed of light. Instead, the gravitational wave is causing a slight change in frequency which produces a shift in energy equivalent to imparting kinetic energy to a mass equal to the interactive mass discussed. Now we can conceptually understand why gravitational waves are so hard to detect. They are interacting with the tremendously large energy density of the spacetime field. Even with a large frequency mismatch, the gravitational waves are still changing the frequency of a very large energy of dipole waves in spacetime.

Connection to Black Holes: So far, the discussion has centered of gravitational waves with angular frequency ω and reduced wavelength λ interacting with the energy density of the spacetime field. However, for general use the energy density characteristics of the spacetime field should really be expressed using the substitution $\lambda = r$, where r is the radius of a spherical volume of the spacetime field rather than λ or ω pertaining to gravitational waves. For example, later it will be proposed that gravity and electric fields both are the result of a distortion of the spacetime field. Even though the spacetime field has Planck energy density, this implies a Planck length interaction volume. A larger radius volume interacts in such a way that there is a reduction in the coupling efficiency similar to the effect described for gravitational waves when $\lambda < L_p$. Therefore the equations for U_i and ρ_i can be rewritten using radius r . Therefore, we have:

$$U_i = k \frac{F_p}{r^2} = k \frac{L_p^2}{r^2} U_p \quad \text{and} \quad \rho_i = k \frac{c^2}{r^2 G}$$

These equations should be compared to the equations for a black hole with Schwarzschild radius $R_s \equiv Gm/c^2$ (explained in chapter 2 as definition used here for Schwarzschild radius). The black hole energy density is designated U_{bh} and the density of a black hole is ρ_{bh} .

$$U_{bh} = k \frac{F_p}{R_s^2} = k \frac{L_p^2}{R_s^2} U_p \quad \text{and} \quad \rho_{bh} = k \frac{c^2}{R_s^2 G}$$

Therefore, it can be seen that we have the same equations. This is another case of general relativity confirming the energy density characteristics of the spacetime field. The picture that will emerge is that black holes occur when the energy within a spherical volume of radius r from fermions and bosons equals the interactive energy of dipole waves (when $U_{bh} = U_i$)

Another insight into black holes can be gained by imaging two reflecting hemispherical shells confining photons at energy density of about 3 J/m³. This photon energy density striking a reflecting surface generates pressure of $P = 2$ newton/m². To hold together the two hemispherical shells would take two opposing forces of 2 newton times the cross sectional area of the hemispheres. Next we will imagine increasing the photon energy density to the point that

it meets the energy density of a black hole with a radius equal to the radius of the hemispherical shells. Ignoring gravity, the force required to hold the black hole size spherical shells together can be easily calculated. For energy propagating at the speed of light, as previously demonstrated, energy density equals pressure ($U = kP$). The equation $U_i = F_p/r^2$ becomes $P = F_p/R_s^2$. Ignoring constants near 1, Planck force must be supplied by the spacetime field over area R_s^2 to contain the internal pressure of any size black hole. The smallest possible black hole consisting of photons would be a single photon with Planck energy in a volume Planck length in radius. A confined photon of this energy density would generate Planck pressure = $F_p/L_p^2 \approx 10^{113}$ N/m² but since the area is only L_p^2 , the total force required to hold the two hemispheres together is Planck force $\approx 10^{44}$ N. A super massive black hole such as found at the center of galaxies has much larger radius and therefore much lower energy density. However even a super massive black hole requires the same amount of force (Planck force) to hold the shells together.

Normally physicists merely accept that gravity can generate this force and they do not try to rationalize the physics that causes the various “laws” of physics. In the case of gravity, the spacetime field will be shown to apply a repulsive force (pressure) which we interpret as the force of gravity. The maximum force which the spacetime field can generate is Planck force, therefore all black holes, regardless of size, require this force to confine the internal energy.

Why Does the Energy Density of the Spacetime Field Not Collapse into a Black Hole? The energy in the spacetime field does not collapse and become black holes because this form of energy is the essence of spacetime (vacuum) itself. These waves form the background energetic “noise” of the universe. Some quantum mechanical calculations require “renormalization” which assumes that only differences in energy can be measured. Therefore the background energetic fluctuations which only modulate distance by $\pm L_p$ and the rate of time by $\pm T_p$ can usually be ignored. However, when we are working on the scale which characterizes vacuum energy, then these small amplitude waves must be acknowledged and quantified. These small amplitude waves are the building blocks of everything in the universe. They are ultimately responsible for the uncertainty principle and they give spacetime its properties of c , G , \hbar , and ϵ_0 .

The standard model has 17 named particles with a total of 61 particle variations (color charge, antimatter, etc.). Each of the fundamental particles is described as an “excitation” of its associated field. Therefore, according to the standard model there are at least 17 overlapping fields, each with its associated energy density. For example, the Higgs field has been estimated to have energy density of 10^{46} J/m³. Therefore, even the standard model has energetic “fields” which do not collapse into black holes. The spacetime-based model merely replaces the 17+ separate fields with unknown structure with one “spacetime field” with quantifiable structural properties. Gravitational wave equations have been shown to imply the existence of this vacuum energy density. Zero point energy has long characterized the vacuum as being filled with “harmonic oscillators” with energy of $E = \frac{1}{2} \hbar\omega$ and energy density of $U = k\hbar\omega/\lambda^3$. The spacetime-based model of the universe characterizes the vacuum energy as dipole waves in

spacetime which lack angular momentum. This homogeneous energy density is responsible for the properties of the quantum mechanical vacuum.

Curvature of the spacetime field occurs when energy possessing quantized angular momentum (fermions and bosons) is added to this homogeneous energy density. Black holes with radius r are formed when the energy density of fermions and bosons (quantized angular momentum) equals the interactive energy density of a spherical volume with radius r (when $U_i = U_{bh}$). In this case $r = R_s$ and we need to measure the radius by the circumferential radius method previously explained. Stated another way, the energy density of the spacetime field does not cause black holes, it forms the homogeneous vacuum with no curvature. Introducing fermions and bosons into this homogeneous field distorts this uniform background energy density. When this distorting energy equals the interactive energy density of the spacetime field, then this is the limiting condition. This “contamination” distorts the spacetime field to the extent that it forms a black hole.

Interactive Bulk Modulus: In previous drafts of this book I also included a derivation of the “interactive bulk modulus of spacetime” designated with the symbol K_s . The bulk modulus of a fluid is $K \equiv \frac{\Delta P}{\Delta V/V}$ which is the change in volume/total volume in response to a change in pressure ΔP . This was a tedious calculation which ends up with the same answer as the interactive energy density U_i . Here is the final conclusion of the bulk modulus calculation.

$$K_s = \frac{F_p}{\lambda^2} = \left(\frac{\omega}{\omega_p}\right)^2 U_p \quad K_s = \text{interactive bulk modulus of spacetime}$$

Actually in acoustics it is known that the bulk modulus is the same as the energy density for ideal gasses (ignoring constants near 1). This can be understood because as previously shown, energy density is the same as pressure for energy propagating at the speed of light or for ideal gasses. At the point that $\Delta V/V = 1$, this corresponds to $\Delta P = \Delta U$ which in this context is equivalent to the interactive energy density of spacetime. Therefore, this derivation is not repeated here.

Insights into the Speed of Light: The key concept of spacial relativity is that the speed of light is constant in all frames of reference. In the 19th century physicists postulated that there was a fluid-like medium that propagated light waves called the “luminiferous aether”. This concept was largely abandoned after the Michelson Morley experiment showed that the speed of light was constant in all frames of reference and Einstein’s special relativity generated equations which did not require the aether. However, Einstein himself continued to refer to the aether or “physical space” until his death.¹⁶ The description of the aether was merely changed to correspond to the physical properties of space.

Is there any reason to believe that the spacetime field possesses the property that would allow waves propagating in the spacetime field to propagate at the speed of light in all frames of

¹⁶ L. Kostro, *Einstein and the Ether*, (2,000) Apeiron, Montreal, Canada

reference? Gravitational waves propagate in the medium of the spacetime field and they propagate at the speed of light. In any frame of reference, an observer would see a gravitational wave propagating at the speed of light. If it was possible to do a Michelson Morley experiment using gravitational waves, no motion could be detected relative to the medium of the spacetime field. If spacetime is visualized as a medium consisting of interacting dipole waves propagating at the speed of light, then it is reasonable that it would be impossible to detect any motion relative to this medium. It can be shown that waves of any kind that propagate in the medium with impedance $Z_s = c^3/G$ and strain amplitude $A_s = L_p/\lambda$ will propagate at c , the speed of light.

Vacuum Energy and the Einstein Field Equation: There is also a similarity to the Einstein field equation which can be considered a statement that energy density equals pressure. Ignoring the cosmological constant, the Einstein field equation can be written as:

$$T_{\mu\nu} = \left(\frac{1}{8\pi}\right) \left(\frac{c^4}{G}\right) G_{\mu\nu} \quad \text{set } \left(\frac{c^4}{G}\right) = F_p \text{ and } \left(\frac{1}{8\pi}\right) = k$$

$$T_{\mu\nu} = kF_p G_{\mu\nu}$$

The left side of this equation has $T_{\mu\nu}$ which is the stress energy tensor with units of energy/length³ which is energy density. The right side of this equation has Planck force and $G_{\mu\nu}$ which is the Einstein tensor that expresses curvature with units of: 1/length². Therefore, the right side of this equation is force/area = pressure. Therefore from the dimensions a valid interpretation of this equation is that the field equation is an expression of: energy density = k pressure. The proportionality factor is equal to Planck force (c^4/G) times a numerical factor near 1. In the limit of maximum curvature, Einstein's field equation says that Planck force is the maximum possible force in the universe¹⁷.

Thoughts on the Impedance of Spacetime: It should be emphasized that the impedance of spacetime is one of the few truly fundamental properties of spacetime. For example, later it will be shown that it is possible to make a system of units that use only the properties of spacetime. One of the three properties of spacetime used for this system of units is Z_s , the impedance of spacetime. In Planck units (underlined), the impedance of spacetime is equal to 1 ($Z_s = 1$). Also, the impedance of spacetime has the following connection to other Planck terms:

$$Z_s = m_p/T_p = m_p \omega_p = F_p/c = p_p/L_p$$

where: m_p = Planck mass, T_p = Planck time; ω_p = Planck frequency; F_p = Planck force; p_p = Planck momentum,

The impedance of spacetime is intimately connected to all the Planck terms. These Planck terms represent the limiting values of mass, force, length, momentum, etc. The impedance of spacetime

¹⁷ Gibbons, G. W.: *The Maximum Tension Principle in General Relativity* Found. Phys. 32, 1891 (2002) <http://arxiv.org/pdf/hep-th/0210109v1.pdf>

is the maximum possible value of impedance. In order for gravitational waves to propagate at the speed of light in the medium of the spacetime field, the required impedance is Z_s . The impedance of spacetime also connects the mass of a black hole to its radius. For example $Z_s = 4.038 \times 10^{35}$ kg/s, and a mass of 4.038×10^{35} kg has a defined Schwarzschild radius $R_s \equiv Gm/c^2$ equal to the distance light travels in 1 second (about 3×10^8 meters).

If a medium has impedance, the implication is that the medium has elasticity and energy density. In the case of waves in spacetime, the impedance of spacetime is so large $Z_s = 4.038 \times 10^{35}$ kg/s that even a small strain amplitude produces a very large intensity for a given frequency. This enormous impedance of spacetime can only be achieved if spacetime has the large energy density (about 10^{113} J/m³) implied by zero point energy. The quantum mechanical basis of spacetime is real.

In chapter 3 we saw how a change in the gravitational gamma Γ affected the units of physics. It should be noted that the impedance of spacetime Z_s is one of the few terms that is unaffected by a change in Γ . There is an analysis (not presented here) that concludes that Z_s must be independent of Γ in order for all the laws of physics to be covariant when there is a change in gravitational potential.

Exchange Particles: The standard model uses exchange particles to transfer force. For example, the electromagnetic force is supposedly the result of the exchange of virtual photons between charged point particles. These virtual photons travel at the speed of light, so the electrostatic force is commonly explained as resulting from the emission or absorption of energy traveling at the speed of light. Therefore, the power (P) of virtual photons required to generate a given force is also: $F = P_r/c$. Similarly, gravitons are believed by many scientists to be the exchange particle that conveys the gravitational force. While the spacetime based model of the universe does not require exchange particles, the point is that gravitons supposedly also travel at the speed of light and the force they generate would also be $F = P_r/c$. For example, a person weighing 70 kg is supposedly being pulled towards the earth by about 200 billion watts of gravitons and this is being resisted by about 200 billion watts of virtual photons striking the bottom of a person's shoes to keep the person from sinking into the Earth. It is proposed here that gravitons and virtual photons are replaced with an equally large power of interacting waves in spacetime.

Gluons have been ignored so far, but they are also viewed as having an explanation associated with waves in spacetime (discussed later). The weak force has already been united with the electromagnetic force to form the electroweak force. Therefore, in the discussion to follow, I will concentrate on determining the relationship between the strong force, the electromagnetic force and the gravitational force. However, a brief examination of the weak force will be made later.

Note that I have used the terms "the strong force" and "the gravitational force". Both of these terms are currently out of favor among physicists. At one time "the strong force" was commonly

used to describe the force that bound protons and neutrons together in the nucleus of an atom. Since the discovery of quarks, it was necessary to name the force that binds quarks together and the term “the strong interaction” is now commonly used. With this change in terminology, the force that binds protons and neutrons is now “the residual strong interaction”. I need a simple name for the strongest of all forces. I choose to resurrect the term “the strong force” and redefine this as the resultant force from an interaction between quarks (wave model) and vacuum energy (wave model) that binds quarks together.

Newton considered gravity to be a force, but a popular physical interpretation of general relativity considers gravity to be the result of the geometry of spacetime. The equations of general relativity are commonly interpreted as describing curved spacetime. However, the concept of curved spacetime does not lead to a conceptually understandable explanation of how a force is generated when a mass is held stationary in a gravitational field. It will be shown that gravity is a real force that is closely related to both the electromagnetic force and the strong force. Therefore, the term “the gravitational force” will be used even prior to offering this proof.

Fields

One common conceptual model of the universe among physicists is a model where particles are emphasized. Discrete particles are viewed as points of energy accompanied by a wave function. The Copenhagen interpretation of this wave function is a wave of probability that influences the location of the point particle when there is an interaction (measurement). In other words, this school of thought considers the particle portion the dominant conceptual portion of the wave-particle duality. However, there is an opposing view held by many prominent quantum field theorists. The concept is that the universe is made of multiple fields rather than primarily being particle based. Particles are viewed as quantized excitations (quantized waves) existing within these fields. This has been documented in a paper¹⁸ by Art Hobson titled “*There are no particles, there are only fields*”. This paper gives numerous references supporting this position. For example, as Frank Wilczek explains¹⁹, “In quantum field theory, the primary elements of reality are not individual particles, but underlying fields. For example, all electrons are but excitations of an underlying field,....the electron field, which fills all space and time.” In this conceptual model, each fundamental particle has its own field. Even the standard model is really a quantum field theory. All 17 particles of the standard model are associated with 17 different overlapping fields and this does not even include the gravitational field or other possible fields if more fundamental particles are discovered. This multitude of superimposed fields creates an unappealing complex picture.

¹⁸ A. Hobson “*There are no particles, there are only fields*” Am. J. Phys. **81** (3), March 2013

¹⁹ F. Wilczek, “*Mass Without Mass I: Most of Matter*,” Phys. Today 52(11), 11-13 (1999)

Albert Einstein said the following in his 1923 Nobel lecture, “The intellect seeking after an integrated theory cannot rest content with the assumption that there exists two distinct fields, totally independent of each other by their nature”. He was referring to the electric field and the gravitational field appearing to be distinct but he believed that they must be closely related. Einstein worked for about 30 years attempting to unite these two fields. Today, Einstein’s 2 fields have grown to 17 distinct fields – and counting. Apparently the proliferation of fields has made the concept of uniting these into a single field a distant memory. However, if the basic assumption of this book is that the universe is only spacetime, then the following corollary follows from this starting assumption:

***Corollary Assumption:* There is only one truly fundamental field. This single field is the quantum mechanical model of the spacetime field with its dipole wave vacuum fluctuations. All fundamental particles and all forces are manifestations of this single spacetime field.**

Another way of phrasing the starting assumption (the universe is only spacetime) is the following: **The universe is made entirely of a single field and its quantized components.** This single field is known to us as the spacetime field, but more specifically it is the quantum mechanical (spacetime wave) description of the spacetime field. The spacetime field model has chaotic spatial fluctuations with displacement amplitude equal to Planck length and temporal fluctuations (difference between clocks) with displacement amplitude equal to Planck time. The chaotic sea of dipole waves in the spacetime field that are the basic constituent of spacetime will be shown to have knowable properties such as: wave amplitude, impedance, frequency range, bulk modulus, energy density, propagation characteristics, angular momentum, etc. Later chapters will explain how this single field can form all particles, all forces and what appear to be other fields such as gravitational fields and electric fields.

Summary – Properties of Spacetime: In upcoming chapters we are going to attempt to construct the universe (particles, forces and photons) using only the quantum mechanical properties of spacetime. Besides the standard properties of spacetime described by general relativity, it is useful to summarize the additional properties of spacetime that we have added to our tool bag. These additions are:

- 1) We have concluded that spacetime has a quantifiable impedance of $Z_s = m_p \omega_p = c^3 / G$ and interactive energy density of $U_i = F_p / \lambda^2 = c^2 \omega^2 / G$.
- 2) The quantum mechanical model of spacetime has a sea of high frequency, small amplitude vacuum fluctuations at Planck energy density $\sim 10^{113}$ J/m³. This model is adopted because even the impedance of spacetime obtained from general relativity supports this model.
- 3) Dipole waves are allowed to exist in spacetime but they are subject to the Planck length/time limitation previously discussed. Vacuum fluctuations and zero point energy are actually dipole waves in spacetime. The uncertainty principle and probability

characteristics are the result of the random fluctuations of these dipole waves in spacetime.

- 4) We are armed with the 5 wave-amplitude equations obtained by combining a general wave equation ($J = k A^2 \omega^2 Z$) with the relativistic force equation ($F_r = P_r/c$).
- 5) We presume that the only truly fundamental force is the relativistic force ($F_r = P_r/c$) which is the repulsive force exerted when energy traveling at the speed of light is deflected. The dipole waves in spacetime are always moving at the speed of light even when they are confined to a limited volume.
- 6) From the equivalence of energy density and pressure, it follows that the large energy density of vacuum fluctuations (dipole waves) is exerting an equally large vacuum pressure.
- 7) What appears to be multiple separate fields are different resonances within a single field.

“Elementary particles represent a percentage-wise almost completely negligible change in the locally violent conditions that characterize the vacuum...In other words, elementary particles do not form a really basic starting point for describing nature.” John Archibald Wheeler

Chapter 5

Spacetime Particle Model

“Think of a particle as built out of the geometry of space; think of a particle as a geometrodynamical excitation.”

John Archibald Wheeler

Early Wave-Particle Model: In 1926, Erwin Schrodinger originally proposed the possibility that particles could be made entirely out of waves. However, in an exchange of letters, Henrik Lorentz criticized the idea. Lorentz wrote,

“A wave packet can never stay together and remain confined to a small volume in the long run. Even without dispersion, any wave packet would spread more and more in the transverse direction, while dispersion pulls it apart in the direction of propagation. Because of this unavoidable blurring, a wave packet does not seem to me to be very suitable for representing things to which we want to ascribe a rather permanent individual existence.”

Schrodinger’s idea of a wave-particle was a group of different frequency waves that, when added together, formed a Gaussian shaped oscillating wave confined to a small volume (Fourier transformation). Schrodinger eventually agreed with Lorentz that the waves that formed such a “particle” would disperse. However, this initial failure should not be interpreted as condemning all possible wave explanations for particles. For example, optical solitons are compact pulses of laser light (waves) that propagate in nonlinear optical materials without spreading. They exhibit particle-like properties and will be discussed later.

In this chapter a model of a fundamental particle will be proposed made entirely out of a quantized dipole wave in the spacetime field. Even though this model gives a structure and physical size to an isolated fundamental particle, the reader is asked to reserve judgment about this model until it can be fully explained. The spacetime based model of a fundamental particle has waves with physical size, but this model will be shown to be consistent with experiments that indicate no detectable size in collision experiments. Also the spacetime based model explains how an electron can form a cloud-like distribution under the boundary conditions of a bound electron in an atom.

Brief Summary of the Cosmological Model: We will start with a brief description of the cosmological model proposed to be compatible with the starting assumption. The cosmological model is covered in detail in chapters 13 and 14. If the universe is only spacetime today, it must have always been only spacetime. Not only are all particles, fields and forces derived from the

properties of 4 dimensional spacetime, but all the cosmological properties such as the expansion of the universe are also derived from the changing properties of 4 dimensional spacetime. This will be discussed later. The highest energy density that spacetime can support is Planck energy density ($\sim 10^{113}$ J/m³). One point of possible confusion is that $\sim 10^{113}$ J/m³ is both the energy density at the start of the Big Bang and the current energy density of the spacetime field. What is the difference? Today the energy density of the universe obtained from general relativity and cosmological observations is about 10^{-9} J/m³. However, this is proposed to only be the “observable” energy density of the universe possessed by all the fermions and bosons in the universe. We can only directly interact with fermions and bosons which are waves that possess quantized angular momentum. However, the vastly larger energy density ($\sim 10^{113}$ J/m³) is the “unobservable” vacuum energy of the spacetime field. This is the Planck amplitude waves in the spacetime field which lack angular momentum. This is the structure of the spacetime field itself. This structure gives the spacetime fields constants such as $c, \hbar, \epsilon_0, G, Z_s$, etc.

From our current perspective, space appears to be an empty void. However, as John Archibald Wheeler¹ said, “Empty space is not empty... The density of field fluctuation energy in the vacuum argues that elementary particles represent percentage-wise almost completely negligible change in the locally violent conditions that characterize the vacuum.” It is this energetic vacuum that we are calling the “spacetime field”. Vacuum energy can be said to have a temperature of absolute zero because it lacks any quantized units and temperature is defined as energy per quantized unit. The same energy density at the start of the Big Bang was in the form of 100% quantized spin units. The energy per quantized unit was equal to Planck energy and therefore the temperature at the start of the Big Bang was approximately equal to Planck temperature ($\sim 10^{32}$ °K).

Even though 10^{113} J/m³ is an incredibly large number, it is not a singularity which would be infinite energy density. For the spacetime field to reach Planck energy density (U_p) spacetime must have dipole waves at the highest possible frequency ($\omega_p =$ Planck frequency) and the largest possible amplitude ($A = l$).

$$U = A^2 \omega^2 Z / c \quad \text{set: } A = 1, \quad \omega = \omega_p = \sqrt{c^5 / \hbar G} \approx 1.9 \times 10^{42} \text{ s}^{-1} \quad Z = Z_s = c^3 / G$$

$$U = \frac{c^7}{\hbar G^2} \approx 4.6 \times 10^{113} \text{ J/m}^3 = \text{Planck energy density}$$

Unlike virtual particle pairs which have a very short lifetime, Planck amplitude waves in spacetime can last indefinitely because they are undetectable even if there is continuous observation time. A Planck length displacement of space or a Planck time displacement of time (advance or retard clocks) is fundamentally undetectable. Only if a Planck amplitude wave possesses quantized angular momentum of \hbar or $\frac{1}{2}\hbar$ does it become detectable (observable) by

¹ Misner, C. W., Thorne, K. S. and Wheeler, J A.: *Gravitation*. (W. H. Freeman and Company, New York 1973) P. 975.

us. Therefore today's spacetime has vacuum energy density of 10^{113} J/m³ but none of this vacuum energy possesses quantized angular momentum. The spacetime at the beginning of the Big Bang also had energy density of 10^{113} J/m³ but then 100% of that energy density was observable. Photons propagating in spacetime today are undergoing a redshift because of universal expansion. The photon's lost energy possesses no angular momentum. All of the photon's angular momentum remains in the form of approximately the same number of redshifted photons.

In chapters 13 and 14 the case will be made that what we perceive as an expansion of the universe is actually a more complex transformation of spacetime. Even fermions such as electrons and quarks are also losing energy on a proposed absolute scale. Ultimately, this transformation of spacetime is responsible for converting spacetime from being 100% observable at a temperature of about 10^{32} °K (Planck temperature times a constant) at the beginning of the Big Bang (100% quantized angular momentum) to today where almost all the energy of the spacetime field is in the form of waves that lack angular momentum. It will be shown that this explanation gives the correct difference in temperature between the start of the Big Bang and today's CMB temperature of 2.725 °K.

If we jump forward in time, today only about 1 part in 10^{122} of the total energy in the universe (including vacuum energy) possesses quantized angular momentum of \hbar or $\frac{1}{2}\hbar$. Furthermore, this fraction is continuously decreasing because of the cosmic redshift and another characteristic described later. All the fundamental particles and forces that we can detect are the 1 part in 10^{122} that possesses quantized angular momentum. The vastly larger energy in the universe is the sea of vacuum fluctuations (dipole waves in spacetime) that does not possess angular momentum. The only hint we have that this vast energy density exists is the quantum mechanical effects such as the Lamb shift, Casimir effect, vacuum polarization, the uncertainty principle, etc. However, it will be shown that this sea of vacuum fluctuations is essential for the existence of fundamental particles and forces.

Vacuum Energy Has Superfluid Properties: If we are going to be developing a model of fundamental particles incorporating waves in spacetime, it is important to understand the properties of the medium supporting the wave. In the last chapter we enumerated many properties of the spacetime field. The point was made that the properties of vacuum fluctuations are an integral part of the properties of the spacetime field. However, one property of vacuum energy was intentionally saved for this chapter because it is particularly important in the explanation of fundamental particles formed out of waves in spacetime.

It is proposed that vacuum energy has the property that it does not possess angular momentum. Any angular momentum present in the midst of the sea of vacuum energy is isolated into units that possess quantized angular momentum. These quantized angular momentum units have different properties than vacuum energy.

This concept is easiest to explain by making an analogy to superfluid liquid helium or a Bose-Einstein condensate. When the helium isotope ^4He is cooled to about 2°K , it changes its properties and partly becomes a superfluid. Cooling the liquid further increases the percentage of the helium atoms that are in the superfluid state. Cooling some other atoms to a temperature very close to absolute zero changes their properties and a large fraction of these atoms can occupy the lowest quantum state and exhibit superfluid properties. This is a Bose-Einstein condensate. Since superfluid liquid helium is a special case of a Bose-Einstein condensate, they will be discussed together.

When a group of atoms occupy a single quantum state, the group must exhibit quantized spin on a macroscopic scale. The quarks and electrons that form atoms individually are fermions. However, a Bose-Einstein condensate or superfluid ^4He exhibits quantized spin on a macroscopic scale. The group of fundamental particles can possess either zero spin or an integer multiple of spin units related to \hbar . If we have a group of atoms in a Bose-Einstein condensate and we introduce angular momentum (“stir” the condensate), then we can form “quantized vortices” that possess quantized angular momentum within the larger volume of Bose-Einstein condensate that does not possess macroscopic angular momentum. Therefore a quantum vortex is a group of atoms that has a different angular momentum quantum state (different spin) than the larger group of surrounding atoms that forms the superfluid ^4He or Bose-Einstein condensate. This effect was first discovered with superfluid liquid helium². Dramatic pictures are also available of multiple quantum vortices in a Bose-Einstein condensate^{3,4}.

It is proposed that the quantum fluctuations of spacetime are a Lorenz invariant “fluid” that is the most ideal superfluid possible. Unlike the fundamental particles (fermions) that form a Bose-Einstein condensate, the vacuum fluctuations do not possess any quantized angular momentum. However, vacuum fluctuations are similar to a superfluid or Bose-Einstein condensate because it isolates angular momentum into quantized units. These quantized angular momentum units that exist within vacuum energy are proposed to be the fermions and bosons of our universe. The same way that the quantized vortices cannot exist without the surrounding superfluid, so also the fermions and bosons cannot exist without being surrounded by a sea of vacuum energy.

The total angular momentum present in the quantum fluctuations of spacetime at the start of the Big Bang probably added up to zero. However, even though counter rotating angular momentum can cancel, still there should be offsetting effects that should statistically preserve the quantized angular momentum units from the Big Bang to today (calculated in chapter 13). Dipole waves in spacetime that possess angular momentum would not be the same as the dipole waves that

² E.J. Yarmchuk, M.J. Gordon and R.E. Packard, *Observation of stationary vortex arrays in rotating superfluid helium*, Phys. Rev. Lett. 43, 214-217 (1979)

³ K. W. Madison, F. Chevy, W. Wohlleben and J. Dalibard, *Vortex lattices in a stirred Bose-Einstein condensate* [cond-mat/0004037\[e-print arXiv\]](https://arxiv.org/abs/cond-mat/0004037).

⁴ Ionut Danaila, *Three-dimensional vortex structure of a fast rotating Bose-Einstein condensate with harmonic-plus-quartic confinement*, <http://arxiv.org/pdf/cond-mat/0503122.pdf>

form vacuum fluctuations. A unit that possesses quantized angular momentum loses its ideal superfluid properties because it can interact with another unit of energy that possesses quantized angular momentum (for example, exchange angular momentum).

Spacetime Eddy in a Sea of Vacuum Energy: It is proposed that what we consider to be the fundamental particles today (quarks and leptons) are the spacetime equivalent of the vortices that carry quantized angular momentum in a superfluid. However, the quantized angular momentum entities are better visualized as chaotic eddies that exist in the vacuum fluctuations of the spacetime field. We can only directly interact with the dipole waves in the spacetime field that possess quantized angular momentum. We are unaware of the vast amount of superfluid vacuum energy that surrounds us because it only indirectly has any influence on us.

In the spacetime based model of the universe, fundamental particles are dipole waves in spacetime that possess quantized angular momentum. They are living in a sea of superfluid vacuum fluctuations that cannot possess angular momentum. Fundamental particles cannot exist without the support provided by this sea of superfluid vacuum fluctuations.

Spin and Particle Size: Before describing how fundamental particles can be formed out of the properties of spacetime, I would like to point out several problems with the vague “point particle” description of particles currently used in quantum mechanics. Molecules have experimentally observable size, so we will start there. There is experimental evidence which indicates that molecules possess physical angular momentum. For example, molecules suspended in a vacuum physically rotate at specific frequencies. Each isolated molecule has a fundamental rotational frequency and allowed rotational harmonics of that frequency. For example, a carbon monoxide molecule has a fundamental rotation frequency of 115 GHz. This molecule can only rotate at this frequency or at higher frequencies which are integer multiples of the fundamental frequency. This fundamental rotational frequency corresponds to the carbon monoxide molecule possessing $\frac{1}{2}\hbar$ of angular momentum. The carbon monoxide molecule has physical dimensions which can be measured. The rotation can be visualized as a classical physical rotation. The quantized rotational frequencies are not classical, but even these are conceptually understandable if the molecule is visualized as existing within the superfluid spacetime field which enforces quantized angular momentum.

The reason for going into this detail about the rotation of molecules is that the physical rotation of a molecule is going to be contrasted to fundamental particles which are said to possess an “intrinsic” form of angular momentum known as “spin”. The concept is that the fundamental particles somehow possess a quality with dimensions of angular momentum, but without any part of the fundamental particle undergoing a classical rotation. The problem is that the description of a fundamental particle as a point particle or a Planck length string does not allow for any physical rotation which achieves $\frac{1}{2}\hbar$ of angular momentum. For example, an electron has energy of 0.511 MeV. If a photon had this energy, it would have to propagate at the speed of light around a circle

larger about 10^{-13} m in order to have $\frac{1}{2} \hbar$ of orbital angular momentum. Since relativistic collision experiments seem to imply that an electron is no larger than 10^{-18} m, this 10^{-13} m physical size is rejected. The angular momentum of an electron is the first of three areas that imply a size mystery.

The second conflict is the implied minimum size of an electron calculated from the electric field of an electron. An electron possesses an electric field with measurable energy density. The classical radius of an electron is calculated by finding the radius where the total energy contained in the electron's electric field equals the electron's energy (0.511 MeV). This "classical electron radius" equals 2.8×10^{-15} m. This is the implied minimum size of an electron based on our knowledge of electric fields. Since this is much larger than the previously mentioned 10^{-18} m, this is another size mystery. If an electron is actually approximately Planck length in radius as in some models, then the energy of the electron's electric field should be about 10^{20} times larger than 0.511 MeV. Rather than admit that there is a possible problem with the point particle model, the calculated maximum size of an electron is dubbed the "classical" electron radius. The word "classical" is the kiss of death to any quantum mechanical explanation.

A third problem occurs in quantum electrodynamics calculations. When the size of an electron is required for a calculation, then the analysis gives a ridiculous answer of infinity if the electron is assumed to be a point particle. The process of renormalization is required to eliminate the infinity. However, this is an artificial adjustment of the answer so that it is no longer a faithful extension of the starting assumptions. An analysis of this problem shows that in order to obtain a reasonable answer (not infinity), the radius of the electron must be assumed to be larger than the classical electron radius. This also implies a size mystery.

These three examples are given here because they illustrate some of the problems with the point particle model used in quantum mechanics. The explanation usually given to students is that the point particle model is correct, but quantum mechanics is a mathematical subject. Physical explanations are simply beyond human understanding. How is it possible to conceptually understand a point particle possessing "intrinsic" angular momentum with nothing actually rotating? How is it possible for an electron to be much smaller than its classical radius? Will we ever be able to understand an electric field in terms of something more fundamental? Will we ever be able to understand how a fundamental particle causes curved spacetime? All of these questions will be answered in this book. The first step is to examine the proposed spacetime particle model which solves all of the size mysteries and many other related mysteries.

Rotar: The simplest form of quantized angular momentum that can exist in a sea of dipole waves in spacetime would be a rotating dipole wave that forms a closed loop that is one wavelength in circumference. A dipole wave in spacetime is always propagating at the speed of light, even if it forms a closed loop. This agrees with the highly successful Dirac equation which requires that a fundamental particle such as an electron is always propagating at the speed of

light. Dirac expressed this requirement mathematically as $\pm c$ so an electron can have an average velocity of zero while having a wave moving in a confined volume at a speed of c .

This rotating dipole wave in spacetime is still subject to the Planck length/time limitation, so it can be thought of as being at the limit of causality. Its rotation is chaotic rather than being in a single plane. It has a definable angular momentum, but all rotation directions are permitted with different probabilities of observation. (The exact opposite of the expectation direction has zero probability). Therefore, the proposed model of an isolated fundamental particle is a dipole wave in the spacetime field that forms a rotating closed loop that is one wavelength in circumference.

This obviously is a drastic departure from the standard definition of the word “particle”. The standard model of a fundamental particle is a mass that has no discernible physical size, but somehow exhibits wave properties, angular momentum and inertia. It is an axiom of quantum mechanics that the ψ function has no physical interpretation. This vagueness will be replaced with a tangible physical model that explains many of the properties exhibited by fundamental particles. A new name is required to distinguish between the standard concept of a fundamental particle and the proposed model of a rotating dipole wave in spacetime. The new name for the spacetime model of a fermion will be: “**rotar**”. It is with great reluctance that a new word is coined, but this is necessary for clarity and brevity in the remainder of this book.

The name rotar refers specifically to the spacetime dipole model of a fundamental particle that exhibits rest mass (a fermion). This model, and its variations, is described in detail later. Bosons without rest mass, such as a photon, have a different model and are not covered by the term “rotar”. There will be a spacetime model of a photon, but that will be introduced later. The word “particle” will be used whenever the common definition of a particle is appropriate or when it is not necessary to specifically refer to the spacetime particle model. For example, the name “particle accelerator” does not need to be changed. Even the term “fundamental particle” will occasionally be used in the remainder of this book when the emphasis is on distinguishing a quark or lepton from composite objects such as hadrons or molecules.

Trial and Error: The angular momentum present today in the form of fermions and bosons was present at the Big Bang in the form of photons with the highest energy possible which is Planck energy. This starting condition will be discussed more in the chapters on cosmology. Even though photons make up a small percentage of the energy in the universe today, the photons of the cosmic microwave background still possess the vast majority of the quantized angular momentum in the universe. The early universe was radiation dominated, but energetic photons can combine to form matter/antimatter pairs. However, there is a slight preference for matter (about one part in a billion). As the early universe expanded (transformed), the chaotic dipole waves in spacetime explored every allowed combination of frequency and amplitude in an effort to find the most suitable form to hold the unwanted angular momentum. By trial and error, relatively long lived spacetime resonances were found that both held quantized angular

momentum and also were compatible with the properties of the vacuum energy dipole waves in spacetime. These spacetime resonances are proposed to be the fundamental particles (fundamental rotars). It will be shown later that the known fundamental rotars are resonances that have frequencies between about 10^{20} and 10^{25} Hz.

In the proposed early stages of the Big Bang, the most energetic spacetime particles (rotars) formed first. For example, tauons (tau leptons) formed before muons. These were partially stable resonances. They survived for perhaps 10^{11} cycles, but not indefinitely. They then decayed into other energetic rotars and photons. The radiation dominated universe was undergoing a large redshift. Energy was being removed from photons and transformed into vacuum energy. This lowered the temperature of the observable portion of the universe that possesses angular momentum (photons, neutrinos and rotars). Eventually, other fundamental spacetime resonances (rotars) were formed at lower frequencies (lower energy). Eventually, truly stable resonances formed and these were electrons and the up and down quarks that found stability by forming protons and neutrons.

Wave-Particle Duality: Before launching into a more detailed description and analysis of a rotar, it is interesting to initially stand back and look at the philosophical difference in perspective required to imagine a particle made entirely of dipole waves in spacetime. At first, the idea of a particle made out of waves in spacetime seems to be intuitively unappealing. The essence of a particle is something that acts as a unit. Waves, on the other hand, are imagined to be infinitely divisible. When a particle undergoes a collision, it responds as a single unit in a collision. This property seems incompatible with a rotar made entirely of a wave.

The superfluid properties of the spacetime field makes angular momentum into quantized units of $\frac{1}{2} \hbar$ or \hbar . The same way that a superfluid Bose Einstein condensate isolates angular momentum into discrete vortices, each with \hbar of angular momentum, so also spacetime isolates angular momentum into isolated units possessing quantized angular momentum.. It is not possible to interact with just 1% of a quantized unit of angular momentum. It is all or nothing. Therefore, dipole waves in spacetime possessing $\frac{1}{2} \hbar$ of angular momentum appear to be particles because they respond to a perturbation as a unit.

Later in this book I will postulate a new property of nature called “unity”. This property is closely related to entanglement. It permits a dipole wave possessing quantized angular momentum to communicate internally faster than the speed of light and respond to a perturbation as a single unit. This property would impart a “particle like” property to a quantized dipole wave in spacetime. However, the quantized wave would not exhibit classical particle properties. “Finding” the particle would become a probabilistic event because we are really dealing with interacting with a wave carrying quantized angular momentum that is distributed over a finite volume. A quantized wave in the spacetime field can exhibit both angular momentum and give a physical interpretation to the path integral of QED. There is actually a great deal of appeal to

fundamental particles being made of quantized waves in spacetime, provided that the model is plausible.

Another objection to a rotar model made entirely of waves is that our experience with light seems to imply that waves do not interact with each other. Light does have a very weak gravitational interaction, but overall light waves exhibit almost no interaction. The waves in spacetime that are proposed to be the building blocks of all matter and forces must be able to interact with each other.

Any wave that exhibits nonlinearity will interact to some degree with a similar wave. For example, sound waves have a slight nonlinearity. There is a temperature difference between the compression and rarefaction parts of a sound wave. This slight temperature difference produces a slight periodic difference in the speed of sound. This slight nonlinearity in a single sound wave means that two superimposed sound waves do interact. However, at commonly encountered sound intensities, the interaction between two sound waves is very small.

Gravitational waves also have a slight interaction because general relativity shows that gravitational waves are nonlinear. One of the appeals of dipole waves in spacetime is that they exhibit the required ability to interact with each other. In fact, dipole waves interact so strongly that they would cause a violation of the conservation of momentum without the quantum mechanical Planck length/time limitation previously discussed. The interactions between dipole waves in spacetime will be shown to be responsible for all the forces including gravity.

The spacetime field is the stiffest possible medium. The incredibly large impedance of spacetime ($Z_s = c^3/G \approx 4 \times 10^{35} \text{ kg/s}$) permits a wave with small displacement to have the very high energy density for a given frequency. When we have frequencies in excess of 10^{20} Hz, then waves in spacetime are capable of achieving the energy density of fundamental particles. When we permit the frequency to reach Planck frequency, we can achieve the energy density required at the start of the Big Bang (Planck energy density). Also, a universe made only of spacetime and perturbations of spacetime has an appealing simplicity.

Particle Design Criteria: Everything that has previously been said in this book has set the stage for the task of attempting to design and analyze a plausible model of a fundamental rotar. In designing a rotar from dipole waves in spacetime, there is one factor that will be temporarily ignored. This is the experimental evidence that seems to indicate that fundamental particles are points with no physical size. The rotar model will be shown to exhibit this property, but this will be analyzed later.

It should be expected that the first model of fundamental particles will be overly simplified. For example, this first generation rotar model will make no distinction between leptons and quarks. Subsequent generations of the rotar model should make such a distinction and exhibit other

refinements. The hope is that the first generation rotar model will pass enough plausibility tests that others will be encouraged to improve on this model.

There are 6 considerations that will be brought together in an attempt to design a fundamental particle. These are:

- 1) The universe is only spacetime. The energetic spacetime field contains waves in spacetime. The waves can be dipole waves (with the Planck length/time limitation), quadrupole waves (for example, gravitational waves) or higher order waves. Of these, only dipole waves in spacetime modulate the rate of time and modulate volume. These are the characteristics required to be the building blocks of rotars.
- 2) The rotar model should exhibit inertia. As shown in chapter 1, this requires energy traveling at the speed of light, but confined to a limited volume in a way that the momentum vectors generally cancel.
- 3) The rotar model should exhibit angular momentum. This will be interpreted as implying a circulation (rotation) of the dipole waves in spacetime. Furthermore, there should be a logical reason why fundamental rotars (fermions) with different energy all possess the same angular momentum.
- 4) The rotar model should exhibit de Broglie waves when moving relative to an observer. This implies bidirectional wave motion, at least in the “external volume”. The frequency of the confined dipole waves in spacetime can be calculated by analogy to the de Broglie waves generated by confined light described in chapter 1.
- 5) The rotar model should exhibit action at a distance without resorting to mysterious exchange particles. Both gravity and an electric field should logically follow from the rotar design. To accomplish this, part of the rotar’s dipole wave in spacetime must extend into what we regard as empty space surrounding the rotar.
- 6) The rotar model should logically explain how it is possible for particles to explore all possible paths between two events in spacetime (path integral of QED).

Note to Reader: *The rest of this chapter presents the spacetime-based model of a fundamental particle. In these 11 pages the emphasis will be on describing the particle model and there will be no attempt to justify this model. This spacetime-based particle model will include unfamiliar concepts that may be difficult to initially visualize. Chapters 6, 8 and 10 are devoted to testing this particle model. For example, chapter 6 will subject the particle model to tests of its angular momentum, inertia, energy and the generation of forces (including gravity). These tests will also help to explain the model further.*

Particle Model

Fourth Starting Assumption: A fundamental particle is a dipole wave in spacetime that forms a rotating spacetime dipole, one wavelength in circumference. Inertia is a natural property of this particle design.

A rotating dipole in the spacetime field can be mentally thought of as a dipole wave in spacetime that has been formed into a closed loop, one wavelength in circumference. Recall that a dipole wave in spacetime oscillates both the rate of time and proper volume. For example, one portion of the wave, which we will name the spatial maximum, expands proper volume and slows the rate of time relative to local flat spacetime. The opposite portion of the wave, which we will name the spatial minimum has a reduction of proper volume and an increased rate of time relative to local flat spacetime. If a dipole wave in spacetime possesses quantized angular momentum of $\frac{1}{2}\hbar$, it forms a closed loop that is one wavelength in circumference.

To visualize this, a single cycle wave has been given angular momentum so that the spatial maximum and minimum in a plane wave have now become the two opposite polarity lobes of the rotating dipole wave. The wave is still traveling at the speed of light; it is just traveling at the speed of light around a closed loop. Such a wave is confined energy traveling at the speed of light. While there is angular momentum, the net translational momentum of this quantized wave is zero ($p = 0$ because of opposing vectors). Therefore, just like confined light or confined gravitational waves, a dipole wave rotating at the speed of light satisfies the condition required for it to exhibit rest mass and inertia.

This rotating dipole must be pictured as an isolated rotating dipole wave existing in a sea of vacuum energy/pressure that consists of other non-rotating dipole waves in spacetime. The rotar model implies internal pressure (explained later). The vacuum energy/pressure of the surrounding spacetime field is capable of exerting a far greater pressure than is required to confine the energy density of a rotar. For now the important point is that a rotar (rotating spacetime dipole) can achieve stability by interacting with the surrounding sea of vacuum energy (the surrounding spacetime field). The rotating disturbance is only a quantized unit of angular momentum that can effortlessly move through the superfluid spacetime field.

Illustrations of a Rotar: Figures 5-1 and 5-2 are two different ways of depicting the rotating dipole portion of the rotar model. The spacetime dipole depicted in Figure 5-1 shows two diffuse lobes representing strained volumes of spacetime that are rotating in the sea of vacuum energy. These lobes are designated “dipole lobe A” and “dipole lobe B”. Each lobe exhibits both a slight spatial and a temporal distortion of the spacetime field. For example, lobe A can be considered the lobe that exhibits a proper volume slightly larger than the Euclidian norm (the spatial maximum lobe) and a rate of time that is slightly slower than the local norm. Lobe B has the opposite characteristics (smaller proper volume and faster rate of time). These lobes are always

moving at the speed of light, so it is only possible to infer their effect on time or space by wave amplitudes. Also, the rotar model extends beyond the volume shown, but that portion is not illustrated here.

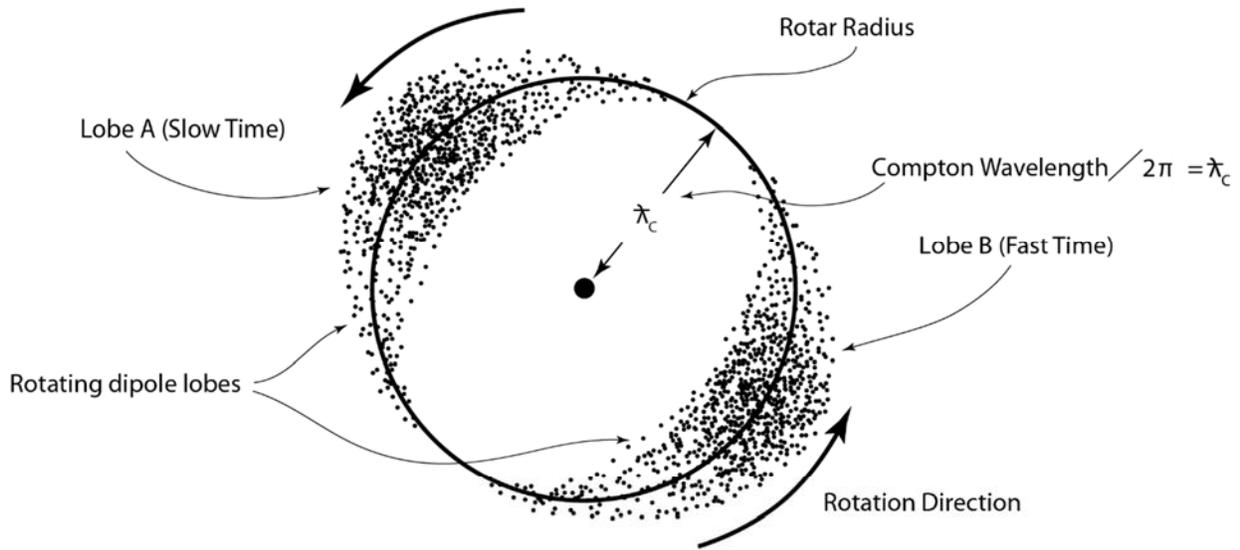


FIGURE 5-1 Depiction of the Rotar Model Emphasizing the Rotating Lobes
This is a rotating spacetime dipole that is one wavelength in circumference.

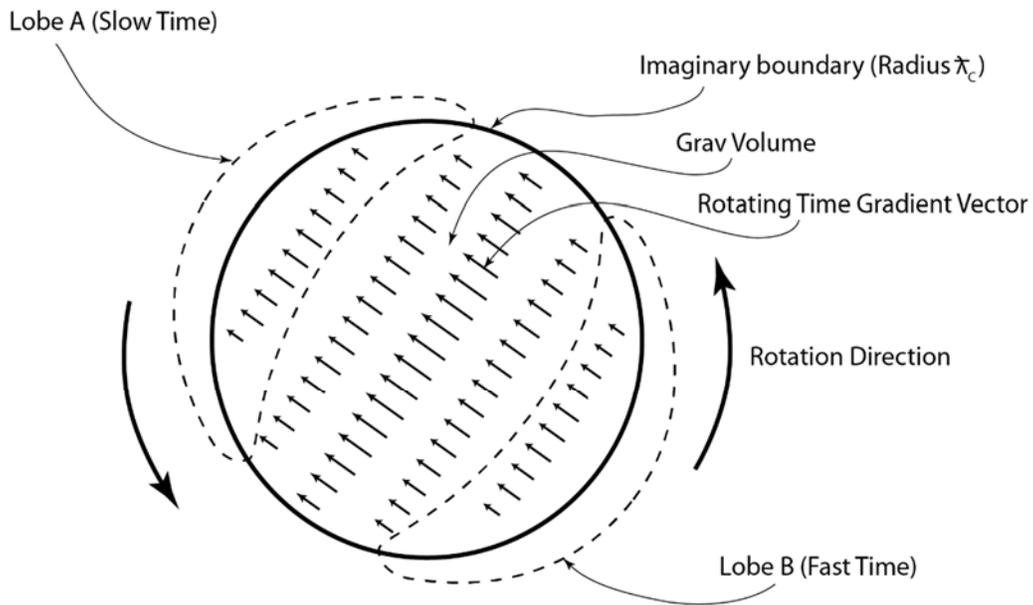


FIGURE 5-2 Depiction of the Rotar Model Emphasizing the Rotating Time Gradient Called a "Grav Field"

Rotar Radius and Rotar Volume : This cross sectional view in Figure 5-1 shows a circle designated “imaginary boundary of the rotating dipole wave”. This circle which is one Compton wavelength in circumference. This circle will sometimes be called the “Compton circle” and the volume within this circle will be called the “quantum volume”. The radius is equal to the fundamental particle’s Compton wavelength divided by 2π which will be designated the reduced Compton wavelength λ_c . This circle and radius λ_c should not be considered as hard edged physical entities. Instead, they should be considered as convenient mathematical references for a rotar. This is similar to the way that the center of mass is a convenient mathematical concept for mechanical analysis.

Figure 5-1 depicts spatial and temporal variations in the properties of the spacetime field. Missing from this figure is all the higher frequency dipole waves in spacetime that are also present in spacetime. For example, the model of the spacetime field is dipole waves which lack angular momentum primarily at Planck frequency with wavelength predominantly equal to Planck length. If figure 5-1 represents an electron, then a dipole wave with wavelength of Planck length would be about 10^{22} times smaller than the radius depicted in figure 5-1. Therefore, the variations shown in figure 5-1 can be thought of as made from a vast number of smaller waves which have slight differences in density resulting in the characteristics shown in this figure.

Since the dipole lobes are quantum mechanical entities, they cannot be accurately described by static pictures. While figure 5-1 depicts a rotation in a single plane, the intended representation is a semi-chaotic rotation that has an expectation direction of rotation, but also other planes of rotation occur with a probabilistic distribution. Also, this is merely quantized angular momentum in the sea of predominantly high frequency dipole waves that make up the spacetime field. This chaotic environment is at the limit of causality. It has an expectation rotational axis, but this chaotic environment creates the quantum mechanical spin characteristics of a particle. The circle depicted in Figure 5-1 should be considered the cross section of an imaginary sphere because the chaotic rotational characteristics allow all rotational axis except the opposite of the expectation axis.. The volume of this imaginary sphere will be designated the “rotar volume V_r ”. While this volume should be $(4/3)\pi\lambda_c^3$, often we are dropping numerical factors near 1 in this plausibility study, so the rotar volume will be considered $V_r \approx \lambda_c^3$.

Rotating Rate of Time Gradient: The presence of these lobes also implies that there is a gradient in the rate of time and a gradient in proper volume between these lobes (and even outside these lobes). If lobe A has a rate of time that is slower than the local norm and lobe B has a rate of time that is faster than the local norm, then this implies that the rotar model also contains a volume of space with a gradient in the rate of time that is rotating with the lobes. Any

gradient in the rate of time produces acceleration. In chapter 2 we showed that the acceleration of gravity was directly related to the gradient in the rate of time:

$$g = c^2 \frac{d\beta}{dr} = - \frac{c^2 d\left(\frac{dt}{dt}\right)}{dr}$$

For example, a 1 m/s² acceleration is produced by a rate of time gradient of: 1.11×10^{-17} seconds/second per meter. The rate of time gradient in the rotar model therefore produces a volume of spacetime that exhibits acceleration similar to gravity but there are also important differences explained below.

Figure 5-2 is intended to illustrate the rotating rate of time gradient present in the rotar model. In figure 5-2 the lobes A and B have been replaced with a dashed outline showing their approximate location. Instead of illustrating the lobes, figure 5-2 shows the rate of time gradient that exists between the lobes. (Only the rate of time gradient inside the rotar volume is shown). The arrows show the direction (vector) of the rate of time gradient and the length of the arrows is a crude representation of the amount of rate of time gradient. The direction of the rate of time gradient rotates with the lobes, so Figure 5-2 should be considered as depicting a moment in time.

Rotating “Grav” Field: A new name is required to describe this rotating acceleration field caused by the rotating rate of time gradient illustrated in figure 5-2. The name “**rotating grav field**” will be used to describe this rotating rate of time field. It will be shown later that this is a first order effect capable of exerting a force comparable to the maximum force of a rotar. However this force vector is rapidly rotating therefore we are not aware of its effect. The gravity produced by a rotar is a vastly weaker force. However, the gravity vector is not rotating and therefore it is additive. This “rotating grav field ” filling the center of the rotar volume will be shown to have an energy density comparable to the energy density of the rotating dipole wave which is concentrated closer to the circumference of the rotar volume. Therefore, the two different types of energetic spacetime approximately fill the entire rotar volume with an approximately uniform total energy density.

Lobe A as described above produces an effect in spacetime that is similar to the effect on spacetime produced by ordinary mass (very small slowing in the rate of time and very small increase in volume). Lobe B, on the other hand, produces an effect that is similar to the effect of a hypothetical anti-gravity mass. It produces a very small increase in the rate of time relative to the local norm and a very small decrease in volume. In lobe B, the very small increase in the rate of time never reaches the rate of time that would occur in a hypothetical empty universe. This will be discussed later, but it will be proposed that the entire universe has a background gravitational gamma Γ that results in the entire universe having a rate of time that is slower than a hypothetical empty universe. It is therefore possible for lobe B to have a rate of time that is

faster than the surrounding spacetime field without having a rate of time faster than a hypothetical empty universe.

Compton Frequency: We will return to figures later, but first we want to calculate the rotational frequency of the rotating dipole. If we presume that a rotar is a confined wave traveling at the speed of light, it is necessary to assign a frequency to this wave. Is it possible to obtain an implied frequency from a particle's de Broglie wave characteristics? In chapter #1 we showed that confined light exhibits many properties of a particle. These include the appearance of the optical equivalent of de Broglie waves when the confined light is moving relative to an observer. If we were only able to detect the optical de Broglie waves present in a moving laser, it would be possible to calculate the frequency of the light in the moving laser. Similarly, we can attempt to calculate a rotar's frequency from its de Broglie waves. We know a particle's de Broglie wavelength ($\lambda_d = h/mv$) and the de Broglie wave's phase velocity ($w_d = c^2/v$). From these we obtain the following angular frequency ω .

$$v_d = \frac{w_d}{\lambda_d} = \left(\frac{c^2}{v}\right) \left(\frac{mv}{h}\right) = \frac{mc^2}{h} \quad v = \text{frequency}$$

$$\omega = 2\pi v_d = \frac{2\pi mc^2}{h} = \frac{mc^2}{\hbar} = \omega_c$$

$$\omega = \omega_c = \frac{mc^2}{\hbar} = \frac{c}{\lambda_c} = \frac{E_i}{\hbar} = \text{Compton angular frequency}$$

This calculation says that a rotar's angular frequency is equal to a rotar's Compton angular frequency ω_c . We will presume that this is a rotar's fundamental frequency of rotation. While the de Broglie wavelength and phase velocity depend on relative velocity, the velocity terms cancel in the above equation yielding a fundamental frequency (Compton frequency) that is independent of relative motion. The reasoning in this calculation can be conceptually understood by analogy to the example in chapter 1 of the bidirectional waves in the moving laser.

A rotar's Compton wavelength will be designated λ_c . The connection between a rotar's Compton wavelength and de Broglie wavelength λ_d is very simple.

$$\lambda_c = \lambda_d \gamma(v/c) \quad \text{where } \gamma \text{ is the special relativity gamma: } \gamma = [1 - (v/c)^2]^{-1/2}$$

$$\lambda_c \approx \lambda_d \gamma \quad \text{Ultra relativistic approximation when } v/c \approx 1$$

The simplicity of these equations show the intimate relationship between a rotar's de Broglie wavelength and Compton wavelength. For another example, imagine a generic "particle" that might be a composite particle such as an atom or molecule. This "particle" is at rest in our frame of reference. Suppose that this particle emits a photon of wavelength λ_γ . This photon has momentum $p = h/\lambda_\gamma$. Therefore the emission of this photon imparts the same magnitude of momentum to the emitting particle but in the opposite vector direction (recoil). Now, the

particle is moving relative to our frame of reference. What is the de Broglie wavelength of the recoiling particle in our frame of reference?

$$\lambda_d = h/p \quad \text{set } p = h/\lambda_\gamma$$

$$\lambda_d = \lambda_\gamma$$

Therefore, we obtain the very interesting result that the de Broglie wavelength of the recoiling particle equals the wavelength of the emitted photon. In Appendix A of chapter 1 it was proven that a confined photon with a specific energy exhibits the same inertia as a fundamental particle with the same energy. Another way of saying this is that a particle with de Broglie wavelength λ_d exhibits the same magnitude of momentum as a photon with the same wavelength. Furthermore, in chapter 1 we saw the similarity between de Broglie waves with wavelength λ_d and the propagating interference patterns with modulation wavelength λ_m . Imparting momentum $p = h/\lambda_\gamma$ to either a fundamental particle with Compton wavelength λ_c or a confined photon with the same wavelength will produce the result: $\lambda_d = \lambda_m = \lambda_\gamma$. Therefore, it is proposed that this offers additional support to the contention that fundamental particles are composed of a confined wave in spacetime with a wavelength equal to the particle's Compton wavelength λ_c . In the remainder of this book we will often use an electron in numerous examples. An electron has the following Compton frequency, Compton angular frequency and Compton wavelength:

Electron's Compton frequency $\nu_c = 1.24 \times 10^{20}$ Hz

Electron's Compton angular frequency $\omega_c = 2\pi \nu_c = 7.76 \times 10^{20}$ s⁻¹

Electron's Compton wavelength $\lambda_c = 2.43 \times 10^{-12}$ m

Electron's reduced Compton wavelength $\lambda_c = 3.86 \times 10^{-13}$ m ($\lambda_c = c/\omega_c$)

Radius of a Rotar: Once we know the rotar's frequency of rotation, we can calculate the rotar's radius assuming speed of light motion. The circle in Figure 5-1 is an imaginary circle with a circumference one Compton wavelength. The radius of the circle one Compton wavelength in circumference is equal to the rotar's reduced Compton wavelength λ_c .

$$\lambda_c = c/\omega_c = \lambda_c/2\pi = \hbar/mc = \hbar c/E_i$$

Where:, λ_c = reduced Compton wavelength = rotar's radius; λ_c = Compton wavelength,

E_i = rotar's internal energy

In quantum mechanics, this distance λ_c is the logical division where a particle's quantum effects become dominant. For example, a fundamental particle of mass m can move discontinuously over a distance λ_c . A particle can go out of existence, or come into existence, for a time equal to λ_c/c . Essentially, the distance λ_c is a rotar's natural unit of length and $1/\omega_c$ is a rotar's natural unit of time. In chapters 6 and 8 it will be shown that the gravitational and electrostatic force exerted by a fundamental particle become much easier to understand when the distance between particles is expressed in the number of reduced Compton wavelengths rather than the number of meters.

Analysis of the Lobes: Suppose that it was possible to freeze the motion of the rotating dipole and examine the difference between the two lobes. The slow time lobe (lobe A) can be thought of as having a proper volume that exceeds the anticipated Euclidian volume as previously explained. The fast time lobe (lobe B) can be thought of as having less proper volume than the anticipated Euclidian volume (the spatial minimum lobe). This connection between volume and the rate of time is well established for the effects of gravity. However, gravity is a static effect on spacetime. This effect on space produced by a rotar's dipole wave in spacetime results in the distance between two points on the Compton circle changing slightly as the dipole rotates.

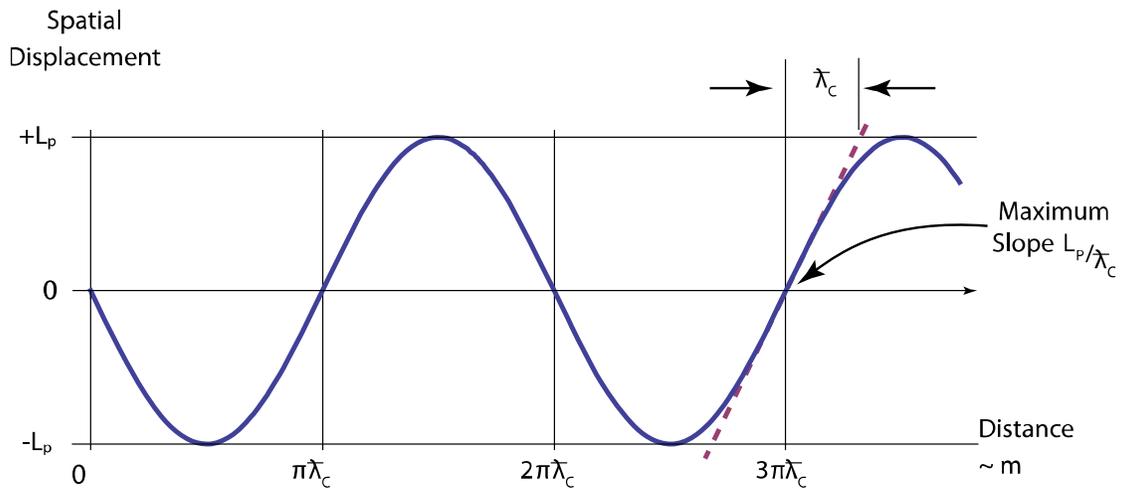


FIGURE 5-3

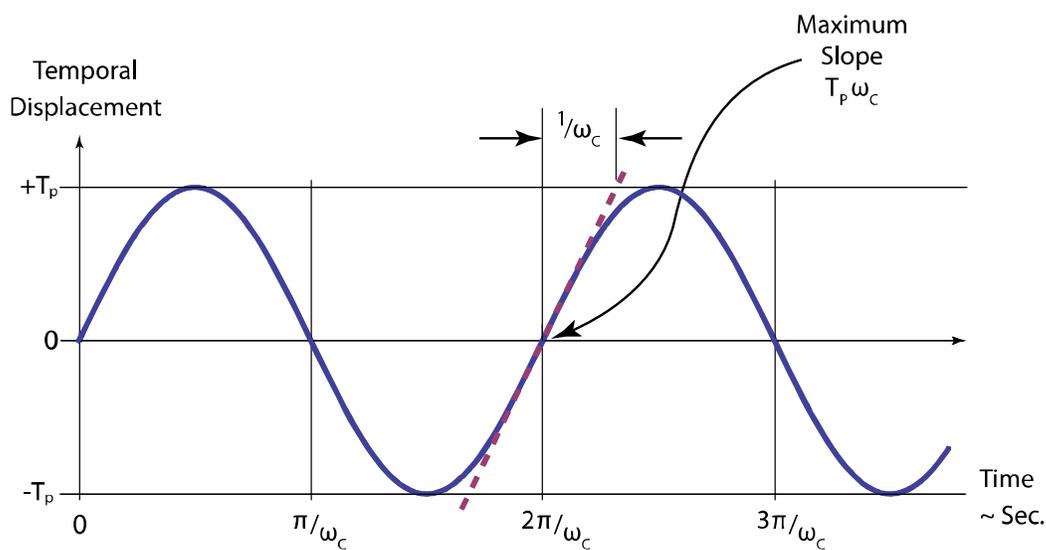


FIGURE 5-4

Similarly, if it was possible to freeze the rotation we would find a different rate of time between the two lobes. Since the lobes are always moving at the speed of light, the effect is that the rate of time fluctuates at a point on the Compton circle (radius = λ_c) and the distance between two points on the Compton circle also fluctuates.

All quantized dipole waves have maximum spatial displacement amplitude equal to \pm Planck length ($\pm L_p$) as the quantum dipole rotates. To illustrate this concept, imagine two points located on the Compton circle of Figure 5-1 separated by a circumferential distance equal to λ_c (separated by one radian). As the lobes rotate they modulate volume and result in the separation distance between these two points increasing and decreasing by Planck length ($\pm L_p$). Figure 5-3 is a graph of the spatial effect produced by the rotating spacetime dipole. In figure 5-3 the “Y” axis is the spatial displacement produced by the rotating dipole between these two points ($\pm L_p$). The “X” axis is length in units of λ_c . It should be noted that the “Y” axis is about a factor of 10^{23} smaller scale than the “X” axis if we presume that λ_c is an electron’s reduced Compton wavelength ($\lambda_c \approx 3.86 \times 10^{-13}$ m and $L_p \approx 1.6 \times 10^{-35}$ m).

Figure 5-4 is a graph of the temporal effect of the rotating spacetime dipole. It was previously stated that in Figure 5-1 we can consider lobe “A” as exhibiting a rate of time slower than the local norm and lobe “B” as exhibiting a rate of time faster than the local norm. To illustrate this concept further, we will imagine a thought experiment where we place a hypothetical perfect clock at a point on the circumference previously designated the “Compton circle” in Figure 5-1. Previously we imagined freezing the rotation of the dipole. Now in figure 5-4 we imagine having the dipole rotate and we are monitoring the time at only one point on the imaginary Compton circle and comparing this to a “coordinate clock” at another location in flat spacetime. The clock monitoring a point on the edge of the dipole will be called the “dipole clock”.

As lobes A and B rotate past the dipole clock location, the dipole clock would speed up and slow down relative to the coordinate clock that is unaffected by the rotating dipole. Both clocks are started at the same moment. In flat spacetime, we would expect both clocks to perfectly track each other. Figure 5-4 plots the temporal displacement of spacetime produced by the rotating dipole wave (Y axis) versus time as expressed in units of $1/\omega$ (X axis). For example, an electron has angular frequency of $\omega_c \approx 7.76 \times 10^{20}$ s⁻¹. Therefore, for an electron $1/\omega_c \approx 1.29 \times 10^{-21}$ s. As can be seen in figure 5-4 the dipole clock speeds up and slows down relative to the coordinate clock. The maximum time difference between the two clocks is plus or minus Planck time T_p ($\pm \sim 5 \times 10^{-44}$ s). This maximum time difference is a quantum mechanical limit for a displacement of spacetime that is undetectable. This oscillation of the rate of time is what has been called “dynamic Planck time T_p ”. Figure 5-4 only shows what happens during a short time period ($\sim 10^{-20}$ s) after starting the dipole and coordinate clocks. The time difference over a longer time will be discussed in a later chapter and shown to result in a net reduction in the rate of time.

Strain Amplitude – A_β : The strain amplitude of the wave depicted in figures 5-3 and 5-4 is just the maximum slope of these waves. The dashed line in figure 5-3 represents the maximum slope which occurs when the sine wave crosses zero. This maximum slope can be a dimensionless number if the “X” and “Y” axis have the same units which cancel when expressing slope. For example, in figure 5-3 both the “X” and “Y” axis have units of length. The maximum displacement is one unit of Planck length ($L_p \approx 1.6 \times 10^{-35}$ m). The “X” axis is length units expressed as multiples of λ_c . For an electron $\lambda_c = 3.86 \times 10^{-13}$ m. The maximum slope occurs at $Y = 0$. The maximum slope in figure 5-3 is L_p/λ_c . This dimensionless maximum slope will be designated the “rotar’s strain amplitude” and designated with the symbol A_β . Therefore, one way of expressing a rotar’s strain amplitude is with the ratio of lengths:

$$A_\beta = L_p/\lambda_c = \text{strain amplitude expressed with length ratio}$$

Figure 5-4 is similar to figure 5-3 except that 5-4 is characterizing the effect on the rate of time. The Y axis of this figure depicts the difference between the dipole clock and the coordinate clock shortly after we start both clocks. This difference between clocks can reach \pm Planck time ($\pm T_p$). The “X” axis of figure 5-4 is in units of time expressed as $1/\omega_c$ which for an electron is $1/\omega_c \approx 1.29 \times 10^{-21}$ s. The strain amplitude A_β of the dipole wave can also be expressed using time related symbols:

$$A_\beta = \omega_c/\omega_p = T_p\omega_c \quad \text{strain amplitude expressed using frequency and time}$$

Therefore the dipole waves strain amplitude can be expressed either as a strain of space (L_p/λ_c) or as a strain in the rate of time ($\omega_c/\omega_p = T_p\omega_c$). For an electron $\lambda_c \approx 3.86 \times 10^{-13}$ m and $\omega_c \approx 7.76 \times 10^{20}$ s⁻¹. Therefore, an electron’s dimensionless strain amplitude is: $A_\beta \approx 4.18 \times 10^{-23}$. (This will be discussed in more detail in the next chapter.) Other rotars have different strain amplitudes because they have different Compton angular frequencies and different values of λ_c . Note that the sine waves in figures 5-3 and 5-4 are shifted by π radians (180°). This is because the lobe with maximum proper volume corresponds to the lobe with the minimum rate of time and vice versa.

Conceptual Examples of Wave Amplitude: The rotar model is based on the sea of vacuum fluctuations that form spacetime being dynamically strained. It is important to have a mental picture of the incredibly small displacements of time and space required for this model. For example, for an electron $A_\beta \approx 4.18 \times 10^{-23}$ which is the ratio of L_p/λ_c or $T_p\omega_c$. This spatial strain of the spacetime field causes the orbits of the two lobes to exhibit differences in circumference and radius comparable to Planck length. This is really equivalent to having one of the lobes exceed the electron’s rotar radius by Planck length and the other lobe is less than the Rotar radius by Planck length. This means that the lobes are not exactly symmetrical. Actually, the very concept of a dipole implies that there must be two different (opposite) properties that are

interacting. With electromagnetic radiation, a dipole oscillator has a positive and negative electrical charge. Similarly, a spacetime dipole has two lobes which produce an opposite type of spatial distortion (big and small) of the properties of spacetime or the opposite type of temporal distortion (fast and slow) of the properties of spacetime.

Planck length is so small that it is hard to imagine the very small distortion of spacetime required to make an electron according to the proposed model. We will use the following example to illustrate this incredibly small difference between the two lobes. Suppose we compare an electron's to the radius of Jupiter's orbit. Stretching space by Planck length over a distance equal to an electron's Rotar radius produces a strain of about 4.2×10^{-23} . ($1.6 \times 10^{-35} / 3.9 \times 10^{-13} \approx 4 \times 10^{-23}$). Stretching Jupiter's orbital radius (7.8×10^{11} m) by 3.3×10^{-11} m would produce a comparable strain in space. To put this in perspective, the Bohr radius of a hydrogen atom is $\sim 5.3 \times 10^{-11}$ m. Now imagine a sphere the size of Jupiter's orbit, except that one hemisphere has strained spacetime such that the radius exceeds the prescribed radius by a distance roughly equal to the radius of a hydrogen atom. The other hemisphere is less than the prescribed amount by the radius of a hydrogen atom (a 4×10^{-23} volume difference). Of course, the transition between the two lobes is not an abrupt step. This simplified example is meant to illustrate the very small distortion of the spacetime field involved in the spacetime-based model of a fundamental particle.

Continuing with the example, suppose that we were to compare the rate of time between the two lobes of an electron. Suppose that it was possible to stop the rotation and insert a perfectly accurate clock into the fast lobe of an electron (at distance λ_c) and insert a second perfect clock into the slow lobe. The rate of time difference is so small that it would take about 50,000 times longer than the age of the universe before the two clocks differed in time by one second. This ratio in the rate of time is also about 4×10^{-23} .

In chapter 6 we will analyze this spacetime-based model of fundamental particles to see if the model plausibly yields the correct energy, angular momentum, gravity, etc. However, the above examples begin to give a feel for how particles can appear to be nebulous entities which result in their counter intuitive quantum mechanical properties. Rotars made from small amplitude waves in the spacetime field can be difficult to locate exactly. Furthermore, a property will be proposed later that permits quantized waves in the spacetime field to respond to a perturbation as a single unit. This gives "particle-like" properties to a quantized wave in spacetime and gives rise to the famous wave-particle properties in nature.

Solitons: Why do a few combinations of frequency and amplitude produce resonances that result in fundamental particles and all other frequencies and amplitudes not produce fundamental particles? There must be a combination of properties of spacetime which achieve stability by canceling loss at the few frequencies that form fundamental particles. There appears to be a similarity between the conditions that form a stable rotar and the conditions that form a

stable optical soliton. An optical soliton is formed when a very short pulse of laser light is focused into a transparent material that exhibits a set of complementary optical characteristics. One of these characteristics is the optical Kerr effect. As previously mentioned, this is a nonlinear effect in all transparent materials where the speed of light is dependent on intensity. This nonlinear effect is also wavelength dependent. In some optical materials the dispersion of the optical Kerr effect can be offset against the optical dispersion of the transparent material. These two properties can interact in a way that confines rather than disperses the energy in the pulse of laser light. The dispersion is a loss mechanism for a pulse of laser light. The combination of the two different types of dispersion plus the intensity dependence together can create a stability condition. A pulse of laser light forms a propagating wave that fulfills this stability condition and this combination of effects shape the pulse of light into an “optical soliton”. The term “soliton” is a self-reinforcing wave that maintains its shape as it propagates. The first identified solitons were water waves propagating in a channel. Optical solitons can exhibit many particle-like properties. For example, two optical solitons propagating near each other can attract or repel each other depending on the relative phase of the light. A wonderful video is available at the following website showing particle-like interactions of optical solitons⁵.

The characteristics of the spacetime field appear to form a similar loss cancellation for the 3 charged leptons. These are fundamental particles with rest mass that can exist in isolation. The stability of any rotars depends on the existence of vacuum energy, but there must be a few frequencies and conditions where the stabilization is optimum. This is equivalent to a pulse of light satisfying the soliton condition in a transparent material. The analogy to optical solitons can be extended if a fundamental particle is visualized as propagating along the geodesic at the speed of light.

Dirac Equation: In his 1933 Nobel Prize lecture, Paul Dirac said the following: *“It is found that an electron which seems to us to be moving slowly, must actually have a very high frequency oscillatory motion of small amplitude superposed on the regular motion which appears to us. As a result of this oscillatory motion, the velocity of the electron at any time equals the velocity of light. This is a prediction which cannot be directly verified by experiment since the frequency of the oscillatory motion is so high and the amplitude is so small.”* Perhaps when Dirac gave his lecture he was visualizing a point particle undergoing an oscillatory motion at the speed of light and at the Compton frequency. However, the Dirac equation does not specify a point particle. It is proposed that the rotar model of an electron actually is a better fit to the Dirac equation. A particle with rest mass cannot propagate at the speed of light. Also, such a moving particle would exceed the conditions of the uncertainty principle and it should be possible to do an experiment that would reveal this internal structure.

The proposed model is a dipole wave in spacetime which naturally propagates at the speed of light. The displacement amplitude of this wave is Planck length and Planck time which meets

⁵ <http://www.sfu.ca/~renns/lbullets.html>

the condition of being an undetectable amplitude even though the physical size of the motion has the relatively large radius of λ_c . Finally, the dipole wave in spacetime is modulating the rate of time and proper volume which gives it the ability to produce curved spacetime in the surrounding volume (discussed later).

Chapter 6

Analysis of the Particle Model and Derivation of Gravity

In chapter 5 the spacetime-based model of a fundamental particle was presented without any analysis to see if it can satisfy the known characteristics of fundamental particles. This chapter will be devoted to testing the rotar model of fundamental particles for plausibility. We will first analyze whether this model will appear to be a point particle in collision experiments. Then we will see if the particle model produces the required energy, angular momentum, and forces including the correct gravity. Finally the implied inertia of the particle model will be discussed.

Particle Size Problem: Perhaps the biggest objection to the hypothesis proposed in chapter 5 is that experiments seem to indicate that fundamental particles are points with no physical size. Now we will examine whether the rotar model is compatible with the experiments that seem to indicate a point particle.

Recall that the spacetime field is a sea of waves predominantly at Planck frequency but all other frequencies are also present at lower density. The waves are undetectable as individual waves because their amplitude is a spatial displacement of Planck length and a temporal displacement (difference between clocks) of Planck time. These waves are the zero point energy and vacuum fluctuations required by quantum electrodynamics and quantum chromodynamics. They introduce uncertainty into any measurement. They also have no angular momentum and exhibit superfluid properties. One of these properties is that any angular momentum is isolated into quantized units. As discussed in the last chapter, a superfluid Bose-Einstein condensate isolates angular momentum into small rotating vortices, each one with \hbar angular momentum. It is proposed that the superfluid spacetime field also isolates angular momentum that has existed in the spacetime field since the Big Bang (discussed in chapters 13 and 14).

A fermion such as an electron or quark is nothing more than a unit of quantized angular momentum quarantined by the superfluid spacetime field into quantized units with angular momentum of $\frac{1}{2} \hbar$ or \hbar (fermions or bosons). An electron is a dipole wave rotating at its Compton angular frequency ($7.7634 \times 10^{20} \text{ s}^{-1}$). The point is that an electron, and all other fundamental particles, are nothing but an organized rotation of the spacetime field. There is nothing there if the expectation is a physical object other than spacetime. There is no vibrating string; there is no elastic sphere that can be characterized by a collision experiment. Even though the radius of the rotating dipole wave is a relatively large $4.18 \times 10^{-13} \text{ m}$, this is just a slight rotating distortion of spacetime that is that size.

For an electron, the very small strain produced in the spacetime field is only about 4×10^{-23} (dimensionless strain slope). Spatially, this is a strain of spacetime comparable to stretching Jupiter's orbit by the radius of a hydrogen atom. Temporally this is comparable to retarding the rate of time by one second over 50,000 times the age of the universe. It is only the incredibly large impedance of spacetime ($c^2/G \approx 4 \times 10^{35}$ kg/s) and the high rotational frequency ($\sim 10^{21}$ s⁻¹) that gives this small strain of spacetime a detectable physical presence. Even then, the oscillations are not detectable as waves because the maximum displacement of spacetime is only Planck length and Planck time.

When we do detect the presence of an electron, it exhibits properties that are not explainable from classical physics. For example, "finding" an electron (interacting with a wave with quantized angular momentum) is a probabilistic event. An electron can seem to jump from one location to another without traversing the space between these two points. This is because the rotating dipole in spacetime that is an isolated electron is distributed over a relatively large volume with a radius in the range of 4×10^{-13} m. Interacting with the quantized angular momentum happens at a point anywhere within this volume but even sometimes outside this volume. This gives the appearance of a point particle discontinuously jumping from point to point. Also the quantized angular momentum causes the electron's energy to be quantized. The list of counter-intuitive properties of an electron is long, but the non-classical property of interest here is the fact that an electron seems to have no physical size in a collision experiment.

Even though the rotar model gives a physical size to fundamental particles, it is not the classical "billiard ball" type of physical size. For example, a "collision" between an electron and a positron (rotar model) often results in these two rotating dipole waves merely passing through each other with the only interaction being a slight scattering from the original trajectories. When an electron and positron annihilate each other in an interaction that forms positronium (not a high speed collision), about 10^{-10} seconds is required for this annihilation (photon emission) to take place. In a collision at near light speed the overlap time is less than 10^{-20} seconds in the frame of reference where the total momentum is zero. When the collision energy is less than the about 1 GeV, then the scattering cross-section of an electron-positron collision decreases as the collision energy increases. At higher collision energy where new fundamental particles can be formed the interaction cross-section becomes complex with the formation of new particles.

In a collision between two electrons, the electrostatic repulsion can be visualized as momentarily bringing the two colliding electrons to a halt. What happens to the kinetic energy at the moment of closest approach? With the rotar model the kinetic energy of each electron is momentarily converted into internal energy of the two electrons. This increase in energy means that the frequency increases, the wavelength decreases, the circumference decreases, and the rotar radius decreases. These changes keep the angular momentum constant because the decrease in radius offsets the increase in mass/energy. The rotar radius \mathcal{A}_c scales with the rotar's internal energy E_i as: $\mathcal{A}_c = \hbar c/E_i$. At the moment of "closest approach" the two rotars are actually partially

overlapping. They also have the smaller radius and higher frequency appropriate for their higher energy condition.

How does this radius compare with the particle size resolution limit in a collision experiment? This resolution limit is set by the uncertainty principle $\Delta x \Delta p = \hbar/2$. We have been ignoring dimensionless constants like $1/2$, so we will use $\Delta x \Delta p = \hbar$ and then include a single all-inclusive constant k . In a collision between two electrons, we have an uncertainty about the momentum transferred at the moment of closest approach. Is the collision head on or a glancing collision? All we really know is the maximum momentum available, so the uncertainty becomes $\Delta p = mv$. For a collision between electrons with ultra-relativistic velocity ($v \approx c$), the special relativity gamma is $\gamma \approx E_k/mc^2$ where E_k is the relativistic kinetic energy. Also, when γ is large, the momentum is: $p \approx \gamma mc$. With this information we can solve for Δx .

$$\Delta x = \frac{\hbar}{\Delta p} = \frac{\hbar}{\gamma mc} = k \left(\frac{\hbar}{mc} \right) \left(\frac{mc^2}{E_k} \right) \quad \text{dimensionless constant } k \text{ included}$$

$$\Delta x = k \frac{\hbar c}{E_k}$$

Therefore, in a collision between ultra-relativistic rotars, the kinetic energy is momentarily added to the rotar's internal energy ($E = mc^2$ energy) for a total energy of $E + E_k \approx E_k$. This means that the rotar radius momentarily shrinks to $\mathcal{A}_c \approx \hbar c/E_k$ which matches the uncertainty resolution limit of the experiment $\Delta x = \hbar c/E_k$. It is no coincidence or lucky result that the resolution of the experiment matches the momentary size of a rotar. If fundamental particles really are rotars with a probabilistic interaction radius, then this size must match the uncertainty in the interaction.

The combination of the overlap and the reduction in \mathcal{A}_c results in an expectation separation distance that is less than the Δx uncertainty resolution of the experiment that attempts to measure the size of the rotar (particle). This is analogous to the uncertainty principle saying that an experiment cannot simultaneously measure the position and momentum of a particle to better than $1/2\hbar$. Similarly, an experiment cannot measure the size of a fundamental particle because the measurement process introduces energy that momentarily decreases the size of the particle to below the measurement resolution ($\mathcal{A}_c = \hbar c/E_i < \Delta x$). This is a classic case of the experiment distorting the property being measured and invalidating the measurement. Therefore, the rotar model gives a plausible explanation of why fundamental particles always appear to be point particles in experiments that attempt to measure their size.

The current upper limit for the size of an electron is set by an experiment using two electrons accelerated to a kinetic energy of about 50 GeV. When the rotar model of an electron undergoes a collision, the 50 GeV kinetic energy is temporarily converted to the electron's internal energy. This momentarily increases the electron's internal energy (dipole wave energy) by a factor of 100,000 and reduces the rotar radius by a factor of 100,000. An isolated electron has a rotar

radius of about 4×10^{-13} m. However when 50 GeV of kinetic energy is converted to an electron's internal energy at the moment of closest approach, this reduces λ_c by a factor of 100,000 to about 4×10^{-18} m. Combined with the ability to partially overlap rotar volumes, the electron always has an instantaneous size smaller than the Δx resolution limit of the experiment. A 50 GeV electron undergoing a collision temporarily becomes much smaller than a proton ($\sim 10^{-15}$ m) and can be used as a probe of the internal structure of a proton.

The rotar model of an electron also has an advantage over the point particle model of an electron when it comes to explaining the behavior of an electron in an atom. An electron bound in an atom appears to be bigger than the isolated rotar size. For example, an electron bound in a hydrogen atom has a different boundary condition than an isolated electron. This creates a different stability condition that results in the dipole wave energy of the electron distributed around the nucleolus of an atom in a way that enlarges the apparent size and explains the cloud-like quality of an electron bound in an atom.

Equations Demand Size: One of the strengths of the spacetime model of fundamental particles is that it gives a plausible explanation of how the fundamental particle (rotar) can have a physical size equal to the reduced Compton wavelength (equal to λ_c) and yet also always appear to be a point particle in collision experiments. One of the “mysteries” of quantum mechanics has been that the equations of quantum mechanics yield an unreasonable answer of infinity when they incorporate the assumption that fundamental particles are point particles. These equations are screaming that this is a wrong starting assumption. Yet the equations are ignored because the physical interpretation of experiments is that the fundamental particles must be point particles.

However, this is a failure of the physical interpretation of the experiments, not a failure of the equations. The process of renormalization used to eliminate the infinity is actually adjusting the starting assumption to give a physical volume to fundamental particles. Physicists believe that experiments are the ultimate referee of a theory. Usually experiments are easy to interpret correctly. However, the physical interpretation of collision experiments always makes the erroneous assumption that the colliding particles do not change any of their characteristics compared to the same particles not undergoing a collision. In particular, the assumption is that the physical size of a fundamental particle remains constant, even if the collision is ultra-relativistic. However, where is the kinetic energy stored at the instant when both particles are stopped? It is proposed that the collision experiments are giving the correct answer for this instant but this collision moment cannot be extrapolated to deduce the size of isolated particles. This is like a self-fulfilling prophecy. If you assume point particles, then you can interpret the experimental results to support this model.

Stability Mechanism: How exactly does the spacetime dipole achieve stability? What prevents the waves from simply propagating in a straight line rather than forming a rotating dipole? This question will be addressed later, but an introductory explanation will be given here. Chapter 5

started by recounting Erwin Schrodinger's attempted to give a wave based explanation to fundamental particles. Schrodinger eventually abandoned this explanation because he was unable to explain what prevented his "wave packet" from dissipating.

The proposed rotar model has a single frequency dipole wave in spacetime that forms a rotating closed loop. This dipole wave is still propagating at the speed of light. This model achieves a large energy density that will be calculated later. However, it also implies a large pressure required to confine this energy. In fact, any concentration of energy density fundamentally implies pressure. Therefore, this proposed rotar model requires some means to counteract the pressure associated with the energy density. This is accomplished by an interaction with the vacuum energy dipole waves in the spacetime field. This vacuum energy possesses a vastly larger energy density than any rotar. Therefore the vacuum energy exists at a vastly larger pressure than is required to stabilize the rotar. There are only a few quarks and leptons in the standard model. These represent only a few Compton frequencies that have achieved at least partial stability interacting with the surrounding vacuum energy dipole waves in spacetime. This explanation will be expanded later.

Rotar Energy Test: Now we are going to subject the rotar model and the concept of dipole waves in spacetime to a critical test. We will use one of the 5 wave-amplitude equations and attempt to calculate the energy of any rotar. We are not attempting to calculate the energy of specific particles. Instead, we are checking to see if the concept of dipole waves in spacetime that are confined to a specific volume can produce the equivalent mass/energy for a rotar. For this plausibility test to be successful, inserting a rotar's amplitude, frequency and volume into the wave-amplitude equation must produce the correct energy for a rotar (ignoring dimensionless constants near 1). The equation to be used is:

$$E = k A^2 \omega^2 Z V / c \quad \text{wave-amplitude equation expressing energy } E \text{ in a volume } V$$

We know that the angular frequency ω equals the Compton frequency: $\omega = \omega_c = c/\lambda_c = mc^2/\hbar$. We will also set the amplitude as: $A_\beta = L_p/\lambda_c = T_p\omega_c$. Where A_β = strain amplitude in the rotar volume of a rotar. This amplitude was obtained in the last chapter using the starting assumption about the maximum displacement of spacetime allowed by quantum mechanics for dipole waves in the spacetime field.

The volume term V should be equal to the volume of the rotar volume: $V = k\lambda_c^3$. It is true that we are not addressing the question about how uniformly this volume is filled, but this is just a plausibility test and we are using the constant k which permits us to be vague about this point. Finally, the impedance term Z is set equal to the previously obtained impedance of spacetime: $Z_s = c^3/G$. We will lump all dimensionless constants into a single constant k .

$$E = k A^2 \omega^2 Z V / c \quad \text{set } A = A_\beta = L_p/\lambda_c \quad \omega = \omega_c = c/\lambda_c \text{ and } Z = Z_s = c^3/G$$

$$E = k \left(\frac{L_p}{\lambda_c} \right)^2 \left(\frac{c}{\lambda_c} \right)^2 \left(\frac{c^3}{G} \right) \left(\frac{\lambda_c^3}{c} \right) = k \frac{L_p^2 c^4}{G \lambda_c} = k \left(\frac{\hbar G}{c^3} \right) \left(\frac{c^4}{G} \right) \left(\frac{mc}{\hbar} \right)$$

$$E = k mc^2$$

This important plausibility test is successful. The rotar model establishes the famous relationship between energy and mass (inertia). We have shown that an amplitude of $A_\beta = L_p/\lambda_c$, a frequency of ω_c and a volume of $k\lambda_c^3$, together produce the correct energy of $E = mc^2$ (times a possible constant). The mass in this equation should be thought of as the inertia exhibited by confined energy circulating at the speed of light. The calculation that was just made represents a bridge between the familiar concept of particles exhibiting mass and the unfamiliar concept of confined waves in the spacetime field that exhibit energy and inertia.

We are presuming that $k = 1$. We actually have a little bit of flexibility in this regard. Previously we gave an example where the displacement amplitude was defined as the normal \pm amplitude of a sine wave. It would also be possible to define the amplitude as the RMS amplitude or the peak to peak amplitude. These three ways of defining amplitude all apply to the same wave. Furthermore, there may be another way of defining amplitude. I am going to presume that some definition of amplitude will permit $k = 1$.

It should be emphasized that the rotar radius λ_c is a convenient mathematical representation of a rotar model, but the rotar does not abruptly stop at a distance of λ_c . The rotar model is more complex than this and part of the quantum wave that forms the rotar extends beyond the rotar radius. For example, it will be shown later that the rotar's electric field and gravity are the result of the rotar's wave structure that extends far beyond the rotar radius. However, the energy in the electric and gravitational fields beyond λ_c contains less than 1% of the rotar's total energy. The use of λ_c can be thought of as a convenient mathematical tool to easily represent the entire rotar in simple calculations.

Angular Momentum Test: The next test of the model is to see if the model has approximately the correct angular momentum. We will build on the energy calculation and test to see if the angular momentum \mathcal{L} of this rotar model has the same angular momentum for all fundamental particles regardless of mass/energy and furthermore whether this angular momentum is equal to \hbar when numerical factors near 1 are ignored.

$$\mathcal{L} = pr \quad \text{set: } p = \text{momentum} = E/c = mc \quad \text{and} \quad r = \lambda_c = \hbar/mc;$$

$$\mathcal{L} = mc(\hbar/mc) = \hbar$$

Mass cancels and all mass/energy has the same angular momentum. This solves one of the problems associated with fundamental particles. How is it possible that particles with vastly different energy possess the same angular momentum? The standard approach has been to merely label it as "spin" and declare that this is merely one of the many mysteries of quantum

mechanics beyond human understanding. When we adopt a different model of a fundamental particle, we discover that the answer is actually quite simple.

We still have the pesky problem that the angular momentum should be $\frac{1}{2} \hbar$ rather than \hbar . It turns out that there are actually two considerations we haven't accounted for and both have the effect of lowering the angular momentum towards $\frac{1}{2} \hbar$. First, this angular momentum is at the limit of causality and it does not have a single well defined axis of rotation. You can visualize the rotating dipole wave as existing in the spacetime field which is a sea of Planck amplitude waves at all frequencies up to Planck frequencies. This turbulence causes the spin axis to have an expectation direction, but all other rotational directions are permitted with lower probability except for the opposite of the expectation direction which has a probability of zero. A graph of the probabilities of spin direction is shown in figure 10-8. The point is that this distribution of spin directions lowers the angular momentum around the Z axis. In fact, it appears to lower the Z axis angular momentum towards half of the angular momentum it would have if there was a fixed axis and rotational direction. However, this is a simplified analysis, and there is still another consideration. Therefore I will leave the analysis to others.

The second consideration is that a rotating wave is distributed over a volume. If we only had energy traveling at the speed of light around a circle (a hoop) of radius λ_c , (for example, light in a waveguide) then we should use the moment of inertia of a hoop ($I = mr^2$). However, the dipole wave is diffuse and as shown in figure 5-2, there is also a "rotating grav field" filling the center of the rotar volume. In chapter 8 it will be shown that the energy density contained in the strongest part of the rotating grav field (the center) is exactly the same as the energy density contained in the strongest part of the rotating dipole wave (the circumference). In fact, the rotating grav field is a fundamental part of the dipole wave and energy is just being transferred between these two states. This means that the energy density is relatively evenly distributed across the rotar volume. The moment of inertia of a rotar is most closely approximately by the moment of inertia for a disk: ($I = \frac{1}{2} mr^2$). We will calculate the angular momentum of the disk analogy spinning in a plane.

$$\begin{aligned} \mathcal{L} &= I \omega \quad \text{set:} \quad I = \frac{1}{2} mr^2 = \frac{1}{2} m \lambda_c^2 \quad \omega = c/\lambda_c \quad \lambda_c = \hbar/mc \\ \mathcal{L} &= (\frac{1}{2} m \lambda_c^2) \left(\frac{c}{\lambda_c} \right) = (\frac{1}{2} mc) \left(\frac{\hbar}{mc} \right) \quad \text{note that mass cancels} \\ \mathcal{L} &= \frac{1}{2} \hbar \end{aligned}$$

Therefore, this is another consideration which also lowers the angular momentum towards $\frac{1}{2} \hbar$. In fact, if we combine both considerations we would have angular momentum lower than $\frac{1}{2} \hbar$. A third consideration is that a rotar is also not a spinning disk. Its energy does not end abruptly at the radial distance λ_c . In fact, the energy distribution is not known beyond the generalizations presented here. Calculating the energy distribution and angular momentum is a complicated problem that requires a more advanced model and a rigorous analysis. The point is that there

are a large number of ways that the energy can be distributed within the model that result in angular momentum of $\frac{1}{2} \hbar$. In fact, achieving this angular momentum would become one of the requirements for choosing the “correct” energy distribution. However, this is a successful plausibility test. The proposed model inherently incorporates angular momentum into the structure of a rotar and it is plausible that further analysis will confirm $\frac{1}{2} \hbar$.

Molecules also possess quantized angular momentum, but in the case of molecules it is easy to prove that this quantized angular momentum results from the physical rotation of the molecule. There are other examples of quantized angular momentum involving the rotation of physical objects such as the quantized vortices that form in superfluid liquid helium. The point is that the angular momentum is physical. There is no need to invoke the abstract concept of an object possessing “intrinsic angular momentum” in these cases. Something external is enforcing this quantization of angular momentum. The spacetime based model proposed here attributes this enforcement to all matter (fundamental particles, molecules, etc.) being immersed in a sea of superfluid vacuum energy. This spacetime based model also gives a conceptually understandable explanation of how a fundamental particle such as an electron can possess angular momentum. The electron is a rotating disturbance in the spacetime field with a physical size that gives conceptually understandable angular momentum. The concept that a point particle can possess angular momentum is an admission that the model being used is inadequate.

Planck’s Constant *Always* Implies Angular Momentum: The spacetime based model of the universe elevates angular momentum to the single characteristic which creates all quantized effects including particles. There is a good article¹ that also makes the point that “spin” of fundamental particles implies physical rotation of a wave. In the conclusion of this article, the statement is made, “*The preceding has great intuitive appeal because it confirms our deep prejudice that angular momentum ought to be due to some kind of rotational motion. But the rotational motion consists of a circulation of energy in the wave fields rather than the rotation of some kind of rigid body.*” Another statement from this article is, “*A comparison between calculations of angular momentum in the Dirac and electromagnetic fields shows that the spin of an electron is entirely analogous to the angular momentum carried by a classical circularly polarized wave.*”

All the energy of an electron can be traced to the fact that the electron possesses angular momentum. The previous calculation in this chapter that resulted in $E = k mc^2$ made some simplifying assumptions, but even with a more advanced model, all the observable energy is either directly attributable to angular momentum or associated with effects such as the grav field or the electric field which are both the result of quantized angular momentum. The dimensional analysis units of angular momentum are: ML^2/T . Merely multiplying angular momentum by frequency (rotation rate) with units $1/T$ yields energy with units of ML^2/T^2 . This is stated because the current attitude is to treat h or \hbar as a constant that happens to have units which are

¹ Ohanian, H. "What is spin?" Am. J. Phys. 54, 500 (1986);

the same as angular momentum but angular momentum is not a key part of the explanation. For the energy of a photon we say $E = \hbar\omega$. However, this is not an abstract equation. As will be shown in chapters 9 and 10, there is real angular momentum associated with a photon. Multiplying this angular momentum by rotation frequency gives the photon's energy.

When an electron is placed in an external magnetic field that is not aligned with the electron's magnetic moment, the electron undergoes Larmor precession. This is analogous to the precession exhibited by a gyroscope when a torque is applied with a component perpendicular to the axis of rotation.

There is no such thing as "intrinsic angular momentum". This term implies an abstract property which does not include anything that is physically rotating. If dipole waves in spacetime and quantized angular momentum are elevated to the status of physical entities, then all of physics would be transformed into "classical physics". All of physics would potentially be conceptually understandable and a new golden age of physics would be born.

720° Rotation Test: One of the biggest mysteries of quantum mechanics is that fundamental particles with spin $\frac{1}{2}$ needs two full rotations ($2 \times 360^\circ = 720^\circ$) until they return to the same state. Since there is nothing in our macroscopic world with symmetry like that, the structure of spin $\frac{1}{2}$ particles such as an electron is often considered to be beyond our conceptual understanding. The calculation that demonstrates this 720° effect involves referencing the phase of an electron that is going to undergo a rotation against a hypothetical standard electron that is not going to undergo a rotation. The spin of an electron gives the electron a magnetic field with North and South poles. It is possible to impose an external magnetic field which can be used to rotate the electron since the electron's North – South magnetic poles attempt to remain aligned with the external magnetic field. Any rotation of the external magnetic field also causes the electron to undergo precession, but that is another subject. The point is that when the electron has undergone one complete 360° flip, it is out of phase with the reference electron. It takes another 360° flip to bring the test electron back into phase with the reference electron.

The first point is that this experiment is not exactly the same as rotating a classical object such as a ball through 360°. We are referencing the phase of an electron not some feature on the surface of a ball. The electron has no physical surface. Next, we will attempt to visualize what will happen if we subjected the rotar model of an electron to a force which caused the axis of rotation to be flipped 360°. The first consideration is that the rotating dipole wave that forms the electron is already propagating at the speed of light. It is not possible to maintain its physical size and frequency when we also flip the axis of rotation because maintaining phase would require parts of the dipole wave to exceed the speed of light. The external magnetic field must exert a force on the electron to cause the axis of the electron to rotate. This force applied through a distance is adding energy to the electron which causes the rotational frequency to increase and the radius (r_c) to decrease. This would produce a phase change relative to a standard which is

not undergoing such an axis flip. I cannot prove that it would take a 720° axis flip to return to the original phase, but a 360° rotation definitely will not return to the original phase.

Dipole Moment: Not only does the proposed rotar model give the same angular momentum to all rotars, the rotar model also specifies that all rotars have the same dipole moment d_m . The dipole moment of a rotar is the dipole amplitude times the rotar radius. We will calculate the value of the dipole moment shared by all rotars.

$$d_m = A_\beta \mathcal{A}_c = \sqrt{\frac{Gm^2}{\hbar c}} \left(\frac{\hbar}{mc} \right) = \sqrt{\frac{\hbar G}{c^3}} \quad d_m = \text{dipole moment} \quad A_\beta - \text{see explanation below}$$

$$d_m = L_p \quad L_p = \text{dynamic Planck length}$$

A dipole made of two electrically charged particles has a dipole moment with units of Coulomb meters. However, a spacetime dipole has a dipole moment with units of just meters because A_β is a dimensionless number. Rotars with a large mass have a large value of A_β , but this is offset by a small rotar radius \mathcal{A}_c . Therefore, all rotars have the same dipole moment of dynamic Planck length L_p .

Planck Units: Before proceeding further, I would like to pause and discuss “Planck units” which are physical units of measurement derived from 5 physical constants which are: \hbar , c , G , the Coulomb force constant $1/4\pi\epsilon_0$ and the Boltzmann constant k_B . These 5 constants are combined to give 5 Planck “base units”: Planck length L_p , Planck time T_p , Planck mass m_p , Planck charge q_p and Planck temperature \mathcal{T}_p as well as numerous “derived Planck units”. Some of the more important derived Planck units are: Planck energy E_p , Planck force F_p , Planck energy density U_p , Planck pressure \mathcal{P}_p , Planck density ρ_p , Planck voltage \mathcal{V}_p , and Planck impedance Z_p .

We have already frequently mentioned Planck length, Planck time and Planck mass. However, it will be shown that the properties of spacetime are most naturally expressed in Planck units. Going further with this thought, Planck units are based on the properties of spacetime. We can actually learn about the properties of spacetime by examining a particular unit when it is expressed in Planck units.

The table below gives the conversions for these Planck units. Also, this table is repeated at the end of the book in chapter 15 for easy reference. Any serious analysis of the spacetime model of the universe will make frequent reference to this table.

Planck Units

L_p = Planck length	$L_p = cT_p = \sqrt{\hbar G/c^3}$	$1.616 \times 10^{-35} \text{ m}$
m_p = Planck mass	$m_p = \sqrt{\hbar c/G}$	$2.176 \times 10^{-8} \text{ kg}$
T_p = Planck time	$T_p = L_p/c = \sqrt{\hbar G/c^5}$	$5.391 \times 10^{-44} \text{ s}$
q_p = Planck charge	$q_p = \sqrt{4\pi\epsilon_0\hbar c}$	$1.876 \times 10^{-18} \text{ Coulomb}$
T_p = Planck temperature	$T_p = E_p/k_B = \sqrt{\hbar c^5/Gk_B^2}$	$1.417 \times 10^{32} \text{ }^\circ\text{K}$
E_p = Planck energy	$E_p = m_p c^2 = \sqrt{\hbar c^5/G}$	$1.956 \times 10^9 \text{ J}$
ω_p = Planck angular frequency	$\omega_p = 1/T_p = \sqrt{c^5/\hbar G}$	$1.855 \times 10^{43} \text{ s}^{-1}$
F_p = Planck force	$F_p = E_p/L_p = c^4/G$	$1.210 \times 10^{44} \text{ N}$
P_p = Planck power	$P_p = E_p/T_p = c^5/G$	$3.628 \times 10^{52} \text{ w}$
U_p = Planck energy density	$U_p = E_p/L_p^3 = c^7/\hbar G^2$	$4.636 \times 10^{113} \text{ J/m}^3$
\mathbb{P}_p = Planck pressure	$\mathbb{P}_p = F_p/L_p^2 = c^7/\hbar G^2$	$4.636 \times 10^{113} \text{ N/m}^2 (= U_p)$
ρ_p = Planck density	$\rho_p = m_p/L_p^3 = c^5/\hbar G^2$	$5.155 \times 10^{96} \text{ kg/m}^3$
A_p = Planck acceleration	$A_p = c/T_p = \sqrt{c^7/\hbar G}$	$5.575 \times 10^{51} \text{ m/s}^2$
V_p = Planck voltage	$V_p = E_p/q_p = \sqrt{c^4/4\pi\epsilon_0 G}$	$1.043 \times 10^{27} \text{ V}$
\mathbb{E}_p = Planck electric field	$\mathbb{E}_p = F_p/q_p = \sqrt{c^7/4\pi\epsilon_0\hbar G^2}$	$6.450 \times 10^{61} \text{ V/m}$
\mathbb{B}_p = Planck magnetic field	$\mathbb{B}_p = Z_s/q_p = \sqrt{\mu_0 c^7/4\pi\hbar G^2}$	$2.152 \times 10^{53} \text{ Tesla}$
\mathbb{I}_p = Planck current	$\mathbb{I}_p = q_p/T_p = \sqrt{4\pi\epsilon_0 c^6/G}$	$3.480 \times 10^{18} \text{ amp}$
Z_p = Planck impedance	$Z_p = \hbar/q_p^2 = 1/4\pi\epsilon_0 c$	$29.98 \text{ } \Omega$

It is often said that Planck units are the “natural units” because they are based on 5 constants of nature. However, this explanation does not do justice to the importance of Planck units. The properties of spacetime are finite. These Planck units represent the limiting values (maximum of minimum) that spacetime can support. For example, it is impossible to make a length measurement between two points more accurate than Planck length (device independent). It is also impossible to make a time measurement more accurate than Planck time. As previously explained, the spacetime field has dipole waves which are modulating the distance between two points by Planck length and modulating the rate of time (the difference between two clocks) by Planck time. Therefore, the inability to make measurements smaller than Planck length and Planck time can be considered to be due to the “noise” created by vacuum fluctuations.

One of the many insights obtained from Einstein’s field equation is that the universe has a limit to the maximum possible force that can be exerted and this limiting force is equal to

Planck force^{2,3}. (This ignores a numerical factor near 1.) The equations of general relativity deviate from Newtonian gravitational physics in strong gravity partly because of the existence of a maximum possible force which introduces nonlinearity. Therefore, general relativity and quantum mechanics agree on the significance of Planck force. If two of the same size black holes are about to merge, the force between them is Planck force. It does not matter the size of the black holes, the maximum is always Planck force.

Planck energy and Planck mass are a little harder to explain. It is easy to exceed Planck mass ($\sim 2 \times 10^{-8}$ kg) or Planck energy ($\sim 2 \times 10^9$ J), but this assumes a large number of fundamental particles. Planck energy is the maximum energy that a single quantized unit can support. A photon with \hbar of quantized angular momentum cannot have more than Planck energy. A fermion with $\frac{1}{2} \hbar$ of quantized angular momentum cannot have more mass than Planck mass. The rotar model of a fundamental particle with Planck energy would have a radius equal to Planck length and a Compton frequency equal to Planck frequency. This would form a black hole with a Schwarzschild radius $R_s \equiv Gm/c^2$ equal to Planck length. As previously explained, a photon black hole (rotating at the speed of light) has a smaller Schwarzschild radius than a non-rotating black hole. Also, the rotar model of a fundamental particle has energy propagating at the speed of light around a circle with radius \mathcal{A}_c . When scaling gravitational effects produced by a rotar, the appropriate Schwarzschild radius is $R_s \equiv Gm/c^2$ rather than $r_s = 2Gm/c^2$.

Dimensionless Planck Units: The previous Planck units quoted had dimensions. For example, Planck force is $F_p \approx 1.2 \times 10^{44}$ Newton and Planck energy is $E_p \approx 2 \times 10^9$ Joule. There is another form of Planck units that is a dimensionless ratio. For example, there are times when it is very revealing to express force or energy as a ratio relative to the largest possible force or energy. In this case we would divide the particular force or energy by Planck force or Planck energy respectively. When we are expressing force as this dimensionless ratio we will use the symbol $\underline{F} = F/F_p$. Note the underline signifying that this is dimensionless Planck units. Similarly dimensionless Planck energy \underline{E} would be the actual energy E in SI units divided by Planck energy therefore: $\underline{E} = E/E_p$. While force and energy were used as examples, the concept applies to all other units. Therefore we would have \underline{m} , $\underline{\omega}$, etc.

It is counter intuitive to mix different units in an equation. Even though we know that we are dealing with dimensionless ratios, it does not seem correct to write an equation which equates dimensionless energy to dimensionless force. However, on the level where we are reducing everything to a distortion of spacetime, there is actually a way of looking at force and energy where they are equivalent. A specific amount of energy in the form of fermions requires a specific amount of force to stabilize them. This statement might not be understandable now, but

² T. Jacobson, "Thermodynamics of Spacetime: The Einstein Equation of State." Phys.Rev. Lett. **75**, 1260 (1995)

³ G. W. Gibbons, "The Maximum Tension Principle in General Relativity." Found. Phys. **32**, 1891 (2002)
<http://arxiv.org/pdf/hep-th/0210109.pdf>

in later chapters this will become clearer. The point is that if a particular term is expressed as a dimensionless number such as 10^{-20} , then it is using 10^{-20} of the available properties of spacetime and there is a connection to another term which also is using 10^{-20} of the available properties of spacetime. We will next return to the particle properties previously being explained.

Quantum Amplitude Equalities: The strain amplitude A_β of the spacetime wave inside the rotar volume of a rotar is an important dimensionless number for a rotar that has been designated with the symbol A_β . This symbol was chosen because it is amplitude that affects the rate of time and proper volume with similarities to gravitational magnitude β . The above calculation used the substitution that $A_\beta = L_p/\lambda_c$, but there are several other ways of expressing this strain amplitude.

$$A_\beta = L_p/\lambda_c = T_p\omega_c = \sqrt{Gm^2/\hbar c} = m/m_p = E_i/E_p = \omega_c/\omega_p = \sqrt{R_s/\lambda_c} = \sqrt{P_c/P_p}$$

E_i = internal energy of a rotar (mc^2 energy)

R_s = Schwarzschild radius $R_s \equiv Gm/c^2$

P_c = circulating power $P_c = E_i \omega_c = \omega_c^2 \hbar$ (explained later)

The symbols m_p , ω_p , E_p , and P_p are Planck mass, Planck energy and Planck power. They are defined further in the table below.

To help convey the significance of this string of equalities, I will use an electron for a numerical example. The mass of an electron is: $m_e = 9.1094 \times 10^{-31}$ kg

Electron's Characteristics

$\lambda_c = \hbar/mc = c/\omega_c = 3.8616 \times 10^{-13}$ m	Compton radius (rotar radius)
$\omega_c = mc^2/\hbar = c/\lambda_c = 7.7634 \times 10^{20}$ s ⁻¹	Compton angular frequency
$E_i = mc^2 = \hbar\omega_c = 8.1871 \times 10^{-14}$ J	internal energy
$P_c = E_i \omega_c = \omega_c^2 \hbar = 6.356 \times 10^7$ w	circulating power (explained below)

Electron's Characteristics in Dimensionless Planck Units

$A_\beta = \sqrt{Gm^2/\hbar c}$	= 4.185 x 10 ⁻²³	strain amplitude
$L_p/\lambda_c = 1.616 \times 10^{-35}/3.8616 \times 10^{-13}$	= 4.185 x 10 ⁻²³	Compton radius (rotar radius)
$\omega_c T_p = \omega_c/\omega_p = 7.76 \times 10^{20}/1.855 \times 10^{43}$	= 4.185 x 10 ⁻²³	Compton frequency
$m/m_p = 9.109 \times 10^{-31}/2.176 \times 10^{-8}$	= 4.185 x 10 ⁻²³	mass
$E_i/E_p = 8.187 \times 10^{-14}/1.956 \times 10^9$	= 4.185 x 10 ⁻²³	energy
$\sqrt{R_s/\lambda_c} = (6.76 \times 10^{-58}/3.86 \times 10^{-13})^{1/2}$	= 4.185 x 10 ⁻²³	Schwarzschild radius
$\sqrt{P_c/P_p} = (6.36 \times 10^7/3.63 \times 10^{52})^{1/2}$	= 4.185 x 10 ⁻²³	circulating power
$(U_q/U_p)^{1/4} = (1.42 \times 10^{24}/4.64 \times 10^{113})^{1/4}$	= 4.185 x 10 ⁻²³	energy density
$(A_q/A_p)^{1/2} = (9.74 \times 10^6/5.58 \times 10^{51})^{1/2}$	= 4.185 x 10 ⁻²³	grav acceleration
$(g_q/A_p)^{1/3} = (4.08 \times 10^{-16}/5.58 \times 10^{51})^{1/3}$	= 4.185 x 10 ⁻²³	gravitational acceleration at λ_c

It is amazing that the dimensionless number A_β that represents the strain amplitude of a rotar is related to so many rotar properties. These include the rotar's mass, energy, Compton frequency, Schwarzschild radius, rotar radius and circulating power (defined below). These properties can also be expressed in dimensionless Planck units. As previously explained, symbols written in bold and underlined such as \underline{m} and $\underline{\lambda}_c$ will represent values expressed in dimensionless Planck units. Using this designation, A_β has the following equalities:

$$A_\beta = \underline{m} = \underline{\omega}_c = \underline{E}_i = 1/\underline{\lambda}_c = \underline{P}_c^{1/2} = \underline{A}_q^{1/2} = \underline{U}_q^{1/4} = \underline{R}_s^{1/2} \quad \text{dimensionless Planck units}$$

Each fundamental rotar has a single dimensionless number that expresses all of a rotar's unique properties. Angular momentum and charge are not unique to a specific fundamental particle. For example, an electron, muon and tauon each have their own unique values of quantum strain amplitude A_β (shown below). The values of angular momentum and charge are not unique.

$$\begin{aligned} A_\beta &= 4.18 \times 10^{-23} && \text{electron's amplitude, Planck frequency, mass, energy and inverse size} \\ A_\beta &= 8.66 \times 10^{-21} && \text{muon's amplitude, Planck frequency, mass, energy and inverse size} \\ A_\beta &= 1.46 \times 10^{-19} && \text{tauon's amplitude, Planck frequency, mass, energy and inverse size} \end{aligned}$$

Maximum Amplitude Rotar: Out of curiosity, let's calculate the mass of the rotar that has the maximum possible amplitude which is a quantum amplitude of $A_\beta = 1$.

$$\begin{aligned} A_\beta &= \sqrt{Gm^2/\hbar c} && \text{substitute } A_\beta = 1 \text{ and square both sides} \\ 1 &= Gm^2/\hbar c \\ m &= \sqrt{\hbar c/G} = m_p && A_\beta = 1 \text{ when the mass equals the Planck mass } (m_p). \end{aligned}$$

Therefore, the proposed rotar model has Planck mass as the natural basis. However, $A_\beta = 1$ not only represents a rotar with Planck mass, but because of the above equalities, $A_\beta = 1$ also represents a rotar with Planck angular frequency ω_p , and a rotar with a rotar radius equal to Planck length l_p . Going even further, a rotar with $A_\beta = 1$ also has a circulating power equaling Planck power P_p , an internal energy equal to Planck energy E_p , and an energy density equal to Planck energy density U_p . If there were such a thing as a "Planck rotar", this proposed rotar model would have the Planck rotar as the natural basis.

Circulating Power: A rotar's internal energy is confined energy made of dipole waves in spacetime that are moving at the speed of light. Therefore, there is a specific amount of circulating power in any rotar. The circulating power (P_c) in an isolated rotar is the rotar's internal energy E_i times the rotar's Compton angular frequency ω_c . This is the momentary power that would leave the rotar volume if the circulating wave (rotating dipole) dissipated by all points in the wave traveling in straight lines. The wave would expand beyond the rotar radius in a time equal to $1/\omega_c$.

$$P_c = E_i \omega_c = \omega_c^2 \hbar = m^2 c^4 / \hbar = E_i^2 / \hbar \quad P_c = \text{circulating power}$$

An isolated electron's circulating power is about 63.56 million watts. $(8.2 \times 10^{-14} \text{ J})^2 / \hbar$ This high circulating power can be understood when it is realized that the electron's internal energy $(8.2 \times 10^{-14} \text{ J})$ is multiplied by the electron's Compton angular frequency $(7.8 \times 10^{20} \text{ s}^{-1})$. The concept of circulating power will be important when we consider forces. For future reference, we will calculate the value of circulating power in Dimensionless Planck units by dividing conventional power by Planck power ($P_p = c^5/G$).

$$\underline{P}_c = P_c/P_p = (m^2 c^4 / \hbar)(G/c^5) = Gm^2/\hbar c \quad \underline{P}_c = \text{circulating power in Planck units}$$

Characteristics of an Electron: It is very useful to have a single table of the rotar characteristics and standard characteristics of an electron to test concepts. Therefore, the following table is provided here and in chapter 15 which is a compilation of equations and definitions.

Constants of an Electron	
$A_\beta = 4.1854 \times 10^{-23}$	= electron's strain amplitude
$\lambda_c = 3.8616 \times 10^{-13} \text{ m}$	= electron's Compton radius (rotar radius)
$\omega_c = 7.7634 \times 10^{20} \text{ s}^{-1}$	= electron's Compton angular frequency
$\nu_c = 1.2356 \times 10^{20} \text{ Hz}$	= electron's Compton frequency
$P_c = 6.356 \times 10^7 \text{ w}$	= electron's circulating power
$F_m = 0.21201 \text{ N}$	= electron's maximum force at distance of λ_c
$R_s = 6.7635 \times 10^{-58} \text{ m}$	= electron's Schwarzschild radius $R_s \equiv Gm/c^2$
$U = E_i/\lambda_c^3 = 1.42 \times 10^{24} \text{ J/m}^3$	= electron's energy density (cubic)
$U = (3/4\pi)E_i/\lambda_c^3 = 3.397 \times 10^{23} \text{ J/m}^3$	= electron's energy density (spherical)
$V = \lambda_c^3 = 5.7584 \times 10^{-38} \text{ m}^3$	= electron's rotar volume (cubic)
$A_g = 9.7413 \times 10^6 \text{ m/s}^2$	= electron's grav acceleration at center of rotar volume
$m_e = 9.1094 \times 10^{-31} \text{ kg}$	= electron's mass
$E_i = 8.1871 \times 10^{-14} \text{ J}$	= electron's energy
$e = 1.6022 \times 10^{-19} \text{ Coulomb}$	= electron's charge

Forces

We are next going to examine the strong force, the electromagnetic force and the gravitational force between two of the same rotars. The only force exerted by dipole waves in spacetime is the relativistic force ($F_r = P_r/c$). Therefore, we would expect that the force between particles should be a simple function of the rotar's circulating power. Initially, we will examine the forces exerted under the simplest condition for the rotar model of fundamental particles. The forces will be calculated between two of the same rotars separated by the rotar's natural unit of length – separated by \mathcal{A}_c . This is an unrealistic assumption for an actual experiment because a separation distance of \mathcal{A}_c corresponds to the point where quantum mechanics becomes dominant. It is impossible to precisely hold this separation distance. However, this important separation distance can be rationalized as merely an extrapolation from longer distance to a separation distance of \mathcal{A}_c .

In later chapters we will examine other distances, but the spacetime based rotar model presented thus far only is able to define the characteristics at a distance equal to the rotar radius \mathcal{A}_c . It is reasonable that if the spacetime based model is correct, then the simplest separation distance would be \mathcal{A}_c , the rotar's natural unit of length. Calculations at arbitrary distance involve an additional consideration of how waves in the external volume of a rotar fall off with distance. Initially limiting the separation distance just to \mathcal{A}_c (the rotar radius) involves the fewest assumptions. We know the strain amplitude of a rotar at this distance is: $A = A_\beta = T_p \omega_c = L_p / \mathcal{A}_c$. Therefore, this fundamental test condition will be used exclusively for the remainder of this chapter.

Theoretical Maximum Force: We will begin this examination of forces by asking a simple question. Is there a theoretical maximum force that a fundamental rotar with a known energy can generate at a particular distance? This question considers only the energy of a rotar and the distance. Other characteristics of the rotar will determine whether the rotar can actually interact and achieve anything close to the theoretical maximum force. At this early stage of development of forces we are dealing with the relativistic force in its simplest form. Since the relativistic force is only repulsive, it follows that a simplified model of the theoretical maximum force will describe a repulsive force. Later the model will be expanded and eventually yield the strong force which is an attracting force with asymptotic freedom characteristics. For now we are merely logically following the narrow path associated with the starting assumption.

The standard model describes the strong force (the strong interaction) as the exchange of gluons between quarks. There are subtleties in this exchange that are explained by invoking color charge and quantum chromodynamics (QCD). We are starting from first principles and so far know nothing about gluons, etc. We only know the simplified rotar model presented so far. We have a dipole wave in spacetime that possesses quantized angular momentum and a specific amount of energy. The dipole wave is propagating at the speed of light in a closed loop one

wavelength in circumference. This concept defines a specific rotational frequency and a specific amount of circulating power.

Maximum Force from Circulating Power: We will first use the concept of circulating power P_c of a fundamental rotar. Previously; it was found that the rotar model implies that every rotar can be considered to have a circulating power equal to:

$$P_c = E_i \omega_c = \omega_c^2 \hbar = \hbar c^2 / \lambda_c^2 \quad P_c = \text{circulating power of a rotar inside } \lambda_c$$

Previously we concluded that the starting assumption (the universe is only spacetime) implied that there is only one truly fundamental force – the relativistic force $F_r = P_r/c$. The strongest force that a fundamental rotar can exert at distance λ_c will occur if all of a rotar’s circulating power is deflected (set $P_r = P_c$). This presumes two of the same rotars, each with internal energy of E_i . Only quarks are actually capable of exerting something close to this maximum force, but it is still possible to calculate the theoretical maximum force that any rotar can generate if all the rotar’s circulating power is deflected. This is equivalent to saying that some rotars cannot deflect all the circulating power at a separation distance of λ_c , but it is possible to calculate the maximum force that would be generated if all the circulating power was deflected. We take the relativistic force equation $F_r = P_r/c$ and set $F_r = F_m$ and $P_r = P_c = \hbar c^2 / \lambda_c^2$.

$$F_m = P_c/c = E_i / \lambda_c = m^2 c^3 / \hbar = \omega_c^2 \hbar / c = A \beta^2 F_p \quad F_m = \text{rotar's maximum force at distance } \lambda_c$$

Later we will compare this value of the maximum possible force at λ_c to the electrostatic force at this distance to see if it is reasonable. However, first I want to explain a qualification on the physical interpretation of this maximum force $F_m = E_i^2 / \hbar c$. This equation represents the maximum force that can be exerted if two of the same rotars are held stationary at a distance equal to their rotar radius λ_c . If two rotars are colliding at relativistic velocity, then a greater force can be generated because kinetic energy is converted to increase the rotar’s internal energy E_i at the instant of collision. This momentarily increases the internal energy E_i of the colliding rotars which also momentarily increases F_m , ω_c and P_c , and decreases the rotar radius λ_c .

For example, an electron with relativistic velocity equal to 50 GeV can temporarily convert this kinetic energy into internal energy in a collision raising the electron’s internal energy from ~ 0.5 MeV to 50 GeV, a factor of about 100,000. This would momentarily decrease the electron’s rotar radius by a factor of 10^5 from 3.86×10^{-13} m to 3.86×10^{-18} m. This would also increase both the circulating power and the maximum force by a factor of 10^{10} . Therefore, an electron undergoing a collision can exhibit a force greater than the theoretical maximum force calculated for an isolated electron (no collision). Trying to remove a quark from a hadron also changes the internal energy of the quark and can affect the binding force. This will be discussed later.

Maximum Force from the Wave-Amplitude Equation: We will also calculate the maximum force using the wave-amplitude equation: $F = A^2 \omega^2 Z \mathcal{A} / c$. We have previously used a similar equation to calculate the energy in a rotar. For that calculation we made the following substitutions: $A = A_\beta = L_p / \lambda_c$; $\omega = \omega_c = c / \lambda_c$; and $V = k \lambda_c^3$. This time we have an area term \mathcal{A} . Since the presumption is that we have two of the same rotars separated by λ_c , this means that the interaction area would be a constant times λ_c^2 . ($\mathcal{A} = k \lambda_c^2$). There are many other numerical factors close to 1 that have been previously ignored, so we will also ignore this constant.

$$F = A^2 \omega^2 Z \mathcal{A} / c \quad \text{set: } A = A_\beta = L_p / \lambda_c; \quad \omega = \omega_c = c / \lambda_c; \quad Z = Z_s = c^3 / G; \quad \mathcal{A} = \lambda_c^2$$

$$F_m = \left(\frac{L_p}{\lambda_c} \right)^2 \left(\frac{c}{\lambda_c} \right)^2 \left(\frac{c^3}{G} \right) \left(\frac{\lambda_c^2}{c} \right) \quad \text{set: } L_p^2 = \hbar G / c^3;$$

$$F_m = \frac{\hbar c}{\lambda_c^2} = \frac{E_i^2}{\hbar c} = \frac{\hbar \omega_c^2}{c} = \frac{m^2 c^3}{\hbar} = A_\beta^2 F_p$$

Once more, I want to emphasize that this calculation assumed amplitude $A = A_\beta$ and distance $r = \lambda_c$ which was implied when we set area $\mathcal{A} = \lambda_c^2$ with the constant ignored. This is mentioned because in chapter 8 we will extend both the electrostatic force and the gravitational force to arbitrary distance. Also in a later chapter, two competing versions of the maximum force will be shown to make up the more complex strong force between quarks. The condition known as asymptotic freedom will be analyzed and shown to result from competing maximum forces which reach equilibrium. However, a slight displacement from this equilibrium separation distance results in a net restoring force which increases with displacement and can almost reach the maximum force.

Coulomb Force: To evaluate the maximum force it is necessary to compare it to the Coulomb force (electromagnetic force) that would exist between two electrically charged rotars at the separation distance of $r = \lambda_c$. There are actually two possible values of charge q that are interesting and we will evaluate both of them. One obvious choice is to use elementary charge e . However, the other interesting value is Planck charge $q_p = \sqrt{4\pi\epsilon_0 \hbar c} = e / \sqrt{\alpha} \approx 1.88 \times 10^{-18}$ Coulomb which is about 11.7 times larger than elementary charge e . Planck charge is derived from ϵ_0 , the permittivity of free space and is the best choice of a unit of charge when we are comparing forces because Planck charge avoids dealing with the fine structure constant $\alpha = e^2 / 4\pi\epsilon_0 \hbar c \approx 1/137$. The fine structure constant α is known to be the coupling constant relating to the strength of the electromagnetic interaction between a particle with charge e and a photon. By choosing Planck charge we are setting this coupling constant equal to 1. By eliminating the coupling constant α , we would expect that at separation distance of $r = \lambda_c$ the electromagnetic force should be equal to the maximum force if the particle and force models described thus far are correct. The Coulomb force equation $F = q^2 / 4\pi\epsilon_0 \hbar c$ will be used for this critical test. We will use the force symbol F_E to specify that we are representing

the electrostatic force between two Planck charges. Therefore we will make the following substitutions into the Coulomb force equation:

$$F = \frac{q^2}{4\pi\epsilon_0 r^2} \quad \text{set: } F = F_E, \quad r = \lambda_c \quad q = q_p = \sqrt{4\pi\epsilon_0 \hbar c} \quad \text{and} \quad F_m = \hbar c / \lambda_c^2$$

$$F_E = \frac{q_p^2}{4\pi\epsilon_0 \lambda_c^2} = \frac{\hbar c}{\lambda_c^2} = F_m$$

Therefore, this is a spectacular success. When we use Planck charge to set the coupling constant equal to 1 and $r = \lambda_c$, then we obtain the equation that the electrostatic force equals the maximum force $F_E = F_m$. The fact that we obtain answers which imply Planck charge should not be interpreted that somehow Planck charge is a realistic possibility of the charge of a rotar. In the next chapter it will be shown that the wave characteristics which would be required to achieve Planck charge would also make an unstable rotar which would radiate away all its energy in a time period of $1/\omega_c$ which for an electron is only about 10^{-20} s. Planck charge is a theoretical idea that implies all of a particle's energy is transferred to its external field.

Any time in the rest of the book that we are representing the electrostatic force generated by particles with elementary charge e , we will use the symbol F_e . The following is the first of these calculations.

$$F = \frac{q^2}{4\pi\epsilon_0 r^2} \quad \text{set: } F = F_e \quad r = \lambda_c; \quad q = e \quad \alpha = e^2/4\pi\epsilon_0 \hbar c \quad \text{and} \quad F_m = \hbar c / \lambda_c^2$$

$$F_e = \frac{e^2}{4\pi\epsilon_0 \lambda_c^2} = \frac{\alpha \hbar c}{\lambda_c^2} = \alpha F_m$$

Therefore, even using elementary charge e we obtain a connection between the electrostatic force and the maximum force, but this electrostatic force is diminished by the fine structure constant $\alpha \approx 1/137$. The fine structure constant has never been able to be mathematically derived from first principles. It has been the source of mystery for generations of theoretical physicists. Therefore, we also will merely accept this mysterious number as a coupling constant of unknown origin.

Gravity

Now for the big question: Can we develop the force of gravity from first principles using the rotar model? Thus far we have discussed the fundamental dipole wave that can exist in the spacetime field. If we are going to be able to explain all the forces of nature with only dipole waves in spacetime, we have to examine the possibility that under some circumstances a dipole wave in spacetime may not be perfectly sinusoidal. Once again the starting assumption that the universe is only spacetime serves as a wonderful restriction. It keeps us focused on examining only the most basic properties of spacetime. The properties of the spacetime field are finite. There is a maximum force, a maximum frequency and a maximum strain amplitude for dipole waves in spacetime. These maximums can be considered as boundary conditions imposed on dipole waves in spacetime. Such boundary conditions should produce nonlinear effects.

If the universe is only spacetime, we do not have many possible explanations for gravity. In fact, the only plausible possibility is that the spacetime field is a nonlinear medium for dipole waves in spacetime.

Optical Kerr Effect: I see a similarity between gravity and a nonlinear optical effect called the optical Kerr effect. All transparent materials have a maximum intensity limit which is a boundary condition. Therefore, when light passes through any transparent material, a nonlinear effect occurs. Even for wavelengths for which the material is transparent, there is a limit to the maximum intensity (maximum electric field strength) that can propagate through the material. This limit results in nonlinearity (distortion) even for intensities that are far below this limit. The oscillating electric field of the light produces a non-oscillating nonlinear effect which changes the index of refraction of the transparent material. This nonlinear effect reduces the speed of light in the transparent material in addition to the normal reduction due to the material's index of refraction at zero intensity. An expression of the optical Kerr effect is given by the following simplified equation that ignores higher order terms.

$$n_k \approx n_o + k_1 E_\omega^2 \quad \text{simplified optical Kerr effect equation}$$

n_k = the index of refraction which includes the optical Kerr effect contribution

n_o = the normal index of refraction at zero intensity

k_1 = a nonlinear constant that depends on the transparent material

E_ω = electric field strength at frequency ω

This means that the speed of light in any transparent material has a fundamental term (n_o) and a second order term ($k_1 E_\omega^2$). The second order term depends on the square of the alternating electric field produced by the light.

Even sunlight passing through a window produces a slight nonlinear effect in the glass. When a high peak power pulse of laser light is focused in a transparent material, the light can reach oscillating electric field strength where the optical Kerr effect increases the index of refraction to the extent that the laser beam is further concentrated and confined to a small filament. This confinement can be so great that the beam is not allowed to diverge. This effect is easily seen in glass and other solids, but it has even been demonstrated in air.

While the analogy between the optical Kerr effect and gravity is far from perfect, the point is that homogeneous materials like glass or air exhibit a nonlinearity that scales proportional to the square of the electric field strength E^2 where E can be considered a wave amplitude. This squaring produces an effect that is always positive. In the optical Kerr effect, the index of refraction always increases.

This nonlinearity in transparent materials is associated with the fact that any transparent material has a maximum electric field strength limitation. Exceeding this maximum electric field strength will physically damage the transparent material. The most extreme form of damage is ionization of the atoms, but molecules can be decomposed at electric field strength less than the ionization threshold. This maximum field strength introduces a nonlinearity that scales with E^2 and higher powers of E . However, the higher powers only become significant as the limiting intensity is approached. The spacetime field is also a medium that transmits waves. Is there any evidence that the spacetime field is a nonlinear medium?

Gravity – A Nonlinear Effect: We need to consider the force of gravity between two of the same rotars at distance λ_c . If the universe is only spacetime and if there is only one truly fundamental force (the relativistic force) then dipole waves in spacetime must also cause gravity. We are therefore looking for a mechanism whereby a rotar’s circulating power can be converted into a force that has only one polarity and is vastly weaker than the other forces. There is really only one reasonable choice. Gravity must be the result of the spacetime field being a nonlinear medium for dipole waves in spacetime.

Fifth Starting Assumption: **The spacetime field is a nonlinear medium for dipole waves in spacetime. This nonlinearity ultimately produces gravity.**

The gravitational force must be the result of this nonlinearity while the other forces are a direct (linear) function of circulating power. Dipole waves in spacetime have a theoretical maximum amplitude of $A_\beta = 1$. This means that dipole waves in spacetime should also exhibit a nonlinearity that scales with A_β^2 even when $A_\beta \ll 1$. The strain produced by dipole waves in spacetime must have a linear term and a nonlinear term.

$$\text{Strain} = A_\beta \sin\omega t + (A_\beta \sin\omega t)^2 = A_\beta \sin\omega t - \frac{1}{2} A_\beta^2 \cos 2\omega t + \frac{1}{2} A_\beta^2 \quad (\text{bold for emphasis})$$

The linear term is $(A_\beta \sin \omega t)$ and the nonlinear term is $(A_\beta \sin \omega t)^2$. There are also higher order nonlinear terms (greater than square) but these can be ignored because A_β is a number very close to zero and any higher powers (cube or above) of this are insignificant. The nonlinear term has been further expanded into a weak oscillating term $(A_\beta^2 \cos 2\omega t)$ and a non-oscillating term that is always positive ($\frac{1}{2} A_\beta^2$). It is proposed that the strain in spacetime produced by the non-oscillating term (A_β^2 at distance λ_c) is responsible for the general relativistic curvature of spacetime which results in gravity.

An analysis in chapter 8 will show how the nonlinear term $(A_\beta \sin \omega t)^2$ leads to both gravitational attraction as well as the gravitational effect on time and distance. In this chapter we are going to start with a simplified analysis that concentrates only on the magnitude of the force exerted by the gravity of a rotar. With this limitation we again are developing an over-simplified repulsive force with the correct magnitude of gravity. This will later be improved into an attracting force that also exhibits the spatial and temporal properties of gravity. The actual force of gravity will be shown in chapter 8 to result from a strain in spacetime that produces an unbalanced force on opposite sides of a rotar.

It is easy to demonstrate that the nonlinearity of the spacetime field gives the correct magnitude of the gravitational force at distance λ_c using a calculation that is somewhat oversimplified. Previously we were using $A = A_\beta$ as the substitution of the wave amplitude for the maximum force and other rotar properties. To prove that gravity is caused by the nonlinearity of spacetime, we will now square the strain amplitude term and make the nonlinear amplitude substitution $A = A_\beta^2$ into the force equation: $F = kA^2 \omega^2 Z_s A / c$.

$$F = kA^2 \omega^2 Z_s A / c \quad \text{for gravity set: } A = A_\beta^2 = L_p^2 / \lambda_c^2, \quad \omega = \omega_c, \quad Z = Z_s = c^3 / G, \quad \mathcal{A} = k \lambda_c^2$$

$$F_g = A_\beta^4 \omega_c^2 Z_s \mathcal{A} / c = \left(\frac{L_p^4}{\lambda_c^4} \right) \left(\frac{c^2}{\lambda_c^2} \right) \left(\frac{c^3}{G} \right) \left(\frac{\lambda_c^2}{c} \right) = \left(\frac{\hbar^2 G^2}{c^6} \right) \left(\frac{m^2 c^2}{\hbar^2} \right) \left(\frac{1}{\lambda_c^2} \right) \left(\frac{c^4}{G} \right)$$

$$F_g = \frac{Gm^2}{\lambda_c^2} \quad \text{magnitude of the gravitational force between 2 particles of mass } m \text{ at distance } \lambda_c$$

Even though this is oversimplified, I find this calculation very exciting! We obtain the Newtonian gravitational force equation starting with rotating dipole waves in spacetime. It was not necessary to make an analogy to acceleration. This particular calculation was for two of the same rotars at a separation distance of λ_c , but in chapter 8 we will be able to broaden this to the more general case of any mass/energy at any distance. Furthermore, the model will be improved and result in this being an attracting force. To my knowledge, this is the first time that the gravitational force has ever been calculated from conceptually understandable first principles. There were no vague analogies to restraining a mass from following a geodesic.

This implies that gravity is really a force and not the result of the geometry of spacetime. Static curved spacetime is the result of dynamic (oscillating) curved spacetime exhibiting a nonlinear

effect. In chapter 4 we described how the quantum mechanical model of the spacetime field possesses elasticity, impedance, energy density, etc. Introducing matter (dipole waves with quantized angular momentum) into this homogeneous medium produces distortion which has both a linear and a nonlinear component. Gravity is the nonlinear component. From the above calculation it is not hard to see that eventually we will obtain the Newtonian equation: $F = Gm_1m_2/r^2$. Even though this is a successful plausibility calculation, in chapter 8 it will be shown to be an oversimplification that gets the magnitude correct but the vector wrong. Additional steps will be introduced to obtain the complete picture. It should be recognized that for single particles the Newtonian gravitational equation can be considered almost exact. However, there are also small nonlinearities which are being ignored in these simple calculations. General relativity differs from Newtonian gravity because general relativity incorporates nonlinearities including a maximum possible force (Planck force). While this book does not carry this model to the strong gravity limit, it appears that a mature model incorporating nonlinear terms would be compatible with general relativity. In fact, chapters 8 and 10 discuss subtleties that go further than general relativity.

Review: We have just calculated a simplified version of Newton's gravitational equation from a set of starting assumptions. The steps that brought us to this point will be briefly reviewed.

The key assumptions are:

- 1) The universe is only spacetime.
- 2) Dipole waves in spacetime are permitted by quantum mechanics provided that the displacement of spacetime does not exceed the Planck length/time limitation.
- 3) Energy in any form is fundamentally made of dipole waves in spacetime propagating at the speed of light.
- 4) There is only one fundamental force: the relativistic force. This force occurs when waves in spacetime, propagating at the speed of light, are deflected.
- 5) Fundamental particles are dipole waves in spacetime that form a rotating dipole, one wavelength in circumference that possesses circulating power.
- 6) The spacetime field is a nonlinear medium for dipole waves in spacetime. This nonlinearity ultimately produces gravity.

Waves in the spacetime field are like sound waves propagating in the medium of the spacetime field. Spacetime has an impedance ($Z_s = c^3/G$) and the force generated by deflecting waves in spacetime is: $F = A^2\omega^2Z_s\mathcal{A}/c$ where A is amplitude and \mathcal{A} is area. Assumption #6 says that the spacetime field is a nonlinear medium. This nonlinear effect can be considered the source of a new nonlinear wave that has strain amplitude that is the square of the amplitude of the fundamental wave amplitude: $A_{\beta^2} = A_{\beta g} = L_p^2/\lambda_c^2$. Inserting this amplitude into the force equation above yields $F_g = Gm^2/\lambda_c^2$ which is a simplified version of Newton's gravitational equation that assumes two of the same mass particles at distance λ_c (dimensionless constants near 1 ignored).

Connection Between the Forces and Circulating Power: If the forces of nature are caused by the interaction of waves in spacetime, then there should be a simple relationship between the force and the circulating power (P_c). I previously proposed that there is only one truly fundamental force in nature – the relativistic force ($F_r = P_r/c$). This is the repulsive force exerted when relativistic power (power propagating at the speed of light) is “deflected” which includes absorbed and reflected. For this to appear to be an attracting force this interaction must include pressure (repulsive force) exerted by vacuum energy. This is discussed in chapter 8. However, in all cases a force generated by a rotar must be related to both the circulating power and the rotar radius of the rotar. Furthermore, since gravity is the result of nonlinearity, we would expect that the gravitational force would be a function of P_c^2 while the other forces would be a linear function of P_c .

We are therefore going to perform a critical test of the rotar model and the concept of a single fundamental force. There is no single rotar that exhibits all three of the following properties: elementary charge, the strong force and gravity. Quarks and the charged leptons only exhibit 2 of the 3 properties. However, it is possible to calculate the magnitude of these three forces as if they were possessed by a single pair of the same rotars separated by a distance equal to their rotar radius. We will also be assuming the hypothetical case of two particles with Planck charge in some of the following calculations.

This critical test will examine whether there is an easy to understand relationship between the magnitudes of the forces (F_m, F_E, F_e, F_g) and the circulating power P_c of the rotar causing the force. This comparison will be done using the natural Planck units of force and power (bold and underlined indicates Dimensionless Planck units – $\underline{F}_m, \underline{F}_{E_2}, \underline{F}_{e_2}, \underline{F}_g$, and \underline{P}_c). Initially, all comparisons will be made at the rotar’s natural unit of length, its rotar radius $\lambda_c = c/\omega_c = \hbar/mc$. This is the only distance that we know the circulating power. Substitutions that will be used:

$$r = \lambda_c = \frac{\hbar}{mc}; \quad F_m = \left(\frac{m^2 c^3}{\hbar}\right); \quad F_p = \frac{c^4}{G}; \quad P_c = \left(\frac{m^2 c^4}{\hbar}\right); \quad P_p = \frac{c^5}{G}; \quad \frac{q_p^2}{4\pi\epsilon_0} = \hbar c, \quad \frac{e^2}{4\pi\epsilon_0} = \alpha\hbar c,$$

$$\underline{F}_g = \frac{F_g}{F_p} = \left(\frac{Gm^2}{\lambda_c^2}\right) \left(\frac{G}{c^4}\right) = Gm^2 \left(\frac{m^2 c^2}{\hbar^2}\right) \left(\frac{G}{c^4}\right) = \left(\frac{G m^2}{\hbar c}\right)^2$$

$$\underline{F}_m = \frac{F_m}{F_p} = \left(\frac{m^2 c^3}{\hbar}\right) \left(\frac{G}{c^4}\right) = \frac{Gm^2}{\hbar c}$$

$$\underline{F}_E = \frac{F_E}{F_p} = \left(\frac{q_p^2}{4\pi\epsilon_0\lambda_c^2}\right) \left(\frac{G}{c^4}\right) = (\hbar c) \left(\frac{mc}{\hbar}\right)^2 \left(\frac{G}{c^4}\right) = \frac{Gm^2}{\hbar c}$$

$$\underline{F}_e = \frac{F_e}{F_p} = \left(\frac{e^2}{4\pi\epsilon_0\lambda_c^2}\right) \left(\frac{G}{c^4}\right) = (\alpha\hbar c) \left(\frac{mc}{\hbar}\right)^2 \left(\frac{G}{c^4}\right) = \alpha \left(\frac{Gm^2}{\hbar c}\right)$$

$$\underline{P}_c = \frac{P_c}{P_p} = \left(\frac{m^2 c^4}{\hbar}\right) \left(\frac{G}{c^5}\right) = \frac{Gm^2}{\hbar c}$$

Since all of these are related to $Gm^2/\hbar c$, we obtain simple relationships between forces and circulating power when we are dealing with two of the same rotars with charge e or q_p and separated by a distance λ_c . Recall that the concept of a single relativistic force says that there should be an easy to understand relationship between force and circulating power.

$$\begin{aligned} \underline{F}_m &= \underline{P}_c & \underline{F}_m &= \text{maximum force in dimensionless Planck units (closely related to the strong force)} \\ \underline{F}_E &= \underline{P}_c & \underline{F}_E &= \text{electromagnetic force in dimensionless Planck units where } q = q_p \text{ (Planck charge)} \\ \underline{F}_e &= \alpha \underline{P}_c & \underline{F}_e &= \text{electromagnetic force in dimensionless Planck units where } q = e \text{ (elementary charge)} \\ \underline{F}_g &= \underline{P}_c^2 & \underline{F}_g &= \text{gravitational force in dimensionless Planck units} \end{aligned}$$

This is a spectacular success that strongly supports the spacetime based model of forces. This simplification of relationships occurs at the spacetime based model's fundamental unit of length (the reduced Compton wavelength). The maximum force deflects all of the circulating power ($\underline{F}_m = \underline{P}_c$). The electromagnetic force also deflects all the circulating power if we assume Planck charge $\underline{F}_E = \underline{P}_c$ but elementary charge e only deflects about $1/137$ of the circulating power and is therefore about 137 times weaker ($\underline{F}_e = \alpha \underline{P}_c$). However, forces \underline{F}_m , \underline{F}_E and \underline{F}_e are similar because they all scale linearly with circulating power (scale with \underline{P}_c^1). Gravity is different because it is the result of a nonlinear effect and scales proportional to \underline{P}_c^2 . When circulating power is expressed in dimensionless Planck units it is always a dimensionless number close to zero. Therefore squaring this number produces a number even closer to zero. The weakness of gravity compared to the other forces is due to the difference between \underline{P}_c and \underline{P}_c^2 . The analysis of gravity will continue in chapter 8, but gravity is the result of the spacetime field being a nonlinear medium that scales with amplitude squared which in turn results in a \underline{P}_c^2 scaling of the gravitational force.

We can also relate the rotar's internal energy \underline{E}_i , energy density \underline{U}_q , Schwarzschild radius \underline{R}_s , reduced Compton wavelength $\underline{\lambda}_c$ and strain amplitude A_β to the forces between two of the same rotars separated by distance λ_c when terms are expressed in dimensionless Planck units. Again we show the relationship to $Gm^2/\hbar c$.

$$\begin{aligned} \underline{E}_i &= E_i/E_p = (mc^2) \sqrt{\frac{G}{\hbar c^5}} = \sqrt{\frac{Gm^2}{\hbar c}} \\ \underline{U}_q &= U_q/U_p = \left(\frac{m^4 c^5}{\hbar^3}\right) \left(\frac{\hbar G^2}{c^7}\right) = \left(\frac{Gm^2}{\hbar c}\right)^2 \\ \underline{R}_s &= R_s/L_p = \left(\frac{Gm}{c^2}\right) \sqrt{\frac{c^3}{\hbar G}} = \sqrt{\frac{Gm^2}{\hbar c}} \\ \underline{\lambda}_c &= \lambda_c/L_p = \left(\frac{\hbar}{mc}\right) \sqrt{\frac{c^3}{\hbar G}} = \sqrt{\frac{\hbar c}{Gm^2}} \\ A_\beta &= L_p/\lambda_c = \sqrt{\frac{\hbar G}{c^3}} \left(\frac{mc}{\hbar}\right) = \sqrt{\frac{Gm^2}{\hbar c}} \end{aligned}$$

Combining all of these we obtain:

$$\underline{F}_g = \underline{F}_m^2 = \underline{F}_E^2 = (\underline{F}_e/\alpha)^2 = \underline{P}_c^2 = \underline{E}_i^4 = \underline{U}_q = \underline{R}_s^4 = 1/\underline{\lambda}_c^4 = A_\beta^4$$

This is one of the most important findings in this book. It is a series of equalities that can be rewritten as 54 individual equations. The simplicity of this series of equations is jaw dropping. It shows how the gravitational force is closely related to not only the maximum force and the electromagnetic force but also to a rotar's energy, circulating power, energy density, Schwarzschild radius, Compton wavelength and strain amplitude. It will be shown later that the strong force is also related to these forces.

Just to help internalize these relationships, we will use two electrons separated by $\lambda_c = 3.86 \times 10^{-13}$ meters as illustration. All the other values are for electrons expressed in dimensionless Planck units. Readers are invited to substitute the following values of \underline{F}_m , \underline{F}_e , \underline{F}_g , \underline{P}_c , \underline{E}_i and A_β into the above equations.

$$\begin{aligned} \underline{F}_g &= F_g/F_p = (Gm^2/\lambda_c^2)/(c^4/G) &&= 3.07 \times 10^{-90} \\ \underline{F}_m &= F_s/F_p = (\hbar c/\lambda_c^2)/(c^4/G) &&= 1.75 \times 10^{-45} \\ \underline{F}_e &= F_e/F_p = (e^2/4\pi\epsilon_0\lambda_c^2)/(c^4/G) &&= 1.28 \times 10^{-47} \\ \underline{P}_c &= P_c/P_p = (\hbar c^2/\lambda_c^2)/(c^5/G) &&= 1.75 \times 10^{-45} \\ \underline{E}_i &= E_i/E_p = (mc^2)(G/\hbar c^5)^{1/2} &&= 4.19 \times 10^{-23} \\ \underline{U}_q &= U_q/U_p = (m^4 c^5/\hbar^3)(\hbar G^2/c^7) &&= 3.07 \times 10^{-90} \\ \underline{R}_s &= R_s/L_p = (Gm/c^2)(c^3/\hbar G)^{1/2} &&= 4.19 \times 10^{-23} \\ \underline{\lambda}_c &= \lambda_c/L_p = (\hbar/mc)(c^3/\hbar G)^{1/2} &&= 2.39 \times 10^{22} \\ A_\beta &= L_p/\lambda_c = (Gm^2/\hbar c)^{1/2} &&= 4.19 \times 10^{-23} \end{aligned}$$

Alternative Derivation: While the above calculations that relate the forces to circulating power is one way of deriving these equations, there is another derivation that is similar but makes some different points. It is based on the idea that we should be able to calculate the magnitude of the force exerted by waves in spacetime with amplitude A_β at frequency ω_c and separation distance λ_c using the following wave amplitude equation: $F = A^2 \omega^2 Z_s \mathcal{A}/c$. We will start by making the substitution of $A = A_\beta$ for the maximum force F_m at the separation distance equal to the rotar radius R_q of a rotar.

$$\begin{aligned} F &= A^2 \omega^2 Z_s \mathcal{A}/c \quad \text{set: } F = F_m, \quad A = A_\beta = L_p/\lambda_c = E_i/E_p = \underline{E}_i, \quad \omega = \omega_c = c/\lambda_c, \quad Z = Z_s, \quad \mathcal{A} = k\lambda_c^2 \\ F_m &= A_\beta^2 \omega_c^2 Z_s \mathcal{A}/c = \underline{E}_i^2 (c/\lambda_c)^2 (c^3/G) (\lambda_c^2/c) \\ F_m &= \underline{E}_i^2 (c^4/G) \quad \text{set: } F_m = \underline{F}_m F_p = \underline{F}_m (c^4/G) \\ \underline{F}_m &= \underline{E}_i^2 \end{aligned}$$

Note: \underline{E}_i is both particle energy in dimensionless Planck units and wave amplitude: $\underline{E}_i = L_p/\lambda_c$

When two particles with elementary charge e are separated by a distance λ_c , then the equation becomes $\underline{F}_e = a\underline{E}_i^2$. However, the fine structure constant is known to be a coupling constant. If we set charge equal to Planck charge $q = q_p$, we are setting this coupling constant equal to 1. Planck charge is based on $1/4\pi\epsilon_0$ and Planck charge is one of the “basic Planck units”. considered to be more fundamental than charge e . Designating the electrostatic force between two Planck charges (q_p) as F_E the equation becomes:

$$\underline{F}_E = \underline{E}_i^2$$

Gravity is proposed to be the result of the spacetime field being a nonlinear medium for dipole waves in spacetime. This nonlinear effect scales with wave amplitude squared and higher order terms can be ignored because they are too small. Therefore, to calculate the gravitational force F_g at this separation distance ($r = \lambda_c$) we substitute $A = A_\beta^2$ into the same force equation.

$$F = A^2 \omega^2 Z_s \mathcal{A} / c \quad \text{set: } F = F_g \text{ and } A = A_\beta^2$$

$$F_g = (A_\beta^2)^2 \omega c^2 Z_s \mathcal{A} / c = \underline{E}_i^4 (c / \lambda_c)^2 (c^3 / G) (\lambda_c^2 / c)$$

$$F_g = \underline{E}_i^4 (c^4 / G) = \underline{E}_i^4 / F_p$$

$$\underline{F}_g = \underline{E}_i^4$$

Therefore, we can combine $\underline{F}_E = \underline{E}_i^2$ and $\underline{F}_g = \underline{E}_i^4$ into the following:

$$\underline{F}_g = \underline{F}_E^2$$

This equation needs to be stated in words for full effect. Assuming a separation distance of $r = \lambda_c$ and $q = q_p$, the gravitational force equals the square of the electrostatic force when terms are stated in dimensionless Planck units. A numerical example helps to internalize this concept. Suppose we assume two particles, each with the mass of an electron $m_e \approx 9.1 \times 10^{-31}$ kg therefore $r = \lambda_c = 4.185 \times 10^{-13}$ m but with Planck charge $q_p = 1.88 \times 10^{-19}$ C Here are the values:

$$F_g = 3.7 \times 10^{-46} \text{ N} \quad \text{and} \quad \underline{F}_g = 3.07 \times 10^{-90} \text{ dimensionless Planck units}$$

$$F_E = 0.212 \text{ N} \quad \text{and} \quad \underline{F}_E = 1.75 \times 10^{-45} \text{ dimensionless Planck units}$$

$$E_i = 8.19 \times 10^{-14} \text{ J} \quad \text{and} \quad \underline{E}_i = 4.18 \times 10^{-23} \text{ dimensionless Planck units}$$

The following equation makes the same assumptions of separation distance and charge, but it does not use dimensionless Planck units.

$$\frac{F_g}{F_E} = \frac{F_E}{F_p}$$

In words, $F_g / F_E = F_E / F_p$ says that at the previously stated conditions, the ratio of the gravitational force to the electrostatic force equals the ratio of the electrostatic force to Planck force. Therefore at $r = \lambda_c$ there is a symmetry between the gravitational force, the electrostatic force and Planck force Continuing with the numerical example previously given, Planck force is:

$F_p = c^4/G = 1.2 \times 10^{44}$ N. Therefore both F_g/F_E and F_E/F_p equal the above dimensionless ratio: 1.75×10^{-45} .

The above equations used Planck charge because Planck charge has a coupling constant of 1 and this simplifies the equations. However, it is easy to convert the above equations to elementary charge e by substituting $F_E = F_e \alpha^{-1}$ where F_e designates charge e and F_E designates Planck charge. The fine structure constant is α , therefore $\alpha^{-1} \approx 137$. In chapter 8 we will extend the force analysis to arbitrary separation distance.

Gravitational Wave Calculation: We will now move on to another plausibility test that can be performed on the proposed rotar model. Recall that dipole waves in spacetime have enough similarities to gravitational waves that we can use gravitational wave equations for analysis. However, we have to ignore dimensionless constants and interpret the results appropriately for dipole waves in spacetime. There is an equation used to estimate gravitational wave amplitude (A_{gw}) at the low intensity limit where nonlinearities can be ignored. This equation can be applied to the proposed rotar model.

$$A_{gw} \approx k G \omega^2 I \varepsilon / c^4 r \quad I = \text{moment of inertia}, \quad \varepsilon = \text{asymmetry of a rotating object}$$

This simplified equation, would normally be used to estimate the gravitational wave amplitude of a rotating rod or a rotating binary star system. It contains an angular frequency term ω , the moment of inertia (I) of the rotating object, the radius r of the rotating object, and a mass asymmetry term ε . For example, a spherically symmetric object would have no asymmetry ($\varepsilon = 0$) and two equal point masses separated by $2r$ would have an asymmetry of $\varepsilon = 1$. We are going to assume that $\varepsilon \neq 0$ and the dimensionless asymmetry term ε will be included in the all-inclusive constant k . We will next convert the moment of inertia term to angular momentum.

$$A_{gw} \approx k G \omega^2 I \varepsilon / c^4 r \quad \text{set: } I = \mathcal{L} / \omega, \quad \mathcal{L} = \text{angular momentum}, \quad \varepsilon \text{ included in } k$$

$$A_{gw} = k G \omega \mathcal{L} / c^4 r$$

The reason for converting to angular momentum is because we want to apply this equation to rotars. We know the angular momentum of particles as $\mathcal{L} = \frac{1}{2} \hbar$. However, the $\frac{1}{2}$ in this angular momentum is subject to interpretation as previously discussed. The constant, whatever its value, will be included in the general constant k . The rotar model implies that $\varepsilon \neq 0$ because the dipole core of a rotar is two lobes rotating at the speed of light. We will also lump the eccentricity term ε , into the general constant k . We will now calculate the hypothetical gravitational wave amplitude for a fundamental rotar.

$A_{gw} = k G \omega \mathcal{L}/c^4 r$ substitute: $\omega = \omega_c = c/\lambda_c$; $\mathcal{L} = k\hbar$ and $r = \lambda_c$

$$A_{gw} = k G \left(\frac{c}{\lambda_c} \right) \left(\frac{\hbar}{c^4 \lambda_c} \right)$$

$$A_{gw} = k (\hbar G/c^3) / \lambda_c^2$$

$$A_{gw} = k L_p^2 / \lambda_c^2 = k A_\beta^2 \quad \text{we will ignore the constant } k$$

This is another surprising connection. We take a gravitational wave equation used in cosmology and insert a rotar's angular momentum $\frac{1}{2} \hbar$ and Compton frequency ω_c . We then determine the gravitational wave amplitude (excluding constant) that would exist at a distance of λ_c . We obtain the amplitude $A_{gw} = L_p^2 / \lambda_c^2 = A_\beta^2$. We previously determined that the nonlinearity of the spacetime field creates a non-oscillating strain amplitude equal to $A_\beta^2 = L_p^2 / \lambda_c^2$ in the rotar volume of a rotar. The same amplitude expression is obtained using an entirely different approach. Previously we employed reasoning based on the quantum mechanical properties of spacetime and also on the spacetime field being nonlinear. Now we obtain the same answer by inserting rotars properties (angular momentum and Compton frequency) into a gravitational wave equation from general relativity.

The above calculation is a success, but it also seems to imply a problem. Are all fundamental rotars continuously radiating away their energy as gravitational waves? It is true that if any arbitrary value of Compton frequency or rotar radius ($\lambda_c = c/\omega_c$) is assumed, then there would probably be radiated power both for the fundamental wave and for the nonlinear wave with amplitude L_p^2 / λ_c^2 . However, it is proposed that the fundamental rotars that do exist correspond to special frequency-amplitude combinations where a wave interaction occurs that cancels this radiated power. Even short lived fundamental rotars, such as the tauon (lifetime $\approx 3 \times 10^{-13}$ s), are long lived compared to the lifetime they would have if their circulating power was radiated. Since $P_c = E_i \omega_c$, the time required to radiate the rotar's internal energy E_i would be the inverse of the rotar's Compton frequency. For a tauon this would be: $1/\omega_c \approx 3 \times 10^{-25}$ second. The tauon's lifetime is about 10^{12} times longer than its $1/\omega_c$ time and is considered to be a "semi-stable particle".

There are an infinite number of possible frequencies, amplitudes and configurations that could hypothetically exist, but do not exist long enough to be considered fundamental rotars. The few frequencies that exist long enough to be considered fundamental rotars have some sort of wave interaction that constructively interferes to reinforce the rotating dipole rotar model and destructively interferes in a way that eliminates radiated energy. There is an analogy to the stability condition achieved by electrons in atoms. Normally an accelerated electron radiates EM radiation. However, the electrons in the ground state of atoms achieve stability by finding a combination of conditions which eliminates energy loss. The bottom line is that the few fundamental rotars that exist belong to the small group of frequency-amplitude-configuration combinations that do not radiate either the fundamental dipole wave in spacetime or the nonlinear wave associated with gravity. Even though there is not continuous loss of energy,

some of the rotar's energy does extend beyond the rotar volume. It will be shown that a particle's gravity and electric field are both the result of standing waves generated by a rotar interacting with the vacuum energy that surrounds a rotar. More will be said about this in chapter 8.

Gravitational Wave Radiation: Out of curiosity, we will calculate how long it would take for an electron to radiate away its internal energy if gravitational waves were being continuously radiated. We will assume a gravitational wave amplitude of $A_{gw} = L_p^2/\lambda_c^2$ and a radiation area equal to the electron's rotar radius squared. We will use one of the 5 wave-amplitude equations that relate the power in a wave.

$$P = A^2 \omega^2 Z \mathcal{A} \quad \text{set } A = A_{gw} = L_p^2/\lambda_c^2 \quad \omega = \omega_c = c/\lambda_c; \quad Z = c^3/G; \quad \mathcal{A} = \lambda_c^2$$

$$P = \left(\frac{L_p^2}{\lambda_c^2}\right)^2 \left(\frac{c}{\lambda_c}\right)^2 \left(\frac{c^3}{G}\right) \lambda_c^2 = \left(\frac{L_p}{\lambda_c}\right)^4 \left(\frac{c^5}{G}\right) \quad \text{set } c^5/G = P_p \text{ (Planck Power)}$$

$$P = \left(\frac{L_p}{\lambda_c}\right)^4 P_p = A\beta^4 P_p$$

To obtain a physical feel for the magnitude of this power, we will examine the gravitational wave power that would be radiated using the properties of an electron. We know that an electron must have a mechanism that cancels this radiated power.

$$P = (4.18 \times 10^{-23})^4 \times 3.63 \times 10^{52} \text{ w} = 1.1 \times 10^{-37} \text{ w}$$

$$t = E_i/P = 8.18 \times 10^{-14} \text{ J} / 1.1 \times 10^{-37} \text{ w} \quad \text{set } E_i = 8.18 \times 10^{-14} \text{ J} = \text{electron's energy}$$

$$t \approx 7 \times 10^{23} \text{ s} \approx 2 \times 10^{16} \text{ years}$$

Therefore, since the universe is 1.38×10^{10} years old, it would take more than one million times the age of the universe (2×10^{16} years) for an electron to radiate away its energy in gravitational waves. While this is a long time, it would be detectable because electrons in the early universe would have more energy (measured locally) than today's electrons. If up and down quarks radiated away power as gravitational waves, they would have radiate away all their energy in a time shorter than the age of the universe because of their much larger Compton frequency ω_c . The power radiated as gravitational waves scales with ω_c^4 .

If rotars radiated energy with amplitude equivalent to the fundamental wave amplitude ($A_f = L_p/r$) with no cancelation mechanism from vacuum energy, then the picture changes completely. If an electron radiated away its energy in a wave at its Compton frequency and its fundamental amplitude, an electron would radiate about 63 million watts and it would survive for a time of only $1/\omega_c$ ($\sim 10^{-20}$ second). This is mentioned because it is proposed that the few fundamental rotars that exist have a cancelation mechanism (discussed later) that prevents this type of energy loss. Standing waves remain in the rotar's external volume after this cancelation. Standing waves have equal power flowing in opposite directions and therefore do not transfer energy. Only traveling waves are continuously transferring energy.

Inertia: In chapter 1, we found that light circulating around a circular fiber optic loop satisfies the condition of $p = 0$ because all momentum vectors cancel. Therefore this circulating light exhibits inertia even though the light is not superimposed like the reflecting box example. For example, suppose that we accelerate a fiber optic loop in a direction parallel to the plane of the loop. Light in different parts of the loop receives different Doppler shifts. For example, light traveling with a vector component in the direction of the acceleration will increase in frequency and light traveling with a vector component in the opposite direction will decrease slightly in frequency. Also light propagating perpendicular to the acceleration vector would be deflected and exert pressure on the wall of the fiber optic loop to keep the light within the fiber. The resultant distribution of frequencies and deflections around the loop produce the same inertial forces on the fiber optic loop as the reflecting box received from accelerating confined light. Even if the loop is only one wavelength in circumference, there would still be the same inertial forces. If the loop is accelerated perpendicular to the rotational plane, the light would exhibit inertia by exerting a pressure difference on opposite sides of the fiber optic.

The rotar model has a dipole wave traveling at the speed of light in a closed loop. This is similar to the example of light in a fiber optic loop, except that there is no physical wall confining the energy circulating at the speed of light. The interaction with the dipole waves in the spacetime field accomplishes the confinement. This is also confined energy propagating at the speed of light. The translational momentum vectors in a stationary rotar add up to zero ($p = 0$). This satisfies the condition to generate inertia by the same mechanism previously explained for the inertia generated by confined light in chapter 1. The inertia of the rotar model exactly matches the inertia of an equal amount of energy in the form of confined photons.

Equivalence Principle: Einstein needed to postulate the “equivalence principle” which states that inertial mass is equivalent to gravitational mass. For example, the equivalence principle implies that the force required to accelerate an electron at a rate of 9.8 m/s^2 is exactly the same as the force required to hold an electron stationary in a gravitational field with acceleration of 9.8 m/s^2 . If the Higgs mechanism is presumed to be the mechanism by which an electron gains inertial mass, then there is no obvious connection to an electron’s gravitational mass. It is therefore necessary to postulate the equivalence principle.

However, the proposed model of the universe reduces inertial mass and gravitational mass to their underlying energy. Energy does not need to be categorized as inertial confined energy or gravitational confined energy. Energy can be mathematically defined at a specific location and in a specific gravitational potential without referencing acceleration. If particles can be reduced to confined energy propagating at the speed of light, then there is no need to postulate the equivalence principle or the Higgs mechanism.

Inertia from the Higgs Field: The Higgs mechanism was originally devised to impart inertia to W and Z bosons. A photon is a boson and it has no rest mass when it is freely propagating. W and Z bosons need to interact with something to give them inertia and prevent them from being massless particles like photons. The spacetime model of the universe has not been developed sufficiently to address this question. Therefore W and Z bosons might interact with the Higgs boson to acquire inertia. However W and Z bosons are extremely rare in nature. Virtually all the mass in the universe is associated with the quarks and leptons that form ordinary matter. Therefore, the most important question concerning inertia is how do leptons and quarks acquire inertia? Is the inertia imposed by an external Higgs field or is the inertia the result of an internal structure that has energy propagating at the speed of light in a confined volume. The rotar model matches the way that confined photons acquire inertia. A rotar is energy propagating at the speed of light in a confined volume resulting in zero momentum ($p = 0$) in a rest frame. Therefore the inertia of a rotar exactly achieves the correct amount of inertia for a given amount of internal energy. The rotar model achieves a connection to gravity. It will also be shown that this structure produces curved spacetime.

The picture of the universe proposed here is very simple. Many of the mysteries of quantum mechanics and general relativity become conceptually understandable in the proposed model. It is predicted that in the future, Occam's razor will prevail and the simplest explanation will turn out to be the correct explanation. At the moment, the spacetime model of the universe with one field and one building block of everything in the universe appears to be by far the simplest model.

Chapter 7

Virtual Particles, Vacuum Energy and Unity

Introduction: In the last chapter we were on a roll calculating a simplified version of the strong force, the electromagnetic force and the gravitational force between two of the same rotars at a fixed separation distance equal to the rotar's rotar radius λ_c . In chapter 8 we will improve the model so that these forces exhibit attraction. We will also extend the calculation of the gravitational force to longer distances and include multiple rotars. However, before doing this it is necessary to lay some additional groundwork. This includes a description of virtual particle pairs, vacuum energy, asymptotic freedom and a proposed property called "unity" that permits quantized waves to exhibit particle-like properties.

In cosmology the terms "vacuum energy" and "dark energy" are often considered synonymous. This book makes a distinction between these two terms. Dark energy is a hypothetical concept that is required to fill the gap between the observed energy density of the universe and the theoretical "critical energy density". The apparent acceleration of the expansion of the universe seems to require a source of diffuse energy density ($\sim 6 \times 10^{-10} \text{ J/m}^3$) distributed throughout the universe that counteracts gravity. This is completely different than the very large energy density ($\sim 10^{113} \text{ J/m}^3$) of the spacetime field and implied by the terms "vacuum energy" or "vacuum fluctuations". Dark energy and the cosmological constant should not be equated to vacuum energy and vacuum fluctuations.

Probabilistic Nature of Rotars: In chapter 5 figures 5-1 and 5-2 show the distortion of spacetime believed to be present in the rotar volume of a rotar. Figure 5-1 shows a dipole wave in spacetime that has formed into a closed loop, one wavelength in circumference. This wave is traveling at the speed of light around the closed loop. We previously calculated the angular momentum of this model. This motion is not in a single plane as depicted; instead it is a chaotic distortion of spacetime. Placing a rotar in a magnetic field can partially align the spin direction giving precession around an expectation spin direction. However, even then almost all rotation directions are possible with different probabilities. The exception is the opposite spin direction to the expectation direction which has a probability of zero.

The chaotic nature of a rotar is due to the fact that the lobes are a slight distortion of energetic spacetime at the limit of causality. This small strain is below the quantum mechanical limit of detection. For an electron the spatial and temporal distortion produced by the rotating dipole wave is less than 1 part in 10^{22} . To a first approximation, the rotar model of an electron is an "empty" vacuum. The dipole lobes of an electron are so close to being homogeneous spacetime that the rate of time in the two lobes only differs by one second in 50,000 times the age of the

universe. The spatial properties of the lobes are so homogeneous that the distortion is equivalent to distorting a sphere the size of Jupiter's orbit by the radius of a hydrogen atom.

The reason that the rotar model can achieve the $E = mc^2$ energy of the fundamental particles is the incredibly large impedance of spacetime (c^3/G) and the large Compton frequency ($\sim 10^{20}$ to 10^{25} Hz) of the fundamental rotars. These lobes are propagating in a closed loop at the speed of light and interacting with vacuum energy so they are approximately confined to a volume. However, "finding the particle" means interacting with this incredibly weak distortion of spacetime in a way that results in a measurable momentum is transferred. This is a probabilistic event that can happen over a substantial volume that scales with λ_c . Furthermore, the chaotic nature of the rotar structure permits the rotating dipole wave to disappear from one volume and reform in an adjacent location that was previously part of the rotar's external volume. The rotating dipole can also be visualized as a rotating rate of time gradient as depicted in figure 5-2.

Virtual Particle Pairs: The term "virtual particle" is commonly applied in two different ways. First, there are the virtual particles that according to the commonly accepted physics theory are the carriers of forces. For example, virtual photons supposedly carry the electromagnetic force. The other type of virtual particles is the virtual particle pairs that are continuously being created from the vacuum and annihilated back into the vacuum. These virtual particle pairs are proposed to be another manifestation of spacetime. The assumption that the universe is only spacetime implies that these virtual particle pairs are just another form that the spacetime field takes. They have no angular momentum and therefore do not have a long term life. Rotars are also a manifestation of spacetime, but the difference is that rotars possess quantized angular momentum of $\hbar/2$. Even when an unstable fundamental particle decays, the angular momentum survives.

A virtual particle pair is a counter rotating matter/antimatter pair. Counter rotating means that the quantized angular momentum is eliminated (zero spin). For an instant the proposed virtual particle model is strained spacetime that looks generally similar to the two dipole lobes depicted in figures 5-1 and 5-2. However, the virtual particle lobes are not rotating. Also, the displacement amplitudes of these waves forming the virtual particle pairs may momentarily exceed the displacement amplitude required for a single particle. However, it is not clear if this is necessary because the short lifetime makes the exact amplitude nebulous.

Such lobe pairs would form randomly out of the dipole waves that are responsible for vacuum energy. If we make an analogy to waves on water, then a virtual particle pair is a wave maximum and minimum that momentarily looks like figures 5-1 and 5-2 in chapter 5. These lobes are separated by a distance comparable to twice the rotar radius (diameter = $2\lambda_c$) of the rotar being simulated. Apparently spacetime has a resonance at conditions that correspond to the formation of virtual particle pairs that correspond to real matter-antimatter pairs such as electron/positron pairs or muon/antimuon pairs. Therefore these frequencies are preferred

over random frequencies. These wave structures form and disappear from the dipole waves that form vacuum energy.

When such a shape forms, it momentarily can look like a particle/antiparticle pair such as an electron/positron pair or a muon/antimuon pair. However, this deception is quickly revealed. For example, with a real electron/positron pair, the two rotars should counter rotate $\frac{1}{2}$ radian each (1 radian total) in a time of $1/2\omega_c = \hbar/2mc^2 \approx 6.4 \times 10^{-22}$ s. The two randomly formed lobes would dissipate into wavelets in a similar time period. This is the same lifetime given to virtual particle pairs by the uncertainty principle. It can be shown that when the energy uncertainty is set as $\Delta E = E_i$, then $\Delta t = 1/\omega_c$ and $\Delta x = \lambda_c$. Therefore, the uncertainty principle is describing the time and distance required for this model of a virtual particle pair to reveal itself and dissipate into other random dipole waves. If we had assumed the shortest time period possible (1 unit of Planck time), then $\Delta E = E_p$ Planck energy and $\Delta x = L_p$ Planck length. When the maximum frequency is set equal to Planck frequency (inverse of Planck time) then the implied energy density equals Planck energy density $U_p \approx 10^{113}$ J/m³. It is proposed that all aspects of the uncertainty principle correspond to the spacetime field. Virtual particle pairs and real particles are both obtained from the spacetime field. The only difference is that real particles are a quantized unit of angular momentum ($\frac{1}{2} \hbar$) while virtual particles have no angular momentum.

Rotar Model Requires Vacuum Pressure: Recall in chapter 4 the point was made that energy density (U) and pressure (\mathcal{P}) both have units of M/T²L and on a fundamental level they are both the same ($U = k\mathcal{P}$). I argued that the implication is that energy density always implies pressure. If a model of a fundamental particle with finite energy has no volume because it either is a point particle or a one dimensional vibrating string, then these models have infinite energy density and infinite internal pressure. Even if a particle is considered to be an “excitation” of a field, the excitation implies volume, energy and finite pressure.

Even if other particle models do not address the question of the need to offset the implied pressure, this is a very important part of the spacetime-based model of the universe. In fact, the explanations of all the forces generated by a particle incorporate the particle’s internal pressure and the offsetting pressure (force) generated by the spacetime field. Therefore an explanation of forces must incorporate rotar’s internal energy density (U_q) and its internal pressure \mathcal{P}_q . Ignoring numerical factors near 1, the energy density and pressure of the rotar’s internal volume can be determined using one of the 5 wave-amplitude equations: $U = \mathcal{P} = kA^2\omega^2Z/c$. Using the substitution: $A = A_\beta = (T_p\omega_c) = \sqrt{\hbar G/c^5} \omega_c$ and previous substitutions:

$$U_q = \mathcal{P}_q = \frac{A_\beta^2 \omega_c^2 Z_s}{c} = \left(\frac{\hbar G \omega_c^2}{c^5} \right) \omega_c^2 \left(\frac{c^3}{G} \right) \left(\frac{1}{c} \right) = \frac{\hbar \omega_c^4}{c^3} = \frac{m^4 c^5}{\hbar^3} = \frac{E_i}{\lambda_c^3} = \frac{F_m}{\lambda_c^2} = A_\beta^4 U_p = A_\beta^4 \mathcal{P}_p$$

In particular, E_i/λ_c^3 has the form of energy density and F_m/λ_c^2 has the form of pressure where F_m is the particle's maximum force.

For example, an electron has: $E_i = 8.19 \times 10^{-14}$ J, $F_m = 0.212$ N and $\lambda_c = 3.86 \times 10^{-13}$ m. Therefore, an electron has energy density and internal pressure of about 10^{24} J/m³ and 10^{24} N/m² respectively. Vacuum energy is required to stabilize and confine this energy density/pressure. Therefore, vacuum energy must exceed this energy density/pressure. If it takes 10^{24} N/m² to stabilize an electron with energy of 8×10^{-14} J, how much pressure does it take to stabilize the highest energy particle? The most energetic particle that has been experimentally observed is the top quark with energy of: $E_i \approx 3 \times 10^{-8}$ J and the Higgs boson is close at $E_i \approx 2 \times 10^{-8}$ J. Using $U = E_i^4/c^3\hbar^3$ the energy density of vacuum energy must exceed about 10^{45} J/m³ and the pressure must exceed 10^{45} N/m² to support these particles. This represents a lower limit for the energy density of vacuum energy. These pressures are easily accommodated by the spacetime based model of vacuum energy.

The high energy density of vacuum energy required by the spacetime based model proposed here should not be surprising since a large vacuum energy density is also required for the formation of virtual particle pairs and many other operations of QED and QCD. The universal spacetime field has various resonances which give rise to the various virtual particle pairs of the standard model. Therefore, one of these resonances could be called the "top quark field" and another could be called the "Higgs field". Some estimates of the Higgs field place the required energy density at about 10^{46} J/m³. It is possible that the Higgs field resonance might have some stabilizing effect on W and Z bosons because this model has not been developed to the point of understanding W and Z bosons. However, it can be said that all fermions achieve their inertia through the same mechanism as the previously discussed confined photons achieve inertia. A Higgs field is not required to impart inertia to either confined photons or fermions.

Astronomical measurements indicate that the universe has average energy density of only about 10^{-9} J/m³ (the "critical density"). About 70% of this is attributed to "dark energy" which supposedly homogeneously fills all of space. The other 30% is ordinary matter and dark matter which are inhomogeneously distributed throughout the universe but can be averaged out if a large enough volume of spacetime is assumed. The existence of dark energy will be examined later. The remaining observable energy density in the universe is fermions and bosons which are dipole waves in spacetime that possesses quantized angular momentum. The vastly larger portion of the universe's energy (dipole waves) does not possess angular momentum and only interacts with our observable universe through quantum mechanics. This vacuum energy density is usually ignored, but it gives spacetime its properties such as constants Z_s , c , G , ϵ_0 , \hbar , etc. and is essential for EQD and QCD calculations. This vacuum energy density is as homogeneous and isotropic as quantum mechanics allows. Gravitational effects are a distortion of this homogeneous spacetime field produced by the 1 part in 10^{120} of the energy in the universe that possesses quantized angular momentum. However, concentrations of fermions such as a

neutron star can produce a condition which comes close to matching the maximum conditions of the spacetime field for a particular wavelength and volume. These conditions which create a black hole will be discussed later.

The energy density of a rotar fundamental particle implies a pressure that must be contained to achieve stability. Vacuum energy can exert this pressure without itself needing to be contained by a still larger pressure vessel. We do not know whether the universe is infinitely large or just vastly larger than our observable portion of the universe. In either case, the vacuum energy/pressure in our observable portion of the universe has nowhere to go. It is in equilibrium with the rest of the observable universe. One inadequacy of point particles and one dimensional strings is that they have energy but no volume. What mechanism contains the infinite pressure of a particle with no volume?

Rotars in Superfluid Vacuum Energy: If I wave my hand through spacetime, I am not aware of any interaction with the vast energy density of spacetime. There is no resistance; therefore it is hard to visualize spacetime as having a large energy density or being a very stiff elastic medium. However, it is necessary for me to remember that the fundamental particles that make up my hand are merely units of quantized eddies. They temporarily organize a volume of chaotic dipole waves so that a Planck length distortion rotates around a circle that is one Compton wavelength is circumference. For example, for an electron the Compton wavelength circumference is about 10^{22} times larger than the Planck length distortion.

This quantized angular momentum can effortlessly pass through the sea of superfluid vacuum fluctuations (dipole waves) without encountering any resistance or leaving a wake. No particular dipole wave is moving and no dipole waves are being compressed. Only when we introduce a new wave, such as a gravitational wave, are we truly interacting with the spacetime field in a way that exposes its impedance and energy density. Spacetime has a bulk modulus but this bulk modulus only reveals itself to a wave in spacetime that is physically introducing a compression and expansion of spacetime.

However, if a rotar possessing quantized angular momentum encounters another rotar with quantized angular momentum, then this is entirely different. Even though these two rotars are also just distortions of spacetime, the quantized angular momentum permits them to exceed the homogeneous energy density of vacuum energy. This starts a chain of interactions with vacuum energy/pressure that ultimately result in the forces of nature. For example, rotars can coalesce into massive bodies ranging from hadrons to galaxies. These are islands of concentrated energy in a sea of superfluid vacuum energy that was previously homogeneous. Each rotar increases the energy density at a specific location causing a disturbance we know as curved spacetime. All other nearby rotars now experience an energy density gradient which results in a gravitational interaction between rotars (particles). The other forces are the result of similar interactions as

will be explained later. Chapters 13 and 14 will discuss further why the energy density of spacetime does not form a black hole.

Is the Spacetime Field the New Aether? If the universe is only spacetime, it should not be surprising that spacetime is ultimately responsible for all of physics. The description of spacetime offered here is a combination of the energetic vacuum fluctuations described by quantum mechanics and the general relativistic description where spacetime can be curved and time is the fourth dimension. Ultimately energetic spacetime even performs the functions previously attributed to the aether. For example, in chapters 9 and 11 a mathematical analysis will indicate that photons are quantized waves propagating in the spacetime field. This sounds a lot like the aether. What are the similarities and differences?

There is a short book titled “Einstein and the Ether” by Ludwik Kostro that I found very interesting and informative. Before reading this book, I assumed that Einstein did not believe in the aether and also assumed that he was a key reason that the aether fell out of favor in modern physics. To my surprise, I discovered that only between the years 1905 and 1916 did he entirely reject the aether. After 1916 he often referred to his relativistic view of the aether and defined the aether as “physical space endowed with physical attributes”. According to Kostro, over Einstein’s life he had 3 different concepts of the aether. After about 1934 he began to substitute the terms “physical space” or “total field” for “the aether”, but he was referring for the same physical concept. Here are some Einstein quotes obtained from the Kostro book, but the original source of the Einstein quotes are also given.

“In 1905 I was of the opinion that it was no longer allowed to speak about the aether in physics. This opinion, however, was too radical as we will see later when we discuss the general theory of relativity. It is still permissible, as before, to introduce a medium filling all space and to assume electromagnetic fields (and matter as well) are its states.”¹

“Physical space and aether are only different terms for the same thing; fields are physical states of space.”²

“According to general relativity, the concept of space detached from any physical content does not exist. The physical reality of space is represented by a field whose components are continuous functions of four independent variables – the coordinates of space and time.”³

¹ A. Einstein, (Morgan Manuscript) Morgan Library, New York, section 13

² A. Einstein *Mein Weltbild* (Amsterdam: Querido, 1934), p. 237

³ A. Einstein, “Relativity and the Problem of Space,” pp. 375-376

“According to the general theory of relativity, space is endowed with physical qualities; in this sense, therefore, there exists an aether.”⁴

“The ether includes all objects of physics... Matter and the elementary particles from which matter is built also have to be regarded as “fields” of a particular kind or as particular “states” of space.”⁵

This last Einstein quote shows that he evolved to a concept of a relativistic aether which included all particles and forces. His concept of the aether was that it included everything in the universe. Einstein’s concept can perhaps be summarized as follows: *The universe is only aether.*

The problem with the term “aether” is that it has so many different meanings that now it is too imprecise a word for scientific discussion. Kostro estimates there were about 14 different descriptions of the aether. The most important ones were the Lorentz aether, the Eddington aether, the Weyl aether and Einstein’s relativistic aether.

The spacetime field described in this book broadly can be considered a model of “the aether” since it describes a universal field that fills all of space. In chapter 9 the spacetime field will also be shown to be associated with the propagation of light. However, the spacetime field is described and quantified to a degree not achieved by any earlier aether concepts. Experiments within current technology cannot detect motion relative to the spacetime field because spacetime is a sea of energetic dipole waves which are always forming new wavelets and all of this is propagating chaotically at the speed of light. As previously explained, gravitational waves propagate in the spacetime field and a hypothetical Michaelson-Morley experiment conducted using gravitational waves would not detect motion relative to the spacetime field.

In chapter 4 it was mentioned that the harmonic oscillators of zero point energy have spectral energy density of: $U(\omega)d\omega = k(\hbar\omega^3/c^3)d\omega$. The quote from Puthoff⁶ is:

“This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. All inertial observers are equivalent. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift. Therefore this spectral energy distribution satisfies the requirement that it should not be possible to detect any difference in the laws of physics in any frame of reference.”

⁴ A. Einstein, *Ather und Relativitatstheorie* (Berlin: Springer, 1920) p.15

⁵ A. Einstein, “Uber den Aether,” VSNG, **105**, 1924 pp. 85-93

⁶ Puthoff, H.E. Phys. Rev. A Volume 40, p.4857, 1989 Errata in Phys. Rev A volume 44, p. 3385, 1991 See also New Scientist, volume 124, p.36, Dec. 2, 1989

This quote is only accurate if we assume that frequency range of the harmonic oscillators of zero point energy extends to infinite frequency. However, the actual zero point energy has an upper frequency limit equal to Planck frequency. With this limit, it is no longer possible to assume that a motion through ZPE is Lorentz invariant in all conceivable frames of reference.

Lorentz Invariance: It is proposed that Lorentz was right when he assumed a preferred frame of reference for his calculations and this preferred frame of reference is the cosmic microwave background (CMB) rest frame. This is the frame which the CMB looks isotropic in all directions. We are currently moving at about 269 km/s relative to the local CMB rest frame, therefore the CMB appears slightly anisotropic from our frame of reference (red and blue shifts). If we could see the Planck frequency dipole waves that form the spacetime field, they also would appear to be slightly anisotropic because of our motion relative to the CMB rest frame. We can never directly observe dipole waves in spacetime because their Planck length and Planck time displacement of spacetime sets a detectable limit as previously discussed. However, there are hypothetical experiments that we can imagine which would reveal an anisotropy if an extremely large frame of reference is assumed relative to the CMB rest frame. For example, it was previously shown that all spacetime particles (rotars) have energy density and therefore an internal pressure. This internal pressure is offset by pressure exerted by the interaction with the surrounding vacuum energy (dipole waves) that stabilized the particle. To achieve this stabilization the vacuum must be able to exert the required pressure on all sides of a particle.

Imagine a particle moving relative to the CMB rest frame at a speed with an extremely large special relativity gamma $\gamma = (1 - v^2/c^2)^{-1/2}$. It is proposed that there are exotic frames of reference which would expose the anisotropy in the frequencies that make up the spacetime field. This would happen if the special relativity γ is so large that the vacuum cannot exert the required pressure on all sides of the particle because one side experiences too large a redshift. Then that type of particle could not exist in that frame of reference. For example, a top quark has energy of $E_i = 2.77 \times 10^{-8}$ J, frequency of $\omega_c \approx 3 \times 10^{26}$ s⁻¹, energy density of about 10^{46} J/m³ and internal pressure of about 10^{46} N/m². To offset this internal pressure a top quark cannot exist in a frame of reference beyond about $\gamma = 7 \times 10^{16}$ relative to the CMB rest frame. Similarly, an electron cannot exist at a frame beyond about $\gamma = 3 \times 10^{22}$. These limits are set because in the redshift direction the dipole wave that form the spacetime field would be Doppler shifted to a frequency that is unable to exert the required pressure to stabilize the top quark or electron.

Another way of looking at this limit is that a top quark or electron propagating at their limiting frame of reference would have a de Broglie wavelength less than Planck length when viewed from the CMB rest frame which is an impossibility. The laws of physics would be different in these exotic frames of reference where fundamental particles beyond a critical energy are not allowed to exist. Therefore, Lorentz invariance is correct for ordinary frames of reference, but Lorentz invariance is not correct in the limit of exotic frames of reference where some particles

cannot exist. Lorentz assumed a preferred frame of reference as the basis of his calculations. Einstein claimed that the theory of relativity did not allow for a preferred frame of reference and Einstein proposed what he called the “relativistic aether”. It is now proposed that Einstein was correct for accessible frames of reference but Lorentz was correct when exotic, high γ frames of reference are considered. It is ironic that the condition which violates Lorentz invariance is also the condition that proves that Lorentz’s assumption about a preferred frame of reference.

This discussion does have one important implication for theoretical physics. String theory is based on three mathematical assumptions. One of these three assumptions is Lorentz invariance which is expressed as an equation. If the previous discussion about limits to Lorentz invariance is correct, then one of the three foundations of string theory would be provably wrong. This would undermine the foundation of string theory.

Returning to Einstein and Lorentz, it must be understood that both Einstein and Lorentz were dealing with mathematical analysis which incorporated assumptions, but neither of them had an actual mechanistic model of the aether such as the dipole wave model with quantifiable properties such as proposed in this book. Therefore, Einstein could simply decide that the aether must possess relativistic properties and formulate equations accordingly. He did not wrestle with the difficult problem of developing a physical model of the universe which achieved this goal. Similarly, Lorentz developed equations for the transformations required to keep Maxwell’s equations unchanged when viewed from different frames of reference. Lorentz assumed a preferred frame of reference for his analysis, but since the length and time transformations made all frames of reference look the same, there would be no way of experimentally identifying the preferred frame of reference. Again, Lorentz did not actually develop a physical model of the universe which achieved the results he calculated.

Stability of a Particle Made of Waves

Schrodinger’s Wave Packet: Previously it was mentioned that about 1926 Schrodinger attempted to explain particles as consisting only of a “wave packet”. Schrodinger’s wave packet had many frequencies that, when added together (Fourier transform), produced a concentrated wave. This was Schrodinger’s wave based model of a particle. He was attacked for this idea by other scientists. The problem was that these many different frequencies could only temporarily add together to form a concentrated wave at a single location that acts like a particle. Another way of saying this is that Schrodinger’s confluence of waves can momentarily create the energy density of a particle, but this implies a pressure. Schrodinger was unable to explain what prevented the wave packet from dissipating and he eventually abandoned this idea.

Radiated Power by Unstable Rotars: The amplitude of the rotar wave within the rotar volume (at distance λ_c) has been given as $A_\beta = L_p/\lambda_c$. A simple extrapolation of this amplitude to

distances beyond λ_c would result in a fundamental wave amplitude of $A_f = L_p/r$ where distance r is greater than λ_c . Rotating dipoles of any type attempt to radiate away their energy. Angular momentum cannot be destroyed but the volume over which the angular momentum is distributed can expand. It is proposed that at the few Compton frequencies that actually form rotars, a type of resonance is formed that offsets the dipole radiation. For any fundamental rotar that achieves sufficient stability to be a named particle, there must be a mechanism which cancels the traveling wave with amplitude $A_f = L_p/r$ and leaves only residual standing waves as evidence of the battle that is taking place. Without some form of cancelation in the external volume, we would expect a rotar to radiate energy into the external volume with amplitude that decreases with $1/r$ at a frequency equal to the rotar's Compton angular frequency ω_c . To calculate the hypothetical radiated power that would occur from amplitude A_f at frequency ω_c we will use one of the 5 wave-amplitude equations: $P = A^2 \omega^2 Z \mathcal{A}$. This equation contains " \mathcal{A} " which is the radiating area. It is not necessary to assume a distance of λ_c for this calculation. We can imagine a spherical shell with arbitrary radius r . Therefore, we only need to calculate the power that passes through this shell. At distance r the surface area " \mathcal{A} " of this imaginary spherical shell with radius r is: $\mathcal{A} = 4\pi r^2$.

$$P = A^2 \omega^2 Z \mathcal{A} \quad \text{set } A = A_f = L_p/r, \quad Z = c^3/G \quad \text{and} \quad \mathcal{A} = 4\pi r^2 \quad (\text{ignore } k)$$

$$P = \left(\frac{L_p}{r}\right)^2 \omega_c^2 \left(\frac{c^3}{G}\right) 4\pi r^2 = \left(\frac{\hbar G}{c^3}\right) \omega_c^2 \left(\frac{c^3}{G}\right) = \omega_c^2 \hbar = P_c$$

$$P = P_c \quad \text{radiated power} = \text{rotar's circulating power } P_c = \omega_c^2 \hbar = E_i \omega_c$$

Therefore, a $1/r$ amplitude distribution means that the radiated power is equal to the rotar's full circulating power $P_c = E_i \omega_c$. At this radiated power, all the rotar's internal energy E_i is radiated away in a time period of only $1/\omega_c$. If an electron radiated power at this rate, it would be radiating about 63 million watts and have a lifetime of less than 10^{-20} seconds. Any structure that is radiating away its internal energy in a time period of only $1/\omega$ has absolutely no stability. In fact, it lasts as long as the uncertainty principle predicts for energy uncertainty ΔE . If a rotar survives for a time period longer than $1/\omega$, this means that there must be some mechanism for reducing the wave amplitude in the external volume from $A_f = L_p/r$.

Wave Cancelation: Here is the picture that I have for the stability of a rotar. It is not a complete picture, but it is sufficiently complete that I find it plausible when combined with the body of other information contained in this book. Imagine a rotating dipole wave in spacetime that is one wavelength in circumference. It is a single frequency, so radiation from this wave attempts to fill the universe. Power would have to be continuously supplied to this rotating dipole. In this case, the outgoing wave is acting exactly as would be expected for a single frequency wave expanding from a source. This would produce perfect monochromatic radiation, limited only by the Fourier transform of the finite emission time. Since a stable rotar is not continuously emitting energy, there must be a new source of offsetting waves.

This cancelation of waves in the external volume does not mean that all traces of wave energy have been eliminated. A very important part of the rotar model is that the destructive interference is incomplete. Standing waves (oscillations where nodes and antinodes are stationary) are left behind. These standing waves interact with vacuum energy in a way that also produces non-oscillating strains in spacetime. Two examples of these residual non-oscillating strains are electric fields (chapter 9) and curved spacetime. In particular, curved spacetime results in a static rate of time gradient and a non-Euclidian spatial distortion (discussed in chapter 8).

Traveling waves imply that power is being transferred in the direction of the wave propagation. Standing waves or a static rate of time gradient implies that no power is being transferred. Therefore, the proposed destructive interference has eliminated the power drain from the rotar, but the remaining standing waves and gradients are the evidence that a destructive interference battle is going on. Standing waves have energy, so this picture implies that a small portion of the rotar's energy is distributed outside the rotar volume. This energy is responsible for the rotar's electric and gravitational fields.

The vacuum energy waves propagating towards the core (wavelets) are returning the radiated power to the rotating dipole core. These returning waves must have the correct phase to constructively interfere with the rotating dipole. Out of the infinite possible combinations of frequency, amplitude and angular momentum, only the electron, muon and tauon have frequency/amplitude combinations to survive as isolated charged rotars (implies rest mass). The quarks only find stability in pairs or triplets. As previously stated, each charged lepton has a single dimensionless number that expresses all its unique characteristics in dimensionless Planck units. Neutrinos will be discussed later.

Attraction and Repulsion: The conventional explanation for action at a distance is that the forces of nature are the result of the exchange of virtual particles. This explanation is conceptually understandable when it is applied to two particles which repel each other such as two electrons. It is possible to imagine virtual photons propagating between two electrons. Each virtual photon carries a small amount of momentum therefore multiple virtual photons together produce what appears to be a continuous repulsive force. However, even for repulsion there is the question: How do virtual photons find a distant point particle? Is there a homing mechanism or are there almost an infinite number of virtual photons exploring every possible location?

When the concept of virtual photon exchange is first introduced to students, the next question is usually "How does the exchange of virtual photons create attraction?" The answer usually includes mention of the uncertainty principle, Feynman diagrams, and mathematical abstractions. These answers still are unsatisfying, but the student reluctantly adopts the idea that it is necessary to move beyond classical physics with its conceptually understandable answers and accept the counter intuitive explanations of quantum mechanics. This book

attempts to bring conceptually understandable ideas to quantum mechanics. The subject of action at a distance, especially attraction, is a prime example of an area that needs an improved explanation.

There is very little “wobble room” for action at a distance if we start with the assumption that the universe is only spacetime. This restriction leads to the concept that there is only one force: the relativistic force $F_r = P_r/c$. This is the force imparted by power traveling at the speed of light. This leads to a surprising realization that the relativistic force is only repulsive.

The same way that photon pressure is only repulsive, waves in spacetime traveling at the speed of light can only produce a repulsive force. What appears to be an attracting force is actually a repulsive force exerted by the vacuum energy/pressure. Each rotar requires vacuum energy to exert a large pressure to stabilize the rotar. Previously we calculated the pressure required to stabilize a rotar is: $\mathbb{P} = m^4 c^5 / \hbar^3$ and applying this pressure over an area of $k\lambda_c^2$ produces a force equal to the rotar’s maximum force ($F_m = m^2 c^3 / \hbar$) ignoring dimensionless constants near 1. If we mentally divide a rotar into two hemispheres, vacuum energy is exerting the rotar’s maximum force F_m to keep those two hemispheres together. This is the same force required to deflect a rotar’s circulating power $P_c/c = \mathbb{P}\lambda_c^2 = F_m$. Even leptons which do not feel the strong force still experience a force equal to the maximum force F_m exerted by the pressure associated with vacuum energy. In chapter 8 it will be shown later that this force exerted by vacuum energy can be unbalanced and can appear to be attraction.

This maximum force was first calculated assuming that the rotar’s full circulating power is deflected. The agent that is accomplishing this deflection must be an external repulsive force. Now we see that the vacuum energy (the spacetime field) is exerting this required force on the rotar. In equilibrium, the compression force exerted by vacuum energy needs to balance the outward force exerted when a rotar’s circulating power is confined (deflected). Therefore, it is reasonable that the force exerted by vacuum energy needs to equal the rotar’s maximum force.

Asymptotic Freedom: The strong force is an attracting force which has the property of allowing quarks bound in hadrons to freely migrate within the natural dimensions of the hadron as if there is no force acting on them. However, if there is an attempt to remove a quark from the hadron (increase the natural separation), then a force of attraction appears and resists increasing this separation distance. Furthermore, this attracting force increases with distance. An attempt to remove a quark from a hadron against this increasing force of attraction produces a new meson rather than a free quark. Once the new meson is formed the attracting force drops to near zero and the meson can be removed. Therefore the strong force has a force characteristic that seems counter intuitive.

The strong force also is responsible for binding protons and neutrons together in the nucleus of an atom. The attraction between nucleons caused by the strong force is substantially larger than

the electromagnetic force generated by the protons attempting to repel each other. It is estimated that the strong force is at least 100 times greater (perhaps $1/\alpha$ times greater) than the electromagnetic force at a distance comparable to the radius of a proton ($\sim 10^{-15}$ m).

Previously in chapter 6 we calculated that the proposed wave model indicated that two quarks should repel each other with a force equal to the rotar's maximum force at a separation distance equal to λ_c . However, this repulsion is only one of two forces acting on quarks when they are bound together in a hadron. The quark is also interacting with vacuum energy in a way that vacuum energy is exerting a large pressure on the quark. An isolated electron has symmetrical vacuum energy pressure exerted on the spherical rotar volume. However, a quark bound in a hadron does not have symmetrical pressure. A feature that makes protons and neutrons stable is that there is an interaction between adjacent quarks which cancels the pressure normally exerted by vacuum energy on the part of the quark that is nearest its neighbor quark. The remaining pressure applied over the remaining portion of the quark exerts a force equal to the quark's maximum force F_m (previously calculated $F_m = P_q \lambda_c^2$).

This unbalanced pressure pushes the quarks together so it appears to be a force of attraction (pseudo-attraction). Ultimately equilibrium is reached where the repulsive force between the two quarks is equal to the maximum force F_m and this also equals the vacuum energy force that pushes the quarks together. Any attempt to either increase or decrease the separation would result in a large force attempting to return the quarks to the separation where the opposing forces balance. This equilibrium is proposed to create the condition known as "asymptotic freedom".

A collision that attempts to remove a quark from a hadron increases the separation between quarks beyond the equilibrium position. The repulsive force exerted by the other rotar rapidly decreases as the separation is increased. Work is being done and it appears as if the pseudo-attraction exerted by vacuum energy/pressure remains constant as the quarks are separated. The decrease in the repulsive force exerted by the other rotar combined with a relatively constant pseudo-attraction force results in a net force that appears to increase with distance. The strong force is proposed to be the net force that results from the two opposing forces. This net force (the strong force) approaches the maximum force as the separation increases. The work done separating quarks increases the energy (frequency) of the quarks (rotars) and eventually the extra energy forms a new meson.

This subject will be discussed further in chapter 12. All that is important for a comparison of forces is that the magnitude of the strong force approaches the maximum force as quarks are separated. For example, the up and down quarks that form an isolated proton would have a maximum force of roughly 80,000 N. This maximum force is obtained from $F_m = m^2 c^3 / \hbar$ where the mass is approximately $1/3$ the proton's mass. The spacetime based model explains forces without exchange particles. Gluons are a key part of the standard model but they are virtual

particles that have not and cannot be directly observed. The need to replace the gluon virtual particle model with a wave based model of forces will be discussed further in chapter 12.

Casimir Effect Similarity: This explanation for attraction (unbalanced pressure from vacuum energy) has some similarities to the explanation for the Casimir effect. Previously it was mentioned that the random waves in vacuum energy are creating all combinations and these include spacetime waves that appear to be zero point electromagnetic radiation. When two metal plates are brought close together, these conductive plates exclude electromagnetic waves with wavelengths larger than the gap between the metal plates. These excluded wavelengths/frequencies are still present on the opposite side of the metal plates. This slightly lowers the pressure exerted by the dipole waves in spacetime (vacuum energy) between the two plates compared to the pressure exerted on the outside of the metal plates where no waves are excluded. Practical considerations such as surface smoothness, electrical conductivity and metallic cut off frequency all serve to degrade the effect from the theoretical performance. The Casimir effect has been experimentally verified to within about 5% accuracy. Assuming an ideal electrically conductive surface, the theoretical pressure \mathbb{P} generated by the Casimir effect with gap size of “ r ” is:

$$\mathbb{P} = (k) \hbar c / r^4 \quad \text{Casimir Pressure } \mathbb{P} \text{ for parallel metal plates separated by “} r \text{”}$$

This should be compared to the pressure \mathbb{P} exerted by vacuum energy on a rotar with rotar radius λ_c :

$$\mathbb{P} = (k) \hbar c / \lambda_c^4 \quad \mathbb{P} = \text{pressure exerted by vacuum energy on rotar with radius } \lambda_c$$

It can be seen that these are the same form if gap size “ r ” is equated to rotar radius λ_c and the constant is ignored.

The point of this is that even electrostatic attraction or the strong force has a similarity to the Casimir effect. The reasoning is that all of these attractions are the result of reducing the pressure exerted by vacuum energy on one side of an object more than the pressure exerted on the opposite side of the object.

This proposal makes attraction conceptually understandable. There is only one fundamental force and this force is only repulsive. We live in a sea of vacuum energy. It is like a fish that lives at great depth in the ocean. The fish is subject to great pressure, but the fish happily goes about its life without realizing that there is any pressure. Only if something happens to create an imbalance of pressure does the great pressure become evident. Even then, anything that lowers the pressure on one side of an object appears to be creating an attraction. The force is delivered by what appears to be a featureless environment (water for the fishes and vacuum for us). Gravitational attraction will be discussed in the next chapter.

“Unity” Hypothesis

The wave-particle duality is perhaps the most basic mystery of quantum mechanics. Both photons and particles exhibit properties that sometimes require a wave explanation and sometimes require a particle explanation. It is possible to imagine a point particle that has a percentage of its energy as a wave surrounding the point particle. However, the experiments seem to indicate that sometimes there are 100% particle properties and other times there are 100% wave properties. These are such different concepts that they seem mutually exclusive.

Today’s physics puts the primary emphasis on the particle interpretation. The waves are considered to be a property of particles rather than particle-like interactions being the property of quantized waves. Not only are the leptons and quarks viewed as particles, but photons, gravitons and gluons are also considered particles. The forces of nature are considered to be carried by “exchange particles”. The wave properties of all particles are recognized, but the particle properties are considered paramount.

My background is lasers and optics. In this field, the wave properties of light are considered paramount. The particle properties of photons are important, but these particle properties are secondary to the wave properties when designing optics or lasers. It is easiest to think of a photon as a quantized wave rather than a particle that possesses wave properties. In this picture, a photon is a quantized wave that is distributed over a volume when the photon is in flight. Absorption of a photon by an atom is easiest to picture as the quantized wave collapsing into the absorbing atom. From this background, there is a predisposition to quantized waves rather than particles. Having admitted my predisposition towards waves, I will start my attack on the concept that photons have particle properties by asserting the following:

There are no experiments that prove that photons have particle properties. All the experiments like the photoelectric effect and atomic photon absorption merely prove that a photon possesses quantized energy. Even Compton scattering will be shown in chapter 11 to have a wave explanation.

It is a common misconception to equate quantization with a particle. However, if spacetime is visualized as the energetic spacetime of quantum mechanics, and if these vacuum fluctuations have superfluid properties, then angular momentum must appear as quantized units. This quantized angular momentum has as a byproduct that energy possessing angular momentum also comes in quantized units. It has been proposed earlier that currently only about 1 part in 10^{120} of all the energy in the universe possesses quantized angular momentum. Energy that possesses quantized angular momentum is the only energy with which we and our instruments can interact. A photon can carry any energy up to Planck energy, but it always carries \hbar of

quantized angular momentum (orbital angular momentum can add multiples of \hbar , but this is a special case). If we can only interact with quantized angular momentum, then everything we interact with will be forced to possess quantized energy. Waves with quantized angular momentum will appear to have particle-like properties.

We are amazed by the apparent mystery of the quantum mechanical properties of particles and photons. However, we must remember that we are only interacting with the minute part of the energy in the universe that possesses angular momentum. This minute part of the total energy of the universe must follow the rules of quantized energy transfer. These rules are enforced by the vast sea of vacuum energy in the superfluid state that surrounds us and fills the universe. For example, a molecule isolated in a vacuum can only rotate at a fundamental rotational rate or at integer multiples of this fundamental rotational rate. These quantized changes in energy are associated with quantized changes in angular momentum. This mystery of quantum mechanics becomes conceptually understandable when it is realized that the molecule really is not isolated. It lives in a sea of superfluid vacuum energy that must isolate pockets of angular momentum.

Enforcing this quantization of angular momentum requires that a unit of energy with quantized angular momentum must be able to collapse faster than the speed of light. Is there any experimental proof that faster than light action can occur? Next, we will attempt to explain how quantized waves in spacetime can exhibit particle-like properties. This explanation starts with entanglement.

Entanglement – Unity Connection: Entanglement occurs when two or more photons or particles interact in a way that their quantum states can only be described with reference to each other. Separating these entangled photons or particles does not break the quantum connection. Therefore, measuring a quantum property of one object affects the quantized state of the second entangled object. This effect happens instantly, even at a large separation distance. The existence of entanglement has been proven in many different experiments.

If entanglement provides an instantaneous response between two entangled particles or photons, is it not reasonable that there should also be a similar effect within a single dipole wave with quantized angular momentum? Chapters 11 and 14 will offer additional insights into entanglement and the super luminal communication. For now we will merely accept entanglement as an experimentally proven effect and examine the implications of its proposed close relative, unity. A purely spacetime wave model of fundamental particles must explain how a wave that is distributed over a volume can exhibit particle-like properties some of the time. If a wave is envisioned as being divisible into smaller parts like a sound wave, then it is impossible for such a wave to exhibit particle-like properties. However, a rotar is a dipole wave in spacetime that is carrying a quantized amount of angular momentum in a sea of vacuum energy that lacks angular momentum. This type of wave can change its energy in a collision, but it always must carry the assigned quantized angular momentum of $\frac{1}{2}\hbar$ or \hbar , for a rotar or photon respectively.

It is true that I am not giving a conceptually understandable explanation of why a superfluid cannot possess angular momentum and why any angular momentum that is present in the superfluid is broken into quantized units. This is an experimentally observed property of superfluid liquid helium and I believe that there is a theoretical explanation for the effect in liquid helium. However, I must admit that I do not have a conceptually understandable explanation for this when it is reduced to waves in spacetime. (This is a good project for someone else.) However, if we assume quantized angular momentum exists, then it is easy to see that a wave carrying quantized angular momentum must respond as a unit to a perturbation. In a collision with another quantized wave, the wave with quantized angular momentum must interact as a unit to precisely preserve the angular momentum.

The preservation of quantized angular momentum requires that the quantized wave possess faster than speed of light internal communication. This is the proposed property called “unity”. The property of unity gives particle-like properties to a wave carrying quantized angular momentum.

The properties of spacetime determine the size ($\frac{1}{2} \hbar$) of the quantized angular momentum. If we accept this as a given, then the property of unity must be a component of any model of particles based only on waves. Some events such as the emission of a photon from an atom occurs over a long enough period of time that there is enough time for the quantized wave to respond without the need to invoke super luminal communication (discussed later). However, other events such as the collision of two rotars at relativistic speed requires that the rotar respond in a time period faster than required for speed of light communication across the physical size of the rotar’s rotar volume. The external volume of a rotar responds differently and will be discussed later.

Nature is capable of super luminal communication as demonstrated by the many experiments that prove the existence of entanglement. The same way that it is not possible to send a message faster than the speed of light using entanglement, it also is not possible to send a message faster than the speed of light when a quantized wave responds to a perturbation as a single unit. This is merely an internal housekeeping function. The entire quantized wave (with quantized angular momentum) must respond as if it is one entangled unit.

Assume that a rotar is the dipole wave model previously described. It is not possible to interact with just 1% of a quantized dipole. It is not possible to transfer less than \hbar of angular momentum. Either 100% of the rotar volume responds to the interaction or none of the rotar volume responds. If there is a transfer of angular momentum, it always occurs in quantized units of \hbar . The communication within a single quantized rotar volume would be instantaneous, just like the response involving two entangled particles. In fact, the response within a single quantized wave should be *better* than when two photons or two particles are entangled.

Sixth Starting Assumption: A wave in spacetime with quantized angular momentum responds to a perturbation as a single unit. This superluminal internal communication gives the quantized wave, particle-like properties.

Unity is proposed to be the property responsible for the mysterious wave-particle duality present everywhere in nature. Every physical entity in the universe is made of dipole waves in spacetime. Unity permits these waves to respond with particle-like properties, but the response exhibits a probabilistic characteristics. Recall the incredibly small distortion of spacetime that forms a fundamental rotar. “Finding” a particle somewhere within a quantized dipole wave is really unity causing the quantized wave to interact with a probe (another wave) in a way that appears to exhibit particle-like properties at a single location. The particle-like properties of a quantized wave can exhibit discontinuous jumps because interacting with the quantized wave can happen at any part of the volume containing the quantized wave. The interaction and the apparent location of the interaction is a probabilistic event.

Collapse of the Wave Function: A “collapse of the wave function” in quantum mechanics is proposed to be related to the property of unity. However, this connection is complicated by the fact that often the mathematical expression of a wave function includes boundary conditions not encountered by isolated rotars. For example, a “particle in a box” or an electron bound in an atom both have restrictive boundary conditions that change the distribution of spacetime waves compared to an isolated rotar. These are more complicated conditions that will be discussed later.

In quantum mechanics, the physical interpretation of the collapse of the wave function is literally that the probabilistic wave properties of a point particle disappear (collapse) when the particle is “found”. The physical interpretation of unity is that a rotar’s wave properties remain after it is “found”. The distributed wave of a rotar just responds to a probe (another wave) as a quantized unit.

Since the rotar is distributed over a volume, there is internal communication within the rotar that occurs faster than the speed of light. Therefore, the rotar responds to a perturbation as if it was concentrated at a single location. Unity allows fundamental rotars to respond to a relativistic collision by momentarily shrinking the radius of the rotating dipole as a single cohesive entity. This reduction in rotar radius happens faster than the speed of light, so it is impossible to detect a fundamental particle’s size using inferences from collisions. In a collision, the angular momentum remains constant, but the frequency and energy increase as the radius decreases. The quantized wave appears to be a point concentration of mass/energy that discontinuously changes location. There is just no literal collapse of waves into a point particle.

The characteristic of unity is the final piece of the puzzle required for fundamental rotars to appear to be point particles. In experiments that attempt to measure the size of the fundamental rotars, the resolution of the experiment depends on the energy of the collision. Imagine two rotars colliding at relativistic velocity. In the interaction, the kinetic energy is temporarily converted to internal energy of the two rotars. In order to preserve the angular momentum of the rotar, it is necessary for the rotar to reduce its rotar radius from the size characteristic of an isolated rotar to the size appropriate for a rotar that has absorbed extra energy. This temporary size reduction gives the energetic rotar a rotar radius comparable to the resolution limit of the collision experiment. Not only does the rotar reduce the size of λ_c in a collision, but this reduction happens faster than the speed of light. The entire energy in the rotar volume reacts as a unit, so the inertia appears to originate from a point. The location of that point is probabilistic, so it can appear that a rotar moves in discontinuous jumps. Later we will address the question of the small amount of a rotar's energy that is external to the rotar volume and responds differently.

Partial Explanation of Unity: The following partial explanation of unity is offered for rotars that exhibit rest mass. Unity within photons will be discussed later. It is hoped that others can improve on this partial explanation.

All rotars with rest mass are proposed to be quantized waves circulating at the speed of light in a confined volume. Even though the circulation happens in a limited volume, the fact remains that these waves do not experience time or distance. There is a fundamental difference between the way we perceive the universe (3 spatial dimensions plus time) and the way quantized waves traveling at the speed of light perceive the universe. They live in a zero dimensional universe. Dipole waves in spacetime consider the universe to be a single point.

It should not be surprising that we find many alien characteristics when we transfer from the 4 dimensional macroscopic perspective into the zero dimensional quantum perspective. Within a quantized wave circulating at the speed of light there is no time and no distance. This gives rise to both the proposed property of unity and to entanglement. Since the rotar perceives that there are no spatial dimensions, an interaction with the rotar cannot take place with only a small portion of the rotar. It is all or nothing.

In this book I have attempted to make quantum mechanical operations conceptually understandable. The above explanation of unity and entanglement is really only a partial explanation. In chapter 11 a model of two entangled photons will make entanglement more understandable. In the cosmology chapters 13 and 14 a new picture of the universe will be offered which will further improve the explanation of unity and entanglement.

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Chapter 8

Gravitational Attraction and Unification of Forces

In chapter 6, the reader was asked to temporarily consider all forces to be repulsive. This was a simplification which allowed the calculations in chapter 6 to proceed without addressing the more complicated subject of attraction. In chapter 7, vacuum energy/pressure was introduced as an essential consideration in the generation of all forces, but especially forces that produce attraction. In this chapter we are going to attempt to give a conceptually understandable explanation for the force of attraction exerted by gravity when a body is held stationary relative to another body.

Physical Interpretation of General Relativity: Einstein's general relativity has passed numerous experimental and mathematical tests. This mathematical success has convinced most physicists to accept the physical interpretation usually associated with these equations. However, the most obvious problem with the physical interpretation is examined in the following quotes. The first is from B. Haisch of the California Institute of Physics and Astrophysics.

"The mathematical formulation of general relativity represents spacetime as curved due to the presence of matter.... Geometrodynamics merely tells you what geodesic a freely moving object will follow. But if you constrain an object to follow some different path (or not to move at all), geometrodynamics does not tell you how or why a force arises.... Logically you wind up having to assume that a force arises because when you deviate from a geodesic you are accelerating, but that is exactly what you are trying to explain in the first place: Why does a force arise when you accelerate? ... This merely takes you in a logical full circle."

Talking about curved spacetime, the book *Pushing Gravity* (M. R. Edwards) states:

"Logically, a small particle at rest on a curved manifold would have no reason to end its rest unless a force acted on it. However successful this geometric interpretation may be as a mathematical model, it lacks physics and a causal mechanism."

General relativity does not explain why mass/energy curves spacetime or why there is a force when an object is prevented from falling freely in a gravitational field. If restraining an object from following a geodesic is the equivalent of acceleration, then apparently the gravitational force is intimately tied to the pseudo force generated when a mass is accelerated. In the standard model, particles possess no intrinsic inertia. They gain inertia from an interaction with the Higgs field. Is the Higgs field also necessary to generate a gravitational force when a particle without

intrinsic inertia is prevented from following the geodesic? Is the Higgs field always accelerating towards a mass in an endless flow that attempts to sweep along a stationary particle? The standard model does not include gravity. Is gravity a force?

The point of these questions is to show that there are logical problems with the physical model normally associated with general relativity. The equations of general relativity accurately describe gravity on a macroscopic scale. However, these equations are silent as to the physical interpretation, especially at a scale (spatial or temporal) where quantum mechanics takes over.

Gravitational Nonlinearity Examined: Previously we reasoned that spacetime must be a nonlinear medium for waves in spacetime and gravity is the result of this nonlinearity. At distance λ_c from a rotar we calculated the gravitational force using one of the 5 wave-amplitude equations $F = A^2\omega^2 Z\mathcal{A}/c$. In this calculation we substituted $A = A\beta^2 = (L_p/\lambda_c)^2 = (T_p\omega_c)^2$. Also the angular frequency ω is equal to the rotar's Compton frequency $\omega = \omega_c$. At distance λ_c of two of the same rotars we obtained $F = Gm^2/\lambda_c^2$. This is the correct magnitude of the gravitational force between two rotars of mass m , but there are two problems. First: the equation $F = A^2\omega^2 Z\mathcal{A}/c$ is for a traveling wave striking a surface. This traveling wave implies the radiation of power that is not happening. Second: a wave in spacetime traveling at the speed of light generates a repulsive force if it interacts in a way that the wave is deflected or absorbed. Gravity is obviously an attractive force. We have the magnitude of the force correct, but the model must be refined so that there is no loss of power and so that the force is an attraction.

There are several steps involved, and it is probably desirable to begin with a brief review. Recall that we are dealing with dipole waves in spacetime which modulate both the rate of time and volume. There are two ways that we can express the amplitude of the dipole in spacetime: displacement amplitude and strain amplitude. The maximum displacement of spacetime allowed by quantum mechanics is a spatial displacement of Planck length or a temporal displacement of Planck time. Since these are oscillation amplitudes, we sometimes use the term "dynamic Planck length L_p " or "dynamic Planck time T_p ". As previously explained, these distortions of spacetime produce a strain in spacetime. The strain is a dimensionless number equivalent to $\Delta l/l$ or $\Delta t/t$. In this case $\Delta l/l = L_p/\lambda_c$ and $\Delta t/t = T_p\omega_c$.

In chapter 5 we imagined a hypothetical perfect clock placed at a point on the "Compton circle" of a rotar as illustrated in figure 5-1. This is the imaginary circle with radius equal to the rotar radius λ_c . This clock (hereafter called the "dipole clock" with time τ_d) was compared to the time on another clock that we called the "coordinate clock" (with time t_c). This coordinate clock is measuring the rate of time if there was no spacetime dipole present. It is also possible to think of the coordinate clock as located far enough from the rotating dipole that it does not feel any significant time fluctuations. Figure 5-3 shows the difference in the indicated time $\Delta t = \tau_d - t_c$. The dipole clock speeds up and slows down relative to the coordinate clock and the maximum difference is dynamic Planck time T_p . Therefore T_p is the temporal displacement amplitude.

There is also spatial displacement amplitude that is equal to dynamic Planck length L_p . The strain of spacetime produced by these displacements of spacetime is depicted in figure 5-4. Within the rotar volume, the strain of spacetime is designated by the strain amplitude $A_\beta = T_p \omega_c = L_p / \lambda_c$. This is equivalent to the maximum slope of the sine wave which occurs at the zero crossing points in figure 5-3.

Nonlinear Effects: The above review now has brought us to the point where we can ask interesting questions: Does the dipole clock always return to perfect synchronization with the coordinate clock at the completion of each cycle? Does the volume oscillation of spacetime produce a net change in the average volume near a rotar? Since we are going to initially concentrate on explaining the gravitational force between two fundamental particles, we will initially concentrate on the effect on time. Therefore, does the rate of time oscillation cause the dipole clock to show a net loss of time compared to the coordinate clock? If spacetime has no nonlinearity then the clocks would remain substantially synchronized. However, if there is nonlinearity, the dipole clock would slowly lose time.

As previously explained, the strain of spacetime (instantaneous slope in figure 5-3) has a linear component and a nonlinear component. The proposed spacetime strain equation for a point on the edge of the rotating dipole is:

$$\text{Strain} = A_\beta \sin \omega t + (A_\beta \sin \omega t)^2 \dots \quad (\text{higher order terms ignored})$$

The linear component is " $A_\beta \sin \omega t$ " and the first term in the nonlinear component is $(A_\beta \sin \omega t)^2$. There would also be higher order terms where A_β is raised to higher powers, but these would be so small that they would be undetectable and will be ignored. This nonlinear component can be expanded:

$$(A_\beta \sin \omega t)^2 = A_\beta^2 \sin^2 \omega t = \frac{1}{2} A_\beta^2 - \frac{1}{2} A_\beta^2 \cos 2\omega t$$

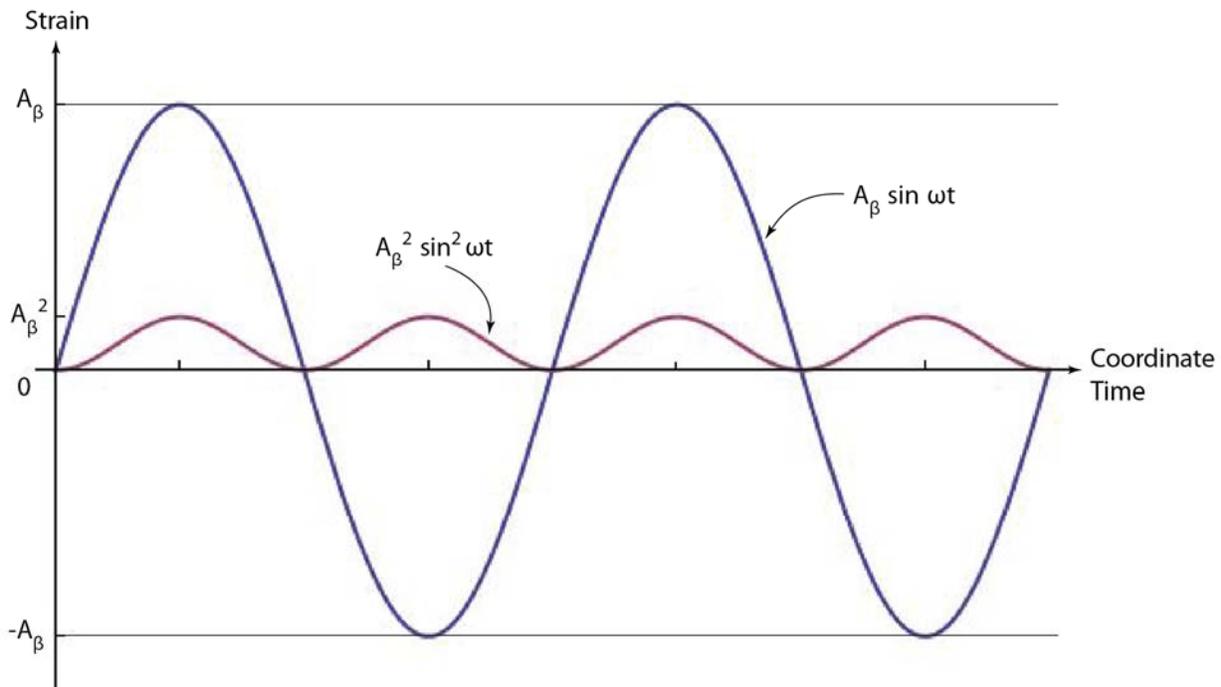


FIGURE 8-1

Figure 8-1 plots the linear component ($A_\beta \sin \omega t$) and the nonlinear component $(A_\beta \sin \omega t)^2$ separately. It can be seen that the nonlinear component is a smaller amplitude because $A_\beta < 1$ and squaring this produces a smaller number. Also the nonlinear component is at twice the frequency of the linear component. Most importantly, the nonlinear component is always positive. Making an electrical analogy, this can be thought of as if the nonlinear wave has an AC component and a DC component. It is obvious that when the linear and nonlinear waves are added together, the sum will produce an unsymmetrical wave that is biased in the positive direction.

It was necessary to use some artistic license in order to illustrate these concepts in figure 8-1. For fundamental rotars the value of A_β is roughly in the range of 10^{-20} . This means that $A_\beta^2 \approx 10^{-40}$ and therefore A_β is approximately 10^{20} times larger than A_β^2 . It would be impossible to see the plot of $A_\beta^2 \sin^2 \omega t$ without artificially increasing this relative amplitude. Therefore, the assumed value in this figure is $A_\beta = 0.2$. In this case the difference between A_β and A_β^2 is only a factor of 5 rather than a factor of roughly 10^{20} . Therefore, for fundamental rotars it is necessary to mentally decrease the amplitude of the nonlinear wave by roughly a factor of roughly 10^{20} .

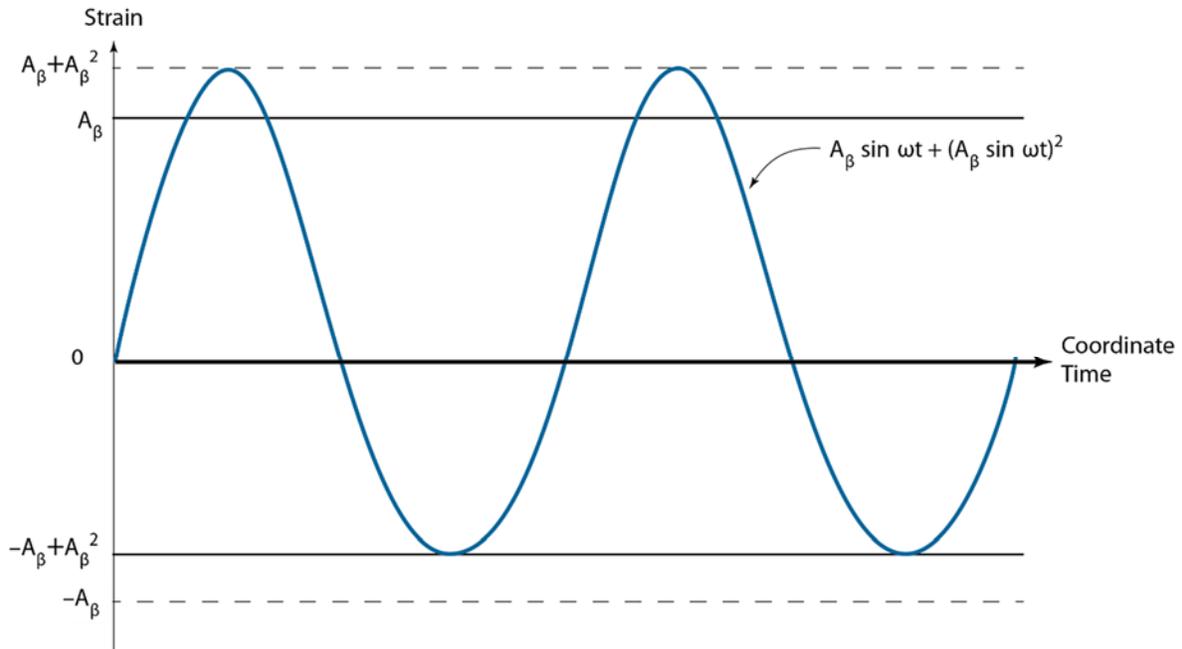


FIGURE 8-2

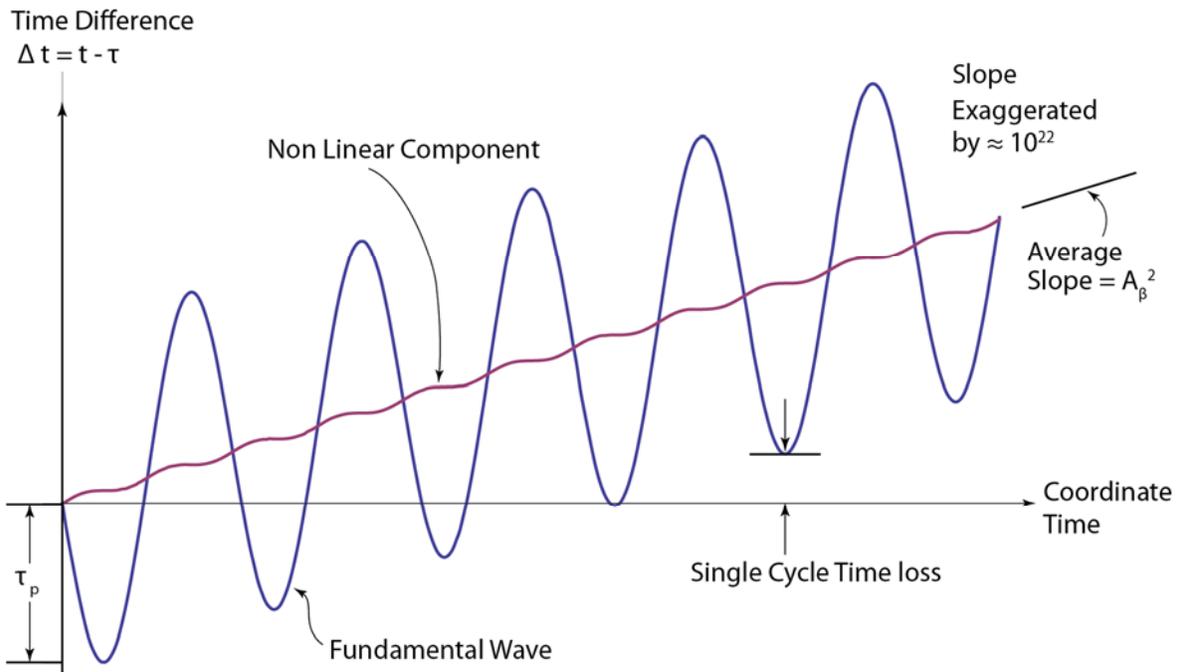


FIGURE 8-3

When we add the two waves together we obtain the plot in figure 8-2. Because of the artistic license, it is visually obvious that this is an unsymmetrical wave. There is a larger area under the positive portion of the wave than the area under the negative portion of the wave. The peak amplitude for the positive portion is $A_\beta + A_\beta^2$ while the negative portion has peak negative

amplitude of: $-A_\beta + A_\beta^2$. If this was a plot of electrical current, we would say that this unsymmetrical wave had a DC bias on an AC current. To use the analogy further, it is as if the nonlinearity causes spacetime to have the equivalent of a small DC bias in its stress.

The dipole clock does not return to synchronization with the coordinate clock each cycle. Figure 8-3 attempts to illustrate this with a greatly exaggerated plot of the difference between the coordinate clock and the dipole clock. The “X” axis of this figure is time as indicated on the coordinate clock while the “Y” axis is the difference between the coordinate clock and the dipole clock ($t - \tau$). If the two clocks ran at exactly the same rate of time, the plot would be a straight line along the “X” axis. Normally this plot for a few cycles should look like a sine wave similar to figure 5-3. However, the purpose of figure 8-3 is to illustrate that over time the coordinate clock pulls ahead of the dipole clock (or the dipole clock loses time). Therefore, for purposes of illustration, this effect of the accumulated time difference has been exaggerated by a factor of roughly 10^{22} .

The unsymmetrical strain plot in figure 8-2 produces a net loss of time on the dipole clock relative to the coordinate clock. In the first quarter cycle of figure 8-3, the coordinate clock falls behind the dipole clock by an amount approximately equal to Planck time. This occurs when the fast lobe of the rotating dipole passes the dipole clock first. However, with each cycle, the coordinate clock gains a small amount of time on the dipole clock. The amount of time gained per cycle is illustrated by the gap labeled “Single cycle time loss”. This is equal to $T_p^2 \omega_c$ which is about 2.2×10^{-66} s for an electron.

The point of figure 8-3 is to illustrate the contribution of the nonlinear effect. The nonlinear wave with strain of $A_\beta^2 \sin^2 \omega t$ at distance λ_c produces the contribution that causes the net loss of time for the dipole clock relative to the coordinate clock. This net time difference between the two clocks (after subtracting $A_\beta \sin \omega t$) is shown as the wavy line labeled “nonlinear component”. The average slope of this line is equal to the gravitational magnitude for the rotar volume which has been designated as $A_\beta^2 = \beta_q$. For an electron this slope is about 1.75×10^{-45} which means that it takes about 30 seconds for the coordinate clock to have a net time gain of Planck time over the dipole clock. This takes about 4×10^{21} cycles rather than 4 cycles as illustrated in figure 8-3. If we subtracted the nonlinear wave component from figure 8-3, we would be left with a sine wave with amplitude of T_p .

The slope on this nonlinear wave component is A_β^2 at distance λ_c which is obtained from the strain equation – the important part is highlighted bold

$$A_\beta \sin \omega t + (A_\beta \sin \omega t)^2 = A_\beta \sin \omega t - \frac{1}{2} A_\beta^2 \cos 2\omega t + \frac{1}{2} A_\beta^2$$

Derivation of Curved Spacetime: The DC equivalent term (non-oscillating term) is A_β^2 . This is the nonlinear strain in spacetime produced by the rotar at distance λ_c . This is an important

concept since it relates to curved spacetime. Before perusing this thought further it is necessary to introduce a new symbol: \mathcal{N} . The natural unit of length for a rotar is λ_c . Therefore we will designate the radial distance from a rotar not in units of length such as meters, but as the number \mathcal{N} of reduced Compton wavelengths (number of rotar radius units).

$$\mathcal{N} \equiv \frac{r}{\lambda_c} = \frac{mcr}{\hbar}$$

For example, the non-oscillating strain in spacetime produced by a rotar should decrease proportional to $1/\mathcal{N}$. We can test this idea since the proposal is that the non-oscillating strain in spacetime at distance λ_c (where $\mathcal{N} = 1$) is equal to A_β^2 and this decreases as $1/\mathcal{N}$. We will evaluate A_β^2/\mathcal{N} and call this the gravitational amplitude A_g .

$$A_g = \frac{A_\beta^2}{\mathcal{N}} = \left(\frac{L_p^2}{\lambda_c^2} \right) \left(\frac{\lambda_c}{r} \right) = \frac{Gm}{c^2 r}$$

Therefore we have succeeded in producing the previously discussed weak gravity gravitational magnitude $\beta \approx Gm/c^2 r$. This is the curvature of spacetime that we associate with gravity.

This simple evaluation is another success of this model because the term $Gm/c^2 r$ is the weak gravity curvature of spacetime produced by mass m at distanced r . For example, the previously defined gravitational magnitude is $\beta \equiv 1 - (d\tau/dt)$. The weak gravity temporal distortion of spacetime is: $dt/d\tau \approx 1 + (Gm/c^2 r)$. In flat spacetime $dt/d\tau = 1$, so the weak gravity curvature term is $\beta \approx (Gm/c^2 r)$. For fundamental particles (rotars) at distance λ_c this term is in the range of 10^{-40} , so this is virtually exact.

The question of how matter “causes” curved spacetime has been a major topic in general relativity and quantum gravity. Now we see the mechanism of how dipole waves in spacetime produce both matter and curved spacetime. This uses equations from quantum mechanics to derive an equation from general relativity. This is not only a successful test of the spacetime based model, but it is also a prediction of this model of the mechanism that achieves curved spacetime.

Oscillating Component of Gravity: There is proposed to be another residual gravitational effect that has not been observed because it is a very weak oscillation at a frequency in excess of 10^{20} Hz. In figure 8-3 the non-linear wave component is shown as a wavy line labeled “nonlinear component”. We can interact with the non-oscillating part of this line responsible for gravity, but there is also a residual nonlinear oscillating component. At distance λ_c this oscillating component has amplitude A_β^2 and frequency $2\omega_c$. What happens to this oscillating component beyond λ_c in the external volume? We know that the few frequencies that form stable and semi

stable rotars exist at resonances with the vacuum fluctuations of spacetime which eliminate energy loss. If the amplitude of the oscillating component was A_{β^2}/\mathcal{N} , then there would be continuous radiation of energy. Energetic composite particles such as protons or neutrons would radiate away all their energy in a few million years. In the chapter 10 an analogy will be made to the energy density of a rotar's electric field. The amplitude term for the oscillating component of gravity will then be proposed to scale as $A_{\beta^2}/\mathcal{N}^2$. This would be an extremely small amplitude and furthermore it is a standing wave that does not radiate energy. However, this oscillating component would theoretically give energy density to a gravitational field. The energy density of a gravitational field and its contribution to producing curved spacetime will be discussed at the end of chapter 10. The oscillating component of a gravitational field may also be important in the evolution of the universe. This will be discussed in chapters 13 and 14.

Summary: Since we need to bring together several different components to achieve gravitational attraction, we will do another review. This time we will emphasize the role of vacuum energy, circulating power, the canceling wave and non-oscillating strain in spacetime. A rotar is a rotating spacetime dipole immersed in a sea of vacuum energy which is equivalent to a vacuum pressure. This vacuum energy/pressure is made up of very high energy density ($> 10^{46}$ J/m³) dipole waves in spacetime that lack angular momentum. The rotar also has a high energy density that is attempting to radiate away energy at the rate of the rotar's circulating power. The rotar survives because it exists at one of the few frequencies that achieve a resonance with the vacuum energy/pressure.

This resonance creates a new wave that has a component that propagates radially away from the rotating dipole and a component that propagates radially towards the rotating dipole. (Tangential wave components are also created, but these add incoherently and effectively disappear.) The resonant wave that is propagating away from the dipole cancels out the fundamental radiation from the dipole. Besides having the correct frequency and phase to produce destructive interference, the canceling wave also must match the rotar's circulating power. This means that the correct pressure is generated from the vacuum energy/pressure that is required to contain the energy density of the rotar. Only a few frequencies that form stable rotars completely satisfy these conditions.

For example, an electron has a circulating power of about 64 million watts. In order to cancel this much power from being radiated from the rotar volume, the cancelation wave generated in the vacuum energy must have an outward propagating component of 64 million watts attempting to leave the rotar's volume and an inward propagating component of the same power. The recoil from the outward propagating component provides the pressure required to stabilize the rotating dipole that is the rotar (the electron). This pressure can be thought of as being carried by the inward propagating component that replenishes the rotating dipole.

If it was possible to see this process, we would not see outward or inward propagating waves. We would only see the sum of these two waves which is a standing wave which decreases in amplitude with distance from the central rotar. A standing wave in the rotar's external volume means that no power is being radiated. These standing waves cause the rotar's electric field (discussed later). We would also see that there was a slight non-oscillating residual strain in spacetime with strain amplitude of $A\beta^2/\mathcal{N} = gm/c^2 r$.

Newtonian Gravitational Force Equation: There are still two more steps before we arrive at the explanation that gives the correct attracting force at arbitrary distance between two rotars. We will start by assuming two of the same rotars (mass m) separated by distance r . It was previously explained that deflecting all of a rotar's circulating power generates the rotar's maximum force F_m . A rotar always depends on the pressure of the spacetime field to contain its circulating power. When the rotar is isolated, the force required to deflect the circulating power is balanced. However, a gravitational field produces a gradient in the gravitational magnitude $d\beta/dr$.

When a first rotar is in the gravitational field of a second rotar, there is a gradient $d\beta/dr$ that exists across the rotar radius of the first rotar. This means that there is a slight difference in the force exerted by vacuum energy/pressure on opposite sides of the first rotar. This difference in force produces a net force that we know as the force of gravity.

This will be restated in a different way because of its importance. Imagine mass m , being a rotar (rotating dipole) attempting to disperse but being contained by pressure generated within the vacuum energy/pressure previously discussed. This pressure exactly equals the dispersive force of the dipole wave rotating at the speed of light. However, if there is a gradient in the gravitational magnitude $d\beta/dr$ then there is a gradient across the rotar which we will call $\Delta\beta$. This affects the normalized speed of light and the normalized unit of force on opposite sides of the rotar. Recall from chapter 3 we had:

$$\begin{aligned} C_o &= \Gamma C_g && \text{normalized speed of light transformation} \\ F_o &= \Gamma F_g && \text{normalized force transformation} \\ \Gamma &\approx 1 + \beta && \text{approximation considered exact for rotars} \end{aligned}$$

Therefore, because of the strain in spacetime, the two sides of the rotar (separated by λ_c) are living under what might be considered to be different standards for the normalized speed of light and normalized force. On an absolute scale, it takes a different amount of pressure to stabilize the opposite sides of the rotar because of the gradient $\Delta\beta$ across the rotar. The net difference in this force is the force of gravity exerted on the rotar.

We will first calculate the change in gravitational magnitude $\Delta\beta$ across the rotar radius λ_c of a rotar when it is in the gravitational field of another similar rotar (another rotar of the same

mass). In other words, we will calculate the difference in β at distance r and distance $r + \lambda_c$ from a rotar of mass m .

$$\Delta\beta = \left(\frac{Gm}{c^2 r}\right) - \left(\frac{Gm}{c^2 (r+\lambda_c)}\right) \approx \frac{Gm\lambda_c}{c^2 r^2} \quad \text{approximation valid if } \lambda_c \ll r$$

The force exerted by vacuum energy/pressure on opposite hemispheres of the rotar is equal to the maximum force $F_m = m^2 c^3 / \hbar$. The difference in the force (absolute value) exerted on opposite sides of the rotar is the maximum force times $\Delta\beta$. Therefore, the force generated by two rotars of mass m separated by distance r is:

$$F = \Delta\beta F_m = \left(\frac{Gm\lambda_c}{c^2 r^2}\right) \left(\frac{m^2 c^3}{\hbar}\right) = \left(\frac{Gm}{c^2 r^2}\right) \left(\frac{\hbar}{mc}\right) \left(\frac{m^2 c^3}{\hbar}\right) = \frac{Gm^2}{r^2}$$

If we have two different mass rotars (mass m_1 and mass m_2), then we can consider mass m_1 in the gravitational field of mass m_2 . In this case, λ_c and F_m are for mass m_1 and $\Delta\beta$ is change in the gravitational magnitude from mass m_2 across the rotar radius λ_c from mass m_1 .

$$F_g = \Delta\beta F_m \approx \left(\frac{Gm_2\lambda_{c1}}{c^2 r^2}\right) \left(\frac{m_1^2 c^3}{\hbar}\right) = \left(\frac{Gm_2}{c^2 r^2}\right) \left(\frac{\hbar}{m_1 c}\right) \left(\frac{m_1^2 c^3}{\hbar}\right)$$

$$F_g \approx \frac{Gm_1 m_2}{r^2} \quad \text{Newtonian gravitational force equation derived from a dipole wave model}$$

Gravitational Attraction: We have derived the Newtonian gravitational equation from starting assumptions, but we still have not shown that this is a force of attraction. However, from the previous considerations, this last step is easy. There is a slightly different pressure required to stabilize the rotar depending on the local value of β or Γ (in weak gravity $\Gamma \approx 1 + \beta$). This can be considered as a difference in net force exerted by vacuum energy on the hemisphere of the rotar that is furthest from the other rotar compared to the hemisphere that is nearest the other rotar. The furthest hemisphere has a smaller average value of Γ than the nearest hemisphere. The normalized speed of light is greater and the normalized force exerted on the farthest hemisphere must be greater to stabilize the rotar. This produces a net force in the direction of increasing Γ . The magnitude of this force is $F = Gm_1 m_2 / r^2$ and the vector of this force is in the direction of increasing Γ (towards the other mass).

We consider this to be a force of attraction because the two rotars want to migrate towards each other (increasing Γ). However, the force is really coming from the vacuum energy exerting a repulsive pressure. There is greater normalized pressure being exerted on the side with the lower Γ . The two rotars are really being pushed together by a force of repulsion that is unbalanced.

Corollary Assumption: The force of gravity is the result of unsymmetrical pressure exerted on a rotar by vacuum energy. This is unbalanced repulsive force that appears to be an attractive force.

Example: Electron in Earth's Gravity: We will do a plausibility calculation to see if we obtain roughly the correct gravitational force for an electron in the earth's gravitational field based on the above explanation. We will be using values for the electron's energy density and the electron's maximum force that were previously calculated by ignoring dimensionless constants. Therefore, we will continue with this plausibility calculation that ignores dimensionless constants. An electron has internal energy of $E_i = 8.19 \times 10^{-14}$ J and a rotar radius of $\lambda_c = 3.86 \times 10^{-13}$ m. Ignoring dimensionless constants, this gives an energy density of about $E_i/\lambda_c^3 \approx 1.4 \times 10^{24}$ J/m³. This rotar model of an electron is exerting a pressure of roughly 1.4×10^{24} N/m². This pressure over area λ_c^2 produces the rotar's maximum force which for an electron is $F_m = 0.212$ N (obtained from $P \lambda_c^2 \approx 1.4 \times 10^{24}$ N/m² \times $(3.86 \times 10^{-13}$ m)² = 0.212 N).

The weak gravity gravitational magnitude is: $\beta \approx Gm/c^2r$. For the earth $m = 5.96 \times 10^{24}$ kg and the equatorial radius is: $r = 6.37 \times 10^6$ m. Therefore, at the surface of the earth the gravitational magnitude is: $\beta \approx 6.95 \times 10^{-10}$. To obtain the gradient in this magnitude we divide by the earth's equatorial radius 6.37×10^6 m to obtain a gradient of $d\beta/dr = 1.091 \times 10^{-16}$ /m. The change in gravitational magnitude $\Delta\beta$ across the rotar radius (3.862×10^{-13} m) of an electron is:

$$\Delta\beta = (1.091 \times 10^{-16}/\text{m}) (3.862 \times 10^{-13} \text{ m}) = 4.213 \times 10^{-29} \quad \Delta\beta \text{ across an electron's } \lambda_c$$

The electron's internal pressure is being stabilized by the pressure being exerted by the spacetime field. However, the homogeneous spacetime field in zero gravity is modified by the earth's gravitational field. As previously calculated, gravity affects not only the rate of time and proper volume, but also the unit of force, energy, etc. The previously calculated normalized force transformation is: $F_o = \Gamma F_g$. The gradient in the earth's gravitational field means that a slightly different value of Γ exists on opposite sides of the electron. This is more conveniently expressed as a difference in the gravitational magnitude $\Delta\beta$ that exists across the electron's radius λ_c . There will be a slight difference in the force exerted by the spacetime field exerted on opposite hemispheres of the electron (rotar). Calculating this difference should equal the magnitude of the gravitational force on the electron.

$$F = \Delta\beta F_m = 4.213 \times 10^{-29} \times 0.212 \text{ N} = 8.89 \times 10^{-30} \text{ N}$$

We will now check this by calculation the force exerted on an electron by the earth's gravity using $F = mg$ where the earth's gravitational acceleration is: $g = 9.78$ m/s²

$$F = mg = 9.1 \times 10^{-31} \text{ kg} \times 9.78 \text{ m/s}^2 \approx 8.89 \times 10^{-30} \text{ N}$$

Success! The answer obtained from the calculation using $F = \Delta\beta F_m$ is exactly correct. Apparently the ignored dimensionless constants cancel. This is another successful plausibility test.

At the beginning of this chapter two quotes were presented that pointed out that general relativity does not identify the source of the force that occurs when a particle is restrained from following the geodesic. M. R. Edwards states: "However successful this geometric interpretation may be as a mathematical model, it lacks physics and a causal mechanism." The ideas proposed in this book give a conceptually understandable explanation for both the magnitude and the vector direction of the gravitational force. The gravitational force was obtained from the starting assumptions without using analogy of acceleration.

Electrostatic Force at Arbitrary Distance: The strain amplitude of the spacetime wave inside the rotar volume has been designated with the symbol $A_\beta = L_p/\lambda_c = T_p\omega_c$. We have just shown that the gravitational effect external to the rotar volume scales with $A_g = A_\beta^2/\mathcal{N} = gm/c^2r$. This is the gravitational curvature of spacetime produced by a rotar with radius λ_c and angular frequency ω_c . Now we will examine the electromagnetic effect on spacetime produced by the effect of the fundamental wave with amplitude A_β (not squared). From chapter 6 we know that this amplitude is associated with the electrostatic force. Now we will extend this to arbitrary distance. As before, we need to match the known amplitude at distance λ_c . This is achieved by scaling distance using $\mathcal{N} \equiv r/\lambda_c$ because $\mathcal{N} = 1$ at distance λ_c . We will again assume that the electrostatic amplitude A_E decreases as $1/\mathcal{N}$ for the electrostatic force we assume $A_E = A_\beta/\mathcal{N} = (L_p/\lambda_c)(\lambda_c/r)$. We will use the equation $F = kA^2\omega^2Z_s\mathcal{A}/c$ and also insert the following: $F = F_E$, $\omega = \omega_c$, $Z = Z_s = c^3/G$, $\mathcal{N} = r/\lambda_c$, $\lambda_c = k\lambda_c^2$ and $\hbar c = q_p^2/4\pi\epsilon_0$

$$F_E = A_E^2\omega_c^2Z_s\mathcal{A}/c = \left(\frac{L_p}{\lambda_c}\right)^2 \left(\frac{\lambda_c}{r}\right)^2 \left(\frac{c}{\lambda_c}\right)^2 \left(\frac{c^3}{G}\right) \left(\frac{\lambda_c^2}{c}\right) = k \frac{\hbar c}{r^2} = k \frac{q_p^2}{4\pi\epsilon_0 r^2}$$

Therefore, we have generated the Coulomb law equation where the charge is $q = q_p$ (Planck charge). It should not be surprising that the charge obtained is Planck charge rather than elementary charge e . Planck charge is $q_p = \sqrt{4\pi\epsilon_0\hbar c}$ (about 11.7 times charge e) and is based on the permittivity of free space ϵ_0 . Planck charge is known to have a coupling constant to photons of 1 while elementary charge e has a coupling constant to photons of α , the fine structure constant. This calculation is actually the maximum possible electrostatic force which would require a coupling constant of 1. The symbol F_E implies the electrostatic force between two Planck charges while F_e implies the electrostatic force between two elementary charges e . The conversion is $F_E = F_e \alpha^{-1}$.

We will continue to use the equation: $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ even though it implies the emission of power which is striking area \mathcal{A} and exerting a repulsive force. This is not happening but the use of $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ gives the correct magnitude of forces. This simplified equation allows a lot of quick calculations to be made which give correct magnitude.

Calculation with Two Different Mass Particles: Until now we have assumed two of the same mass/energy particles when we calculated F_g and F_E . Now we will assume two different mass particles (m_1 and m_2), but we will keep the assumption that both particles have Planck charge. When we have two different mass particles, this means that we have two different reduced Compton wavelengths ($\lambda_{c1} = \hbar/m_1 c$ and $\lambda_{c2} = \hbar/m_2 c$). The single radial separation r now becomes two different values $\mathcal{N}_1 = r/\lambda_{c1}$ and $\mathcal{N}_2 = r/\lambda_{c2}$. Also, there would be two different strain amplitudes $A_{\beta 1} = L_p/\lambda_{c1}$ and $A_{\beta 2} = L_p/\lambda_{c2}$ as well as a composite area $\mathcal{A} = k\lambda_{c1}\lambda_{c2}$.

$$F_g = k \left(\frac{A_{\beta 1}^2 A_{\beta 2}^2}{\mathcal{N}_1 \mathcal{N}_2} \right) \left(\frac{c^2}{\lambda_{c1} \lambda_{c2}} \right) \left(\frac{c^3}{G} \right) \left(\frac{\lambda_{c1} \lambda_{c2}}{c} \right) = k \frac{G m_1 m_2}{r^2}$$

$$F_E = k \left(\frac{A_{\beta 1} A_{\beta 2}}{\mathcal{N}_1 \mathcal{N}_2} \right) \left(\frac{c^2}{\lambda_{c1} \lambda_{c2}} \right) \left(\frac{c^3}{G} \right) \left(\frac{\lambda_{c1} \lambda_{c2}}{c} \right) = k \frac{q_p^2}{4\pi\epsilon_0 r^2}$$

Note that the only difference between the intermediate portions of these two equations is that the gravitational force F_g has the strain amplitude terms squared ($A_{\beta 1}^2 A_{\beta 2}^2$) and the electrostatic force F_E has the strain amplitude terms not squared ($A_{\beta 1} A_{\beta 2}$). The tremendous difference between the gravitational force and the electrostatic force is due to a simple difference in exponents.

Unification of Forces: In chapter 6 we found that there is a logical connection between the gravitational force and the electromagnetic force. However, those calculations were done only for separation distance equal to λ_c . Now we will generate some more general equations for arbitrary separation distance expressed as \mathcal{N} , the number of reduced Compton wavelengths. The following equations could be made assuming two different mass particles, but it is easier to return to the assumption of both particles having the same mass because then we can designate a single value of \mathcal{N} separating the particles. Some of the following equations assume Planck charge q_p with force designation F_E rather than charge e designated with force F_e . The conversion is $F_E = F_e \alpha^{-1}$.

We will start by converting the Newton gravitational equation and the Coulomb law equation so that they are both expressed in natural units. This means that both the forces and the particle's energy will be in Planck units ($\underline{F}_g = F_g/F_p$, $\underline{F}_E = F_E/F_p$, $\underline{E}_i = E_i/E_p$). Also separation distance will be expressed in the particles natural unit of length, the number $\mathcal{N} = r/\lambda_c$ of reduced Compton wavelengths. Also, we assume two particles each have the same mass/energy and they both have Planck charge.

Convert both equations: $F_E = q_p^2/4\pi\epsilon_0 r^2$ and $F_g = Gm^2/r^2$ into equations using \underline{F}_g ; \underline{F}_E and \mathcal{N} .

Substitutions: $r = \mathcal{N}\hbar c/E_i$; $m = E_i/c^2$; $E_i = \underline{E}_i E_p = \underline{E}_i \sqrt{\hbar c^5/G}$

$$\underline{F}_E = \frac{F_E}{F_p} = \left(\frac{q_p^2}{4\pi\epsilon_0 r^2} \right) \frac{1}{F_p} = \left(\frac{4\pi\epsilon_0 \hbar c}{4\pi\epsilon_0} \right) \left(\frac{E_i}{\mathcal{N}\hbar c} \right)^2 \left(\frac{G}{c^4} \right) = \frac{E_i^2 G}{\hbar c^5 \mathcal{N}^2} = \underline{E}_i^2 / \mathcal{N}^2$$

$$\underline{F}_g = \frac{F_g}{F_p} = \left(\frac{Gm^2}{r^2} \right) \frac{1}{F_p} = \left(\frac{G E_i^2}{c^4} \right) \left(\frac{E_i}{\mathcal{N}\hbar c} \right)^2 \left(\frac{G}{c^4} \right) = E_i^4 \left(\frac{G^2}{\hbar^2 c^{10} \mathcal{N}^2} \right) = \frac{E_i^4}{E_p^4 \mathcal{N}^2} = \underline{E}_i^4 / \mathcal{N}^2$$

$$(\underline{F}_g \mathcal{N}^2) = (\underline{F}_E \mathcal{N}^2)^2 = \underline{E}_i^4$$

The equation $(\underline{F}_g \mathcal{N}^2) = (\underline{F}_E \mathcal{N}^2)^2$ clearly shows that even with arbitrary separation distance the square relationship between F_g and F_E still exists. It is informative to state these same equations in terms of power because a fundamental assumption of this book is that there is only one truly fundamental force $F_r = P_r/c$. If this is correct, then we would expect that the force relationship between rotars would also be a simple function of the rotar's circulating power: $P_c = E_i \omega_c = m^2 c^4 / \hbar$. To convert P_c to dimensionless Planck units $\underline{P}_c = P_c / P_p$ we divide by Planck power $P_p = c^5 / G$. Note the simplicity of the result.

$$\underline{F}_E = \underline{P}_c / \mathcal{N}^2$$

$$\underline{F}_g = \underline{P}_c^2 / \mathcal{N}^2$$

So far we have used dimensionless Planck units because they show the square relationship between forces most clearly. However, we will now switch and use equations with standard units. The next equation will first be explained with an example. We will assume either two electrons or two protons (both charge e) and we hold them apart at an arbitrary separation distance r . As before, this separation distance will be designated using the number \mathcal{N} of reduced Compton wavelengths, therefore $r = \mathcal{N} \lambda_c$. Protons are composite particles, but we can still use them in this example if we use the proton's total mass when calculating \mathcal{N} .

Now we imagine a log scale of force. At one end of this force scale we place the largest possible force which is Planck force $F_p = c^4 / G$. At the other end of this log scale of force we place the gravitational force F_g which is weakest possible force between the two particles (either 2 electrons or 2 protons). Now for the magical part! Exactly half way between these two extremes on the log scale of force is the composite force $F_e \mathcal{N} \alpha^{-1}$. In words, this is the electrostatic force F_e between the two particles times the number \mathcal{N} of reduced Compton wavelengths times the inverse of the fine structure constant ($\alpha^{-1} \approx 137$). Particle physicists like to talk about various symmetries. I am claiming that there is a force symmetry between the gravitational force, Planck force and the composite force $F_e \mathcal{N} \alpha^{-1}$. The equation for this is:

$$\frac{F_g}{F_e \mathcal{N} \alpha^{-1}} = \frac{F_e \mathcal{N} \alpha^{-1}}{F_p}$$

It is informative to give a numerical example which illustrates this equation. Suppose that two electrons are separated by 68 nanometers (this distance simplifies explanations). The electrons experience both a gravitational force F_g and an electrostatic force F_e . The electrons have $\lambda_c = 3.86 \times 10^{-13}$ m, therefore this separation is equivalent to $\mathcal{N} = 1.76 \times 10^5$ reduced Compton wavelengths. The gravitational force between the two electrons at this distance would be $F_g = 1.2 \times 10^{-56}$ N and the electrostatic force would be $F_e = 5 \times 10^{-14}$ N. Also $\alpha^{-1} \approx 137$ so combining

F_e , \mathcal{N} and α^{-1} we have: $F_e\mathcal{N}\alpha^{-1} = 1.2 \times 10^{-6}$ N. Also Planck force is $F_p = c^4/G = 1.2 \times 10^{44}$ N. To summarize and see the symmetry between these forces, we will write the forces as follows:

$$\begin{aligned} F_g &= 1.2 \times 10^{-56} \text{ N} & F_g \text{ for two electrons at } 6.8 \times 10^{-8} \text{ m is } 10^{50} \text{ times smaller than } F_e\mathcal{N}/\alpha \\ F_e\mathcal{N}\alpha^{-1} &= 1.2 \times 10^{-6} \text{ N} & F_e\mathcal{N}/\alpha \text{ for two electrons at } 6.8 \times 10^{-8} \text{ m} \\ F_p &= 1.2 \times 10^{44} \text{ N} & F_p \text{ (Planck force) is } 10^{50} \text{ times larger than previous } F_e\mathcal{N}/\alpha \end{aligned}$$

Another way of stating this relationship would set Planck force equal to 1. Therefore when $F_p = 1$ then $F_e\mathcal{N}\alpha^{-1} = 10^{-50}$ and $F_g = 10^{-100}$. The numerical values are not important because different mass particles or different separation distance could be used. The important point is the symmetry between F_p , F_e and F_g when we include \mathcal{N} and α^{-1} in the composite force $F_e\mathcal{N}\alpha^{-1}$.

Force Ratios F_g/F_E and $F_g/F_e\alpha^{-1}$: Next we will show how the wave structure of particles and forces directly leads to equations which connect the electrostatic force and gravity. Previously we started with the wave-amplitude equation $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ which is applicable to waves in spacetime. In this equation A is strain amplitude, ω_c is Compton angular frequency, Z_s is the impedance of spacetime $Z_s = c^3/G$ and \mathcal{A} is particle area. We have shown that the inserting the strain amplitude term $A = A_\beta/\mathcal{N}$ into $F = kA^2\omega_c^2Z_s\mathcal{A}/c$ gives the electrostatic force between two Planck charges F_e . We have also shown that gravity is a nonlinear effect which scales with strain amplitude squared (A_β^2). Inserting $A = A_\beta^2/\mathcal{N}$ into this equation gives the gravitational force F_g between two equal mass particles. Since we have equations which generate F_E and F_g , we should be able to generate new equations which give the ratio of forces F_g/F_E . In the following $A_\beta = L_p/\lambda_c = T_p\omega_c$. For gravity, $A = A_g = A_\beta^2/\mathcal{N}$ and for electrostatic force $A = A_E = A_\beta/\mathcal{N}$.

$$\begin{aligned} F_g &= k(A_\beta^2/\mathcal{N})^2\omega_c^2Z_s\mathcal{A}/c & F_g = \text{gravitational force between two of the same mass particles} \\ F_E &= k(A_\beta/\mathcal{N})^2\omega_c^2Z_s\mathcal{A}/c & F_E = \text{the electrostatic force between two particles with Planck charge} \end{aligned}$$

Set common terms equal to each other: $(k\omega_c^2Z_s\mathcal{A}/c) = (k\omega_c^2Z_s\mathcal{A}/c)$

$$\frac{F_g}{F_E} = \left(\frac{A_\beta^2}{\mathcal{N}}\right)^2 \left(\frac{\mathcal{N}}{A_\beta}\right)^2 \quad \text{where: } A_\beta = L_p/\lambda_c = T_p\omega_c = \text{rotar strain amplitude}$$

$$\frac{F_g}{F_E} = A_\beta^2 = \left(\frac{L_p}{\lambda_c}\right)^2 = (T_p\omega_c)^2 = \frac{F_g}{F_e\alpha^{-1}}$$

The equation $F_g/F_E = A_\beta^2$ shows most clearly the validity of the spacetime based model of the universe proposed here. Recall that all fermions and bosons are quantized waves which produce the same displacement of spacetime. The spatial displacement is equal to Planck length L_p and the temporal displacement is Planck time T_p . Even though all waves produce the same displacement of spacetime, different particles have different wave strain amplitudes because the strain amplitude is the maximum slope (maximum strain) produced by the wave. Therefore a rotar's strain amplitude is $A_\beta = L_p/\lambda_c = T_p\omega_c$. **Now we discover that the force produced by particles with strain amplitude A_β reveal their connection to the underlying physics because $F_g/F_E = A_\beta^2$.**

All the previous equations relating F_g and F_E either specified either a specific separation or specified separation distance using \mathcal{N} . However, $F_g/F_E = A_\beta^2$ does not specify separation. This is possible because the ratio of the gravitational force to the electrostatic force is independent of distance. For example, the ratio for an electron is $F_g/F_e = 2.4 \times 10^{-43}$. However, when we adjust for the coupling constant associated with charge e , the ratio becomes: $F_g/F_e \alpha^{-1} = 1.75 \times 10^{-45}$. The rotar strain amplitude for an electron is $A_\beta = L_p/\lambda_c \approx 4.185 \times 10^{-23}$. Therefore $A_\beta^2 = 1.75 \times 10^{-45}$. Clearly, the derivation of this equation and the physics behind it give strong proof of the wave-based structure of particles and forces. Next we will extend the relationship between these forces one more step to bring a new perspective.

$$\frac{F_g}{F_E} = \frac{L_p^2}{\lambda_c^2} = \left(\frac{\hbar G}{c^3}\right) \left(\frac{mc}{\hbar}\right)^2 = \left(\frac{Gm}{c^2}\right) \left(\frac{mc}{\hbar}\right)$$

$$\frac{F_g}{F_E} = \frac{R_s}{\lambda_c} \quad \text{or:} \quad \frac{F_g}{F_e \alpha^{-1}} = \frac{R_s}{\lambda_c}$$

The equation $F_g/F_E = R_s/\lambda_c$ is very interesting because F_g/F_e is a ratio of forces and R_s/λ_c is a ratio of radii. Recall that $R_s \equiv Gm/c^2$ is the Schwarzschild radius of a rotar because it would form a black hole rotating at the speed of light. Such a black hole has half the Schwarzschild radius of a non-rotating black hole therefore $R_s = Gm/c^2$. Also, $\lambda_c = \hbar/mc$ is the radius of the rotar model of a fundamental particle. For example, for an electron $R_s = 1.24 \times 10^{-54}$ m and an electron's rotar radius is: $\lambda_c = 3.85 \times 10^{-13}$ m. These two numbers seem completely unrelated, yet together they equal the electron's force ratio $F_g/F_e \alpha^{-1} = 1.75 \times 10^{-45} = R_s/\lambda_c$.

However, as the following equations show, there are two amazing connections between R_s and λ_c . First, $R_s \lambda_c = L_p^2$. The second is $\underline{R}_s = \underline{\lambda}_c^{-1}$. In words, this says that the rotar's Schwarzschild radius ($R_s \equiv Gm/c^2$) is the inverse of the reduced Compton radius when both are expressed in the natural units of spacetime which are dimensionless Planck units (\underline{R}_s and $\underline{\lambda}_c$ underlined).

$$R_s \lambda_c = \left(\frac{Gm}{c^2}\right) \left(\frac{\hbar}{mc}\right) = \frac{\hbar G}{c^3}$$

$$R_s \lambda_c = L_p^2$$

$$\underline{R}_s = \underline{\lambda}_c^{-1} \quad \text{equivalent to:} \quad R_s/L_p = L_p/\lambda_c$$

The Schwarzschild radius comes from general relativity and is considered to be completely unconnected to quantum mechanics. A particle's reduced Compton wavelength comes from quantum mechanics and is considered to be completely unconnected to general relativity. However, when they are expressed in natural units (dimensionless Planck units) the two radii are just the inverse of each other $\underline{R}_s = 1/\underline{\lambda}_c$. Also $R_s \lambda_c = L_p^2$. The relationships between R_s and

λ_c are compatible with the wave-based rotar model of fundamental particles but they are incompatible with the messenger particle hypothesis of force transmission.

To summarize all the equations equal to F_g/F_E plus a few more we have:

$$F_g/F_E \alpha^{-1} = F_g/F_E = R_s/\lambda_c = A\beta^2 = \underline{R}_s^2 = \underline{\lambda}_c^{-2} = \underline{\omega}_c^2 = \underline{E}_i^2 = \underline{P}_c$$

All the previous force equations also work with composite particles such as protons if the proton's total mass is used to calculate the various terms such as $\lambda_c = \hbar/mc$. For example, two protons have $F_g/F_E \alpha^{-1} = 5.9 \times 10^{-39}$ at any separation distance. Also for protons $R_s/\lambda_c = 5.9 \times 10^{-39}$ and $(L_p/\lambda_c)^2 = 5.9 \times 10^{-39}$.

I want to pause for a moment and reflect on the implications of all the previous equations which show the relationship between the electrostatic force and the gravitational force. To me, they clearly imply several things. These are:

- 1) Gravity can be expressed as the square of the electrostatic force when separation distance is expressed as \mathcal{N} multiples of the reduced Compton wavelength λ_c .
- 2) The equations relating the gravitational and electrostatic forces imply that they both scale as a fundamental function of a particle's quantum mechanical properties such as Compton wavelength or Compton frequency.
- 3) All the connections between the gravitational force and the electrostatic force are proposed to be traceable to a rotar generating a Compton frequency standing wave in the surrounding volume. Spacetime is a nonlinear medium, so a single standing wave has both a fundamental component (electrostatic) and a nonlinear component (gravity).
- 4) The electromagnetic force is universally recognized as being a real force. The equations show that gravity is closely related. Therefore, gravity is also a real force.
- 5) These equations are incompatible with virtual photons transferring the electrostatic force or gravitons transferring the gravitational force. The equations also appear to be incompatible with string theory.
- 6) There is a quantum mechanical connection between a particle's rotar radius and its Schwarzschild radius.

Derivation of the Equations: I want to relate a brief story about the first time that I proved a relationship between the gravitational and electrostatic forces. As previously stated, the initial idea that led to this book was that light confined in a hypothetical 100% reflecting box would exhibit the same inertia as a particle with the same energy. The other ideas in chapter 1 followed quickly and I was struck with the idea that these connections between confined light and particles were probably not a coincidence. I will now skip ahead several years when I was methodically inventing a model of the universe using only the properties of 4 dimension spacetime. I had the idea of dipole waves in spacetime and quantized angular momentum forming a "rotar" that was one Compton wavelength in circumference and rotating at the

particle's Compton frequency. This implied a spherical volume with radius of $\lambda_c = 3.86 \times 10^{-13}$. I had independently derived $Z_s = c^3/G$ which was key to all the other equations. I had developed the dimensionless wave amplitude for an electron which was $A_\beta = 4.185 \times 10^{-23}$. An important success was to substitute these values into $E = A^2 \omega^2 ZV/c$ and I obtained $E_i = 8.19 \times 10^{-14}$ J for an electron.

The next logical step was to find the force that would exist between two electrons at a distance equal to λ_c . This distance was implied because I was using the only amplitude that I knew which corresponded to a distance equal to λ_c . When I made numerical substitutions for an electron into the equation $F = A^2 \omega^2 Z\mathcal{A}/c$ I obtained $F = 0.212$ N. This was about 137 times greater than the electrostatic force between two electrons at the separation distance λ_c . I was quite happy because I realized that this would be the correct force if the charge was Planck charge q_p rather than elementary charge e . This was actually a preferable result because it corresponded to a coupling constant of 1, which was reasonable for this calculation. This was understandable and it was quite exciting.

Next I thought about gravity. I knew that gravity was vastly weaker than the other forces and only had a single polarity. I was reminded about the optical Kerr effect discussed in the last chapter. This nonlinear effect scales with amplitude squared (electric field squared) and always produces an increase in the index of refraction of the transparent material (a single polarity effect). Gravity has a single polarity and is vastly weaker than the electrostatic force. Therefore, I decided to calculate the force using $F = A^2 \omega^2 Z\mathcal{A}/c$. and set: $A = A_\beta^2 \approx 1.75 \times 10^{-45}$, $\omega_c = 7.76 \times 10^{20}$ s⁻¹, $Z_s = 4.04 \times 10^{35}$ kg/s and $\mathcal{A} = \lambda_c^2 = 1.49 \times 10^{-25}$ m². Using a pocket calculator, there was a *Eureka* moment when I got the answer which exactly equaled the gravitational force between two electrons at this separation ($F = 3.71 \times 10^{-46}$ N).

This story is told because I want to support the claim that the prediction came first. It is often said that the proof of the accuracy of a new idea lies in whether it can make a prediction revealing some previously unknown fact. Usually the proof requires an experiment, but in this case it was a simple calculation. To my knowledge this is the first time that the gravitational force has been calculated from first principles without referencing acceleration.

Gravitational Rate of Time Gradient: In the weak field limit, it is quite easy to extrapolate from the gravitational magnitude β produced by a single rotar at a particular point in space to the total gravitational magnitude produced by many rotars. Nature merely sums the magnitudes of all the rotars at a point in space without regard to the direction of individual rotars. The gravitational acceleration g was previously determined to be:

$$g = c^2 d\beta/dr = -c^2 d(d\tau/dt)/dr.$$

A gravitational acceleration of 1 m/s^2 requires a rate of time gradient of 1.11×10^{-17} seconds per second per meter. The earth's gravitational acceleration of 9.8 m/s^2 implies a vertical rate of time gradient of $1.09 \times 10^{-16} \text{ meter}^{-1}$. This means that two clocks, with a vertical separation of one meter at the earth's surface, will differ in time by 1.09×10^{-16} seconds/second. Similarly, there is also a spatial gradient. A gravitational acceleration also implies that there is a difference between circumferential radius R and radial length L . In the earth's gravity this spatial difference is $1.09 \times 10^{-16} \text{ meters/meter}$ ($\beta \approx 1 - dR/dL$).

Out of curiosity, we can calculate how much relative velocity would be required to produce a time dilation equivalent to a one meter elevation change in the earth's gravity. If elevation 2 is 1 meter higher than elevation 1, then: $dt_1/dt_2 = 1 - 1.09 \times 10^{-16}$. Using special relativity:

$$v = c \sqrt{1 - \left(\frac{dt_1}{dt_2}\right)^2} \quad \text{set } dt_1/dt_2 = 1 - 1.09 \times 10^{-16}$$

$$v = 4.4 \text{ m/s}$$

This 4.4 m/s velocity is exactly the same velocity as a falling object achieves after falling through a distance of 1 meter in the earth's gravity. Carrying this one step further, an observer in gravity perceives that a clock in a spaceship in zero gravity has the same rate of time as a clock in gravity, if the spaceship is moving at a relative velocity of v_e , the gravity's escape velocity. For example, an observer on earth would perceive that a spaceship in zero gravity moving tangentially at about 40,000 km/hr has the same rate of time as a clock on the earth. On the other hand, an observer in the spaceship perceives that a clock on the earth is slowed twice as much as if there was only gravity or only relative motion.

Equivalence of Acceleration and Gravity Examined: Albert Einstein assumed that gravity could be considered equivalent to acceleration. This assumption obviously leads to the correct mathematical equations. However, on a quantum mechanical level, is this assumption correct? Today it is commonly believed that an accelerating frame of reference is the same as gravity. This is associated with the geometric interpretation of gravity. A corollary to this is that an inertial frame of reference eliminates gravity. The implication is that gravity is not as real as the electromagnetic force which cannot be made to disappear merely by choosing a particular frame of reference. It is common for experts in general relativity to consider gravity to be a geometric effect rather than a true force.

The concepts presented in this book fundamentally disagree with this *physical interpretation* of general relativity. There is no disagreement with the equations of general relativity. The previous pages have shown that it is possible to derive the gravitational force using wave properties and the impedance of spacetime. This is completely different than acceleration. Numerous equations in this book have shown that there is a close connection between the gravitational force and the electrostatic force. In particular, I will reference the two equations

which dealt with two different mass particles (m_1 and m_2). The concluding statement in this analysis was:

“Note that the only difference between the intermediate portions of these two equations is that the gravitational force F_g has the strain amplitude terms squared ($A_{s1}^2 A_{s2}^2$) and the electrostatic force F_E has the strain amplitude terms not squared ($A_{s1} A_{s2}$). The tremendous difference between the gravitational force and the electrostatic force is due to a difference in exponents.”

Surely this qualifies as proof that gravity is closely related to the electrostatic force and therefore gravity is also a real force. The implication is that when we get down to analyzing waves in spacetime there is a difference between gravity and acceleration.

An argument not involving dipole waves in spacetime goes as follows: A particle in free fall in a gravitational field has not eliminated the effect of gravity. The particle is just experiencing offsetting forces. The gravitational force is still present in free fall but it is being offset by the inertial pseudo-force caused by the accelerating frame of reference. These two opposing “forces” just offset each other and give the impression that there is no force. The acceleration also produces an offsetting rate of time gradient and an offsetting spatial effect. The pseudo-force of inertia has not been eliminated and the gravitational force has not been eliminated. Einstein obtained the correct equations of general relativity by assuming that gravity was the same of acceleration. Since they exactly offset each other in free fall, this assumption gave the correct equations but the physical interpretation is wrong. On the quantum mechanical scale involving waves, gravity is different than acceleration. One way to prove that gravity is a true force is to show that a gravitational field possess energy density. This will be discussed in chapter 10.

“Grav” Field in the Rotar volume: The above discussion of gravitational acceleration from a rate of time gradient prepares us to return to the subject of the “grav field” inside the rotar volume of a rotar. Recall that the rotating dipole that forms the rotar volume of an isolated rotar was shown in figure 5-1. This rotating dipole wave has two lobes that have different rates of time and different effects on proper volume. The difference in the rate of time between the two lobes produces a rotating rate of time gradient that was depicted in figure 5-2. A rotar is very sensitive to a rate of time gradient. A rate of time gradient of 1.11×10^{-17} seconds/second/meter causes a rotar to accelerate at 1 m/s^2 and the acceleration scales linearly with rate of time gradient. Therefore, the rotating rate of time gradient in the center of a rotar model can be considered to be a rotating acceleration field that has similarities to a rotating gravitational field.

We normally encounter the rate of time gradient in a gravitational field. This is the result of a nonlinearity that produces a static stress in spacetime. A static rate of time gradient has frequency of $\omega = 0$ and no energy density. However, in an actual gravitational field there is also the oscillating component of a gravitational field and this does have energy density that will be discussed later. If a rotating gravitational field is somehow generated, then such a rotating field

would also have energy density. The rotating rate of time gradient (rotating grav field) that is present near the center of a rotar does have energy density that will be calculated next.

In a time period of $1/\omega_c$ the fast time lobe of the dipole gains Planck time (displacement amplitude T_p) and the slow time lobe loses Planck time T_p . These lobes are separated by $2\lambda_c$. Therefore, in a time of $1/\omega_c$ there is a total time difference of $2T_p$ across a distance of $2\lambda_c$. The rate of time gradient per meter is:

$$\frac{dt - d\tau}{dt dr} = \frac{2T_p}{\left(\frac{2\lambda_c}{\omega_c}\right)} = \frac{L_p \omega_c^2}{c^2} = \frac{L_p}{\lambda_c^2}$$

The acceleration produced by this rate of time gradient (grav acceleration a_g) is the rate of time gradient times c^2 . The following are several equalities for grav acceleration a_g :

$$a_g = \left(\frac{dt - d\tau}{dt dr}\right) c^2 = L_p \omega_c^2 = A_\beta^2 a_p = \sqrt{\frac{m^4 c^5 G}{\hbar^3}}$$

$$a_g = \text{grav acceleration} \quad \text{and} \quad a_p = c/t_p = \sqrt{c^7/\hbar G} = \text{Planck acceleration}$$

Comparison of Grav Acceleration and Gravitational Acceleration: How does the rotating grav acceleration at the center of a rotar's rotar volume (a_g) compare with the non-rotating, gravitational acceleration (g_q) at the edge of the same rotar's rotar volume? .

$$g_q = A_\beta^2 \omega_c c \quad \text{rotar's non-rotating gravitational acceleration at distance } \lambda_c \text{ from the center}$$

$$a_g = A_\beta \omega_c c \quad \text{rotar's rotating } (\omega_c) \text{ grav acceleration at the center of a rotar}$$

$$\frac{g_q}{a_g} = A_\beta \quad \text{ratio of } g_q \text{ (static gravitational acceleration at } \lambda_c) \text{ to rotating grav acceleration } a_g$$

For an electron $A_\beta = 4.18 \times 10^{-23}$, so the rotating grav field at the center of the electron is about 2×10^{22} times stronger than the non-rotating gravitational field at distance λ_c . This results in an electron having a rotating grav acceleration of: $a_g = 9.73 \times 10^6 \text{ m/s}^2$. The gravitational acceleration (not rotating) of an electron at distance λ_c is: $g_q = 4.07 \times 10^{-16} \text{ m/s}^2$. Therefore the grav acceleration in the rotar volume of an electron is about a million times greater than the gravitational acceleration at the surface of the earth. The earth's gravity is not rotating and is a nonlinear effect. The electron's grav field is rotating and is a first order effect resulting from the rate of time gradient established in the electron's rotating dipole wave.

Recall the incredibly small difference in the rate of time that exists between the lobes of an electron. It would take 50,000 times the age of the universe for the hypothetical lobe clock running at the rate of time inside the slow lobe to lose one second compared to the coordinate

clock. The difference between the rate of time on the slow lobe clock and the coordinate clock is comparable to the difference in the rate of time exhibited by an elevation change of about 4×10^{-7} m in the earth's gravity. The reason that the rotating grav field has a million times larger acceleration than the earth is because this difference in the rate of time occurs over approximately a million times shorter distance ($\sim 4 \times 10^{-13}$ m). The rotating rate of time gradient inside a rotar is a first order effect related to A_β while the non-rotating gravitational field produced by the rotar is a second order effect related to A_β^2 .

Conservation of Momentum in the Grav Field: It would appear that the concept of a grav field must violate the conservation of momentum. An example will illustrate this point. Suppose that a small neutral particle (such as a neutral meson) wanders into the center of an electron's rotar volume. Even if the mass of the meson is 1000 times larger than the electron, the rotating grav field of the electron should produce the same acceleration of the neutral particle. This would be a violation of the conservation of momentum unless the displacement produced by the rotating grav field is equal to or less than Planck length (the uncertainty principle detectable limit). We will calculate the maximum displacement (x) that takes place in a time period of: $t = 1/\omega_c$. We choose this time period because the rotating vector of the grav field is changing by one radian in a time period of $1/\omega_c$. Hypothetically the neutral particle would nutate in a circle with a radius related to x (ignoring dimensionless constants).

$$x = \frac{1}{2} a t^2 = k \frac{H_\beta \omega_c c}{\omega_c^2} = \frac{\left(\frac{L_p}{\lambda_c}\right) \left(\frac{c}{\lambda_c}\right) c}{\left(\frac{c}{\lambda_c}\right)^2} = L_p$$

$x = L_p$ $x =$ maximum radial displacement produced by a rotar's rotating grav field

Therefore any mass/energy rotar always produces the same displacement equal to Planck length (ignoring dimensionless constants) in the time required for the grav field to rotate one radian. This displacement is permitted by quantum mechanics and is not a violation of the conservation of momentum. This is another successful plausibility test.

Energy Density in the Rotating Grav Field: An accelerating field that is rotating possesses energy density. It would hypothetically be possible to extract energy from such a field if the field produced a nutation that was larger than the quantum mechanical limit of Planck length. No energy can be extracted from a rotar's rotating grav field because the nutation is at the quantum mechanical limit of detection. However, this field still possesses energy density.

Previously we designated the strain amplitude of a rotar as $A_\beta = L_p/\lambda_c = T_p \omega_c = \omega_c/\omega_p$. These were originally defined in terms of the strain amplitude of a dipole wave that is one wavelength in circumference. This definition tended to imply that the energy density of a rotar was distributed around the circumference. However, it is proposed that the rotating gradient that is present at the center of the rotar model can also be characterized as having a dimensionless

amplitude of $A_\beta = L_p/\lambda_c = T_p\omega_c$. This amplitude A_β is just in the form of a rotating rate of time gradient and a rotating spatial gradient. The spatial gradient from the lobe to the center is still L_p/λ_c . The rate of time gradient is still related to $T_p\omega_c$, although this is harder to see. Previously we substituted A_β , ω_c and Z_s into $U = A^2\omega^2Z/c$ and obtained a rotar's energy density in the rotar volume $U_q = k mc^2/\lambda_c^3$. If we ignore the dimensionless constant k , this is the rotar's internal energy in the volume of a cube that is λ_c on a side. Here are some other equalities for U_q .

$$U_q = \frac{m^4 c^5}{\hbar^3} = \frac{E_i}{\lambda_c^3} = A_\beta^4 U_p \quad \text{set } \frac{m^4 c^5 G}{\hbar^3} = a_g^2$$

$$U_q = \frac{a_g^2}{G}$$

Therefore the rotating "grav field" has the same energy density as the energy density of the entire rotar (E_i/λ_c^3). If we broaden the definition of A_β so that it also defines rotating rate of time gradients and rotating spatial gradients, then the energy density of the rotar model becomes homogeneous. The energy density near the center of a rotar is the same as the energy density near the edge. This energy density is just in two different forms. In chapter 6 we attempted to calculate the angular momentum of a rotar. If we assumed that all the energy was concentrated near the edge of a hoop with radius λ_c , then we obtained an answer of angular momentum of \hbar . However, if we assumed that the energy was distributed more uniformly (like a disk) and also rotation in a single plane, then the rotar model would have angular momentum of $\frac{1}{2}\hbar$. The fact that energy is contained in the grav field does smooth out the energy distribution, thereby tending towards the answer of $\frac{1}{2}\hbar$. However, as previously explained, there is also a chaotic rotation where there is an expectation rotational axis but other rotational directions are allowed with less probability. Also, the energy density distribution within a rotar does not end abruptly at a radial distance of λ_c . The details that result in net angular momentum of $\frac{1}{2}\hbar$ will have to be worked out by others.

If a rotating grav field has energy density, does a static gravitational field also have energy density? This question will be examined in chapter 10 after some additional concepts are introduced about the oscillating component of gravity

Energy Density in Dipole Waves: The above insights into the grav field also have implications for any Planck amplitude dipole wave in spacetime, not just the rotating dipoles that form rotars. I am going to talk about dipole waves in spacetime but start off by making an analogy to sound waves in a gas. Sound waves can be depicted with a sinusoidal graph of pressure. The compression regions have pressure above the local norm and the rarefaction regions have pressure below the local norm. These can be represented as a sine wave maximum and minimum. However, if a graph was to be drawn showing the kinetic energy of the molecules in the gas, the maximum kinetic energy occurs in the node regions between the pressure maximum and minimum. A kinetic energy graph depicting motion (velocity) left and right would have a 90° phase shift to the pressure graph. The energy in the sound wave is being converted from

kinetic energy (particle motion) to energy in the form of high or low pressure gas. When these two forms of energy are added together, then a sound wave with a plane wavefront has a uniform total energy density ($\sin^2\theta + \cos^2\theta = 1$). The energy is just being exchanged between two forms.

This concept of energy being exchanged between two different forms also applies to dipole waves in spacetime. In one form, energy exists because the vacuum energy of spacetime is distorted so that there are regions where the rate of time is faster or slower than the local norm. Perhaps this is analogous to the compression and rarefaction representation of a sound wave. The regions between the maximum and minimum rates of time have the greatest gradient in the rate of time. These are the grav field regions and they are analogous to regions in the sound wave where the gas molecules have the greatest kinetic energy. Adding together the two forms of energy density present in either sound waves or dipole waves in spacetime produces a total energy density without the characteristic wave undulations.

The waves in spacetime have sometimes been discussed emphasizing either the temporal characteristics (rate of time gradients, etc.) or emphasizing the spatial characteristics (for example L_p/r). Actually both characteristics are always present; it is sometimes easier to explain using just one characteristic. Therefore, the grav field could have been explained emphasizing the proper volume gradient rather than the rate of time gradient.

Gravitational Potential Energy Storage: When we look at the gravitational effect that a rotar has on spacetime, we conclude that the slowing of the rate of time also produces a slowing of the normalized speed of light ($C_o = \Gamma C_g$ from chapter 3). To reach this conclusion we must assume that proper length is constant, even when there is a change in Γ . This is an unspoken assumption for physics that does not involve general relativity.

The effect on the rate of time and on the normalized speed of light ultimately effects energy, force, mass, etc. as previously discussed. The reason for bringing this up now is that I want to address gravitational potential energy. Gravitational potential energy is considered a negative energy that has its maximum value in zero gravity and decreases when a mass is lowered into gravity. What physically changes when a rotar is elevated or lowered in gravity?

In chapter 3 it was found that substituting the normalized speed of light C_g and the normalized mass M_g into the equation $E = mc^2$ gives energy that scales inversely with gravitational gamma Γ (rest frame of reference). We illustrated this concept by calculating the difference in the internal energy of a 1 kg mass for an elevation of sea level and one meter above sea level. The calculated difference in the normalized internal energy was 9.8 Joules which is exactly the same as the gravitational potential energy.

This change in energy is due to the change in the normalized speed of light affecting the Compton frequency of the rotar as seen from zero gravity. For example, a free electron in zero gravity has

a Compton angular frequency of $7.76 \times 10^{20} \text{ s}^{-1}$. Earth's gravity has $\beta \approx 7 \times 10^{-10}$. A free electron in earth's gravity has a normalized Compton angular frequency that is slower than a zero gravity electron by about 5.4×10^{11} radians per normalized second ($7 \times 10^{-10} \times 7.76 \times 10^{20} \text{ s}^{-1}$). This lower Compton frequency decreases the normalized internal energy of an electron and decreases the gravity (non-oscillating strain) generated by an electron. The non-oscillating strain is responsible for the rotar's gravity, so a rotar at rest in gravity contributes less gravity to the total gravity than the same rotar at rest (same temperature) in zero gravity.

For another example, we will calculate the change in the internal energy of an electron when it is elevated 1 meter in the earth's gravitational field. In chapter 3 there is a section titled "Energy Transformation and Calculation" where the difference in the gravitational gamma was calculated for a 1 meter elevation change near the earth's surface. This was expressed as $\Gamma_2 - \Gamma_1 \approx 1.091 \times 10^{-16} = dt_2/dt_1$. Since the reduced Compton frequency of an electron is about $7.76 \times 10^{20} \text{ s}^{-1}$, this means a 1 meter elevation change will produce a frequency change:

$$\Delta\omega_c = 7.7634 \times 10^{20} \text{ s}^{-1} \times 1.0915 \times 10^{-16} = 84,737 \text{ s}^{-1}$$

$$\Delta E = \Delta\omega_c \hbar = 84,690 \text{ s}^{-1} \times \hbar \text{ Js} = 8.936 \times 10^{-30} \text{ J}$$

We will compare this to the gravitational potential energy stored when an electron is elevated 1 meter in the earth's gravitational field with acceleration of $g = 9.81 \text{ m/s}^2$.

$$\Delta E = m_e \Delta h g = 9.109 \times 10^{-31} \text{ kg} \times 1 \text{ m} \times 9.81 \text{ m/s}^2 = 8.936 \times 10^{-30} \text{ J}$$

These concepts also lead to a physical explanation for potential energy. In chapter 3 the concept of potential energy was related to a reduction in the normalized speed of light reducing the $E = mc^2$ internal energy. Now we go one step further and trace the gravitational potential energy to a change in the rotational frequency of a rotar in a gravitational field. This not only affects the internal energy of the rotar, but it also affects the amount of gravity generated by the rotar.

When we have looked at mass, energy, inertia and gravity from the point of view of a zero gravity observer, we have seen a difference not obvious locally. Since a change in Γ affects mass and energy differently (zero gravity observer perspective) and since gravity scales with energy (not rest mass), to be technically correct the gravitational equations should be written in terms of energy, not mass. The transformations and insights provided here have forced us to recognize that the term "mass" is a quantification of inertia. Mass is not synonymous with matter and mass scales differently than energy when viewed by an observer using the zero gravity coordinate rate of time.

Personal Note:

I want to tell two short personal stories that relate to this chapter. The first story has to do with the gravitational effect on rotar frequency. I normally run almost every day. Some of the best ideas in this book came to me during these daily runs. Many years ago I used to run on flat ground but to preserve my knees I now run up a steep section of a hill and walk down to the starting point. I repeat this for $\frac{1}{2}$ hour which typically is about 15 round trips. As I run up the hill I often am aware that the work that I am doing is ultimately resulting in an increase in the Compton frequency of all the electrons and quarks in my body. Locally there is no measurable change in the Compton frequencies of these rotars, but using the absolute time scale of a zero gravity observer, I am increasing the frequency of these particles. It somehow is comforting to understand the physics of running up a hill. The concept of “gravitational potential energy” has been demystified. I now understand why it is difficult to run up a hill.

The second story is about the experience of resolving a mystery about gravity. When I was initially writing this book, I thought that I had unlocked the key to understanding gravity when I had developed the concepts presented in chapter 6 (the concepts that are now regarded as being oversimplified). The magnitude of the gravitational force was correct and I thought I could easily extrapolate to larger distances and larger mass. Then it occurred to me that the vector was wrong and it was obvious that I was missing other major concepts. I was far from finishing my quest to explain important aspects of gravity.

My initial reaction was to try to rationalize changes that would make the simplified model explain the correct vector (attraction rather than repulsion). This thought process was something like trying to reverse engineer gravity. I was attempting to work backwards from the desired result (attraction) to find the changes to the model that would give the desired result. I spent a long time working backwards from result to cause, but it was getting nowhere. Therefore, in frustration I returned to the approach that I had previously used to develop the model to that point. That approach merely moved forward from the starting assumption (the universe is only spacetime) and accepted the logical extensions of this assumption. Once I got back on this track, I realized that the energy density of the rotar model implied pressure. When I took the logical steps to contain this pressure, I eventually obtained not only the gravitational force with the correct vector but also obtained improved insights into the strong force, the electromagnetic force and the stability of fundamental particles.

While other people are attempting to adjust models to explain specific physical effects, I am finding that logically extending the starting assumption gives unexpected explanations. The expanded model explains diverse effects not initially under consideration. These experiences have given me a great deal of confidence in this model and approach.

Chapter 9

Electromagnetic Fields & Spacetime Units

Introduction: In the last chapter we analyzed gravitational attraction and established the necessity of vacuum energy/pressure in generating the gravitational force. This chapter is an introduction to the electromagnetic (EM) radiation and electrical charge. We will start with a preliminary examination of spacetime characteristics responsible for the electric field of charged particles. After some insights are developed with charged particles we will then switch and examine the properties of spacetime that are affected when electromagnetic radiation is present. An experiment will be proposed. We will then switch back and use some of the insights gained from electromagnetic radiation to develop further the model of a charged particle's electric field. Finally, we will develop a system of fundamental units based only on the properties of spacetime. These units designate charge utilizing only the properties of spacetime.

We tend to think of the electric and magnetic fields associated with EM radiation as being very similar to the electric and magnetic fields associated with charged particles. However, there are obvious differences. The fields associated with EM radiation are always oscillating and they propagate at the speed of light. The fields associated with charged particles are not oscillating and they are not freely propagating. With these differences, it should be expected that there should also be considerable differences in the explanations of the electric field associated with photons compared to the electric field associated with electrons. Developing a model of electric and magnetic fields has been the most difficult task of this entire book. While considerable progress has been made, the model is not complete. Furthermore, the model of the electric field associated with charged particles is less complete than the model of EM radiation. This chapter begins by examining the magnitude and type of distortion of spacetime required to produce elementary charge e .

Spacetime Interpretation of Charge: If the universe is only spacetime, there should be an interpretation of electrical charge, permeability, electric field, etc. that converts these electrical characteristics into properties of spacetime. Like gravity, we might be looking for both an oscillating component and a non-oscillating strain in the spacetime field caused by the oscillating component (waves in spacetime). It will be recognized that there are two types of electric field: 1) The electric field associated with a charged particle which appears to be only static but must also have an oscillating component and 2) the oscillating electric field of electromagnetic radiation. This distinction is made because it will be shown that the electric field associated with a charged particle is more complex.

To obtain an insight into the electrical properties of nature, we will start by expressing the electrical potential \mathbb{V} (the voltage relative to neutrality) for a single particle which has Planck charge ($q_p = \sqrt{4\pi\epsilon_0\hbar c}$) at distance r is:

$$\mathbb{V}_E \equiv \frac{q_p}{4\pi\epsilon_0 r} = \frac{\sqrt{4\pi\epsilon_0\hbar c}}{4\pi\epsilon_0 r}.$$

The symbol \mathbb{V}_E will be used to signify that we are assuming Planck charge q_p . Next we will express electrical potential of Planck charge in dimensionless Planck units. This is done because dimensionless Planck units are fundamentally based on the properties of spacetime. We are attempting to gain an insight into the distortion of spacetime caused by electric charge. If we express this electrical potential in dimensionless Planck units $\underline{\mathbb{V}}_E$ (note underlined), then we are converting to dimensionless Planck units which in this case makes a ratio relative to the largest possible electrical potential, Planck voltage $\mathbb{V}_p = (c^4/4\pi\epsilon_0 G)^{1/2} = 1.043 \times 10^{27}$ Volts

$$\underline{\mathbb{V}}_E = \mathbb{V}_E / \mathbb{V}_p = \frac{\sqrt{4\pi\epsilon_0\hbar c}}{4\pi\epsilon_0 r} \sqrt{\frac{4\pi\epsilon_0 G}{c^4}} = \frac{1}{r} \sqrt{\frac{\hbar G}{c^3}} = \frac{L_p}{r}$$

Before commenting, we will next calculate the electric field in dimensionless Planck units at distance r from Planck charge q_p . The symbol used will be: $\underline{\mathbb{E}}_E = \mathbb{E}_E / \mathbb{E}_p$ where $\mathbb{E}_E \equiv q_p / 4\pi\epsilon_0 r^2$ and Planck electric field is $\mathbb{E}_p = \sqrt{c^7 / 4\pi\epsilon_0 \hbar G^2}$

$$\underline{\mathbb{E}}_E = \mathbb{E}_E / \mathbb{E}_p = \frac{\sqrt{4\pi\epsilon_0\hbar c}}{4\pi\epsilon_0 r^2} \sqrt{\frac{4\pi\epsilon_0 \hbar G^2}{c^7}} = \frac{\hbar G}{c^3 r^2} = \frac{L_p^2}{r^2}$$

What is the physical interpretation of $\underline{\mathbb{V}}_E = L_p / r$ and $\underline{\mathbb{E}}_E = L_p^2 / r^2$? Expressing electrical potential and electric field in dimensionless Planck units is expressing these in the natural units of spacetime. Therefore, we will mine this to extract hints about the effect that Planck charge has on spacetime.

- 1) Since there is no time term in either equation, the implication is that an electrical charge only affects the spatial properties of spacetime. This is also reasonable since a gradient in the rate of time always implies gravitational acceleration. If electrical charge produced a rate of time gradient, then neutral objects such as a neutron would be accelerated by an electric field. Therefore, it is reasonable that an electric field affects only the spatial dimension (the L_p term)
- 2) The presence of Planck length term (L_p) in the voltage and electric field equations implies that Planck length is somehow associated with the electric field produced by Planck charge.
- 3) The dimensionless ratio L_p / r implies a slope. This will have to be a spatial strain of spacetime that can be expressed as a slope.
- 4) Only the radial spatial dimension (r) seems to be affected.

Charge Conversion Constant η : To quantify the magnitude of the effect on spacetime produced by a charge, we will attempt to find a new constant of nature which converts units of electrical charge (Coulomb) into a property of spacetime. Considering the previous 4 points, we would expect that charge might produce a polarized strain of space (radial length dimension) without affecting the rate of time. The validity of this approach will be established only if it passes numerous tests.

There are many ways to derive this charge conversion term. We will use one of the above equations: $V_E/V_p = L_p/r$ where V_E is the electrical potential generated by a Planck charge q_p at distance r . If we solve for Planck charge q_p , while retaining Planck length L_p , we will be able to deduce a charge conversion constant that converts charge into a spatial distortion of the spacetime field.

$$V_E = \frac{q_p}{4\pi\epsilon_0 r} = \frac{L_p V_p}{r}$$

$$q_p = \frac{L_p V_p 4\pi\epsilon_0 r}{r} = L_p \sqrt{\frac{4\pi\epsilon_0 c^4}{G}}$$

The proposed conversion between charge and a spatial distortion of spacetime will be designated as the “charge conversion constant” and designated as eta (η).

$$\eta \equiv \sqrt{\frac{G}{4\pi\epsilon_0 c^4}} = \frac{L_p}{q_p} \approx 8.61 \times 10^{-18} \text{ m/C} \quad \text{charge conversion constant}$$

Eta (η) has units of meters per Coulomb. This unit is reasonable because we are expecting to convert charge into a property of spacetime and the time dimension has been eliminated. The “meters” referenced in meters/coulomb are the radial direction if we are referring to the effect a charged particle has on the surrounding spacetime or if we are referring to an electric field, then the “meters” are in the direction of the electric field. We know that this constant (η) is compatible with the dimensionless voltage equation for Planck charge $V_E = L_p/r$ since that equation was used to define the constant. However, to test this further, we will use eta (η) to eliminate Coulomb from other constants and equations. We will start with two constants: 1) the Coulomb force constant $1/4\pi\epsilon_0$ with units of $\text{m}^3\text{kg}/\text{s}^2\text{C}^2$ and 2) the magnetic permeability constant $\mu_0/4\pi$ with units of $\text{kg m}/\text{C}^2$. Both of these have $1/\text{C}^2$. To eliminate $1/\text{C}^2$ requires multiplying both of these by $1/\eta^2$.

$$\frac{1}{4\pi\epsilon_0} \left(\frac{1}{\eta^2}\right) = \left(\frac{1}{4\pi\epsilon_0}\right) \left(\frac{4\pi\epsilon_0 c^4}{G}\right) = \frac{c^4}{G} = F_p = 1.21 \times 10^{44} \text{ N}$$

Coulomb force constant $\frac{1}{4\pi\epsilon_0}$ converts to Planck force $\frac{c^4}{G}$ with units of Newton.

$$\frac{\mu_0}{4\pi} \left(\frac{1}{\eta^2}\right) = \left(\frac{1}{4\pi\epsilon_0 c^2}\right) \left(\frac{4\pi\epsilon_0 c^4}{G}\right) = \frac{c^2}{G} = 1.35 \times 10^{27} \text{ kg/m}$$

Therefore, vacuum permeability $\frac{\mu_0}{4\pi}$ converts to $\frac{c^2}{G}$ with units of kg/m.

It is quite reasonable that the Coulomb force constant $1/4\pi\epsilon_0$ gets converted to F_p Planck force. If electric charge and an electric field are distortions of the spacetime field, then it is reasonable that the Coulomb force constant converts to the largest force that the spacetime field can exert which is Planck force $F_p = c^4/G$. In fact, this conversion strongly supports the validity of eta (η). If the universe is only spacetime, then it is reasonable that all forces, including the electromagnetic force, should reference Planck force. The vacuum permeability also converts to an important property of spacetime which is c^2/G with units of kg/m. This is the constant that converts mass into length (the radius of a black hole). The next test is to see if $c^2 = 1/\epsilon_0\mu_0$ is still correct when we substitute $\epsilon_0 = G/4\pi c^4$ and $\mu_0 = 4\pi c^2/G$. We obtain: $(4\pi c^4/G)(G/4\pi c^2) = c^2$.

Next we will also convert elementary charge e and Planck charge q_p to a distortion of spacetime by multiplying by η .

$$e\eta = \sqrt{\alpha}L_p \quad \text{conversion of elementary charge } e \quad \text{where: } \alpha = \frac{e^2}{4\pi\epsilon_0\hbar c}$$

$$q_p\eta = L_p \quad \text{conversion of Planck charge } q_p$$

We can now do a more revealing test. We will calculate the force between two electrons (charge e) two different ways. First we will use the conventional Coulomb law equation to calculate this force, then we will calculate the force using the above conversions.

$$F_e = \frac{e^2}{4\pi\epsilon_0 r^2} = \frac{\alpha\hbar c}{r^2} \quad \text{Coulomb law force between two electrons: charge } e \approx 1.6 \times 10^{-19} \text{ C}$$

$$F_e = \frac{F_p \alpha L_p^2}{r^2} = \frac{c^4}{G} \frac{\alpha}{r^2} \frac{\hbar G}{c^3} = \frac{\alpha\hbar c}{r^2} \quad \text{Force equation which converts } e \text{ and } \epsilon_0 \text{ to spacetime strain}$$

This is a successful test. It is interesting to see how $1/4\pi\epsilon_0$ converts to Planck force and still gives the same answer as the Coulomb law equation which utilizes electrical charge and the permittivity of free space. It is interesting to make other tests of η . It always works correctly.

Impedance Calculation

Before proceeding with the following test calculation, I want to tell a story. There are two calculations in this book that gave me the biggest thrill. One of them was when I was able to derive Newton's gravitational equation from my starting assumptions. The second is the following calculation that converts the impedance of free space Z_0 into a distortion of spacetime. This does not seem like a particularly important relationship, which is perhaps the reason that it was so surprising.

Impedance of Free Space and Planck Impedance: The impedance of free space Z_o with units of ohms is a physical constant that relates the magnitudes of the electric field \mathcal{E} and the magnetic field strength \mathcal{H} of electromagnetic radiation propagating in a vacuum.

$$Z_o \equiv \mathcal{E}/\mathcal{H} = \mu_o c = \frac{1}{\epsilon_o c} = \sqrt{\frac{\mu_o}{\epsilon_o}} \approx 376.7 \Omega \quad \text{impedance of free space}$$

Planck impedance Z_p is:

$$Z_p = \frac{Z_o}{4\pi} = \frac{1}{4\pi\epsilon_o c} \approx 29.98 \Omega \quad \text{Planck impedance}$$

The units of the impedance of free space Z_o and Planck impedance Z_p are both L^2M/Q^2T . Therefore to eliminate $1/Q^2$ we must multiply Z_p and Z_s by $1/\eta^2$.

$$Z_p \left(\frac{1}{\eta^2} \right) = \left(\frac{1}{4\pi\epsilon_o c} \right) \left(\frac{4\pi\epsilon_o c^4}{G} \right) = \frac{c^3}{G} = Z_s$$

$$Z_o \left(\frac{1}{\eta^2} \right) = \left(\frac{1}{\epsilon_o c} \right) \left(\frac{4\pi\epsilon_o c^4}{G} \right) = 4\pi \frac{c^3}{G} = 4\pi Z_s$$

$$Z_p \left(\frac{1}{\eta^2} \right) = Z_s \quad \text{and} \quad Z_o \left(\frac{1}{\eta^2} \right) = 4\pi Z_s$$

Planck impedance Z_p corresponds to the impedance of spacetime Z_s and the impedance of free space Z_o corresponds to $4\pi Z_s$ - **Fantastic!**

Impedance of free Space Converts to the Impedance of Spacetime: When we convert the impedance of free space $Z_o \equiv \mathcal{E}/\mathcal{H}$ using the charge conversion constant, Z_o becomes the impedance of spacetime Z_s times a constant (4π). We can ignore the 4π and in fact Planck impedance does eliminate this numerical factor. This is a fantastic outcome because it implies that electromagnetic radiation is some form of wave in the spacetime field. Here is the reasoning. From gravitational wave equations we know that waves propagating in the medium of the spacetime field experience impedance of $Z_s = c^3/G \approx 4 \times 10^{35} \text{ kg/s}$. Now we discover that not only does electromagnetic radiation propagate at the same speed as gravitational waves, and has transverse waves like gravitational waves, but electromagnetic radiation also experiences the same impedance as gravitational waves (the impedance of spacetime). The conclusion is:

Electromagnetic radiation must be a wave propagating in the medium of the spacetime field.

The equation $Z_s = c^3/G$ is only applicable when waves use the spacetime field as the propagation medium. This is understandable and fully expected for gravitational waves, but now we find that electromagnetic radiation must also use the spacetime field as a propagation medium. The

impedance of free space Z_o (fundamental to everything electromagnetic) is: $Z_o/\eta^2 = 4\pi Z_s$ when expressed using a conversion constant η that converts charge to a strain of spacetime with dimensions of length (ignore 4π). This says that photons are not packets of energy that travel THROUGH the empty void of spacetime. Photons are waves IN the medium of the spacetime field. They appear to also have particle properties because photons possess quantized angular momentum. The superfluid spacetime field quarantines angular momentum into quantized units of \hbar for bosons or $\frac{1}{2} \hbar$ for fermions. It is not possible to break apart a unit of quantized angular momentum. The transfer of quantized angular momentum is all or nothing (100% or 0%). The photon's energy also becomes quantized because the energy of a photon is fundamentally associated with the quantized angular momentum. The proposed property of unity makes the energy in the distributed waves collapse (transfer their quantized angular momentum) at faster than the speed of light. This apparently localized interaction gives particle-like properties to photons.

The equation $Z_o/\eta^2 = 4\pi Z_s$ also implies that photons are first cousins to gravitational waves. Photons and gravitational waves disturb the spacetime field's sea of superfluid dipole waves in different ways, but they both are transverse disturbances in the spacetime field that do not modulate the rate of time and propagate at the speed of light. Recall from chapter 4 that the spacetime field is an elastic medium with impedance and the ability to store energy and return energy to a wave propagating in this medium. The implication is that gravitational waves are also quantized and carry quantized angular momentum.

Light waves are not dipole waves in spacetime since we can detect light waves as discrete waves. Recall that it is impossible to detect dipole waves in spacetime. Dipole waves in spacetime modulate the rate of time and proper volume. Their amplitude must be limited to Planck amplitude ($\pm L_p$ and $\pm T_p$). A larger amplitude would produce effects that violate the conservation of momentum and energy. Also, a light wave cannot cause an oscillation in the rate of time because a gradient in the rate of time produces gravitation-like effects. For example, a strong light wave would cause a neutron to undergo a detectable transverse oscillatory displacement similar to the effect on an electron. Therefore, light waves are a spacial wave distortion of the homogeneous spacetime field. Each individual photon has quantized angular momentum and other special properties which will be discussed later.

Constant Speed of Light: Is it reasonable that light waves are propagating in the medium of spacetime? For example, if the propagation medium is the spacetime field, would we expect that it should be impossible to detect motion relative to this medium? First, we know that ϵ_o and μ_o are properties of the spacetime field. We also know that ϵ_o and μ_o remain constant in all frames of reference. Since $c = \sqrt{1/\epsilon_o\mu_o}$ it follows that a wave propagation speed that scales with ϵ_o and μ_o should also be independent of the frame of reference.

Second, gravitational waves are definitely propagating in the medium of the spacetime field and they always propagate at the speed of light in all frames of reference. If it was possible to do a Michelson-Morley experiment using gravitational waves, this experiment would obtain the same result as the experiment using light. In both cases there would be a null result – no motion would be detected relative to the propagation medium. The spacetime field is a sea of dipole waves propagating at the speed of light but also strongly interacting. No motion is able to be detected relative to this medium. Also all observable objects (all particles, fields and forces) are obtained from the single building block of 4 dimensional spacetime. Therefore, all particles, fields and forces compensate with a Lorentz transformation which makes the locally measured speed of light constant. Therefore, the spacetime field possesses the properties required to make the speed of light constant in all accessible frames of reference. (At the end of chapter 14 we will explore the limits of extreme frames of reference where this breaks down.)

Cosmic Speed Limit: The following question has puzzled physicists: Why is there a cosmic speed limit? Now we can answer this question. A photon is not a quantized packet of energy propagating through the empty void of the vacuum. A truly empty vacuum would not dictate any speed limit to a “packet of energy” that is merely propagating through it. However, if a photon is a wave propagating in the spacetime field medium, then the impedance and energy density characteristics of this medium dictate a specific speed of wave propagation. The medium named the “spacetime field” consists of strongly interacting dipole waves in spacetime propagating at the speed of light at all frequencies up to Planck angular frequency ($\omega_p \approx 10^{43} \text{ s}^{-1}$). Photons disturb the homogeneity of this medium and this disturbance also propagates at the speed of light. Photons appear to be particles because photons possess angular momentum and angular momentum is quantized into \hbar or $\frac{1}{2} \hbar$ units by the superfluid spacetime field. Since angular momentum is only transferred in quantized units, this gives particle-like properties to quantized waves. The phrase “wave – particle duality” cannot be conceptually understood since “wave” implies a periodic variation over a volume and “particle” implies a point discontinuity. They are mutually exclusive terms. I propose that bosons and fermions are fundamentally waves which act like particles because they possess angular momentum which is quantized by the superfluid spacetime field.

All particles, fields and forces are also distortions of the spacetime field. There is a single speed limit for all frames of reference because all particles fields and forces compensate their size and other characteristics in a way that achieves a Lorentz transformation which keeps the laws of physics constant. Even the forces between particles compensate to maintain the distance between particles that preserves the locally measured constant speed of light.

Accuracy Check: There is another more subtle implication from the equation $Z_o/\eta^2 = 4\pi Z_s$, and the success of the charge conversion constant. These equations imply to me that the many steps that started with gravitational wave equations and ended with these relationships are correct. The impedance of spacetime c^3/G was deduced from gravitational wave equations. The

impedance of free space Z_o was derived from Maxwell's equations of electromagnetism. Starting from the assumption that the universe is only spacetime, we went looking for a constant to convert charge into a distortion of spacetime: $\eta \equiv (G/4\pi\epsilon_o c^4)^{1/2}$. This resulted in $Z_o/4\pi\eta^2 = Z_s$. These apparently dissimilar impedances are the same when we assume that the universe is only spacetime. This unification of impedances supports the starting assumption.

Spacetime Model of an Electric Field

Electric Field Conversion: Next we will attempt to gain additional insights into electric fields. We had some success describing the voltage and electrical field produced by Planck charge $\underline{V}_E = L_p/r$ and $\underline{E}_E = L_p^2/r^2$. However the underlying mechanism by which a charged particle produces an electric field is somewhat more complex than an electric field produced by a photon. Therefore we will switch to electromagnetic radiation to examine electric and magnetic fields then come back to charged particles later.

In chapter 4 it was stated that the wave-amplitude equation for intensity ($\mathcal{J} = kA^2\omega^2Z$) is a universal classical equation that is applicable to waves of any kind provided that the amplitude and impedance is stated in units that are compatible with this equation. Electromagnetic radiation commonly uses electric field to quantify wave amplitude of EM radiation. Also, the impedance of free space ($Z_o \approx 377$ ohms) is used to quantify the impedance encountered by EM radiation. This way of stating amplitude and impedance is not compatible with the other units of the above wave-amplitude equation. Therefore, this creates the impression that this wave-amplitude equation is less than universal. However, it is possible to convert electric field of EM radiation into an amplitude term that is compatible with the 5 wave-amplitude equations. For example, amplitude of EM radiation can be expressed using strain amplitude A , angular frequency ω and the impedance of spacetime Z_s . It is informative to analyze the connection between electric field (or magnetic field) and the strain in spacetime. This can be easily done using the two different ways of expressing intensity: $\mathcal{J} = kA^2\omega^2Z_s$ and $\mathcal{J} = \frac{1}{2} \mathbb{E}^2/Z_o$. We will equate these and solve for \mathbb{E} and \mathbb{H} . Since these assume EM radiation and not necessarily the electric field of a charged particle, we will designate the electric field of EM radiation as \mathbb{E}_γ and the magnetic field of EM radiation as \mathbb{H}_γ .

$$\begin{aligned} \mathbb{E}_\gamma^2/Z_o &= kA^2\omega^2Z_s && \text{intensity equations ignoring numerical factors near 1} \\ \mathbb{E}_\gamma &= kA\omega\sqrt{Z_sZ_o} && \mathbb{E}_\gamma = \text{Electric field of EM radiation expressed utilizing } A, \omega, Z_s \text{ and } Z_o \\ \mathbb{H}_\gamma &= kA\omega\sqrt{\frac{Z_s}{Z_o}} && \mathbb{H}_\gamma = \text{magnetic field of EM radiation obtained from } \mathbb{H}_\gamma = k\mathbb{E}_\gamma/Z_o \end{aligned}$$

This is interesting, but it still uses Z_o which implies charge. Next we will convert the electric field and magnetic field of EM radiation into a distortion of spacetime using η . This results in Z_o being converted to Z_s . Applying this to $\mathcal{E}_\gamma = kA\omega\sqrt{Z_s Z_o}$ and $\mathcal{H}_\gamma = kA\omega\sqrt{Z_s/Z_o}$ we obtain:

$$\begin{aligned} \mathcal{E}_\gamma/\eta &= kA\omega Z_s & \mathcal{E}_\gamma &= \text{electric field strength of EM radiation} \\ \mathcal{H}_\gamma\eta &= kA\omega & \mathcal{H}_\gamma &= \text{magnetic field strength of EM radiation} \end{aligned}$$

These equations express \mathcal{E} and \mathcal{H} in terms of A , ω and Z_s . However, the remaining task is to be able to define the electromagnetic wave amplitude as a strain in spacetime (define amplitude A). Also, there should be a factor of $\sqrt{4\pi}$ in these equations, but there are other unknown numerical factors near 1 which have been ignored, so these equations are stated using k to represent the unknown numerical factor near 1.

What Is an Electric Field? I find the currently accepted explanation of an electric field as totally inadequate. The electromagnetic force that exists between charged particles is supposedly carried by exchanging virtual photons. However, an electric field has energy density, therefore it has a tangible quality. The energy density implies that an electric field must also have inertia and generate its own gravitational field. This implies that an electric field has more of a physical presence than implied by the concept of virtual photons. One of the characteristics of a virtual photon is that it is undetectable; therefore it is not “falsifiable”. Sometimes an electric field is described as a cloud of virtual photons. More often, physicists prefer to describe the effects of an electric field and avoid addressing the question of what an electric field is. Still, the closest answer usually involves a vague reference to virtual photons.

If we require virtual photons to describe an electric field, this leaves many unanswered questions. For example, do real photons generate an electric field by sending out transverse virtual photons? Why do virtual photons transfer force but not angular momentum? Why does an electric field have energy density if the energy of virtual photons must average out to equal zero? How exactly do virtual photons achieve attraction? What prevents the implied pressure associated with the energy density of a static electric field from dissipating? If an electron is smaller than the classical electron radius ($\sim 10^{-15}$ m), then what prevents the energy in its electric field from exceeding the total energy of the electron?

Some physicists freely admit that virtual photons are merely a mathematical tool. The path-integral formulation of quantum mechanics assumes that virtual photons take all possible paths between two charged particles. In the calculation, paths are allowed where the virtual photon is going faster than the speed of light or violating energy conservation. These calculations give correct answers, but the physical model is lacking.

I could go on with more examples, but the truth is that there are so many conceptual mysteries in the quantum mechanics that physicists learn to embrace the lack of conceptual understanding.

The desire for conceptual understanding is often criticized as a ruminant of classical physics that cannot be fulfilled by quantum mechanics. The equations of quantum mechanics obviously are correct but the conceptual models are lacking. The objective of this book is to present a new model that is conceptually understandable yet is compatible with the equations and experimental verifications of quantum mechanics and general relativity. We start with the electric field associated with EM radiation.

Maximum Confinement of a Photon: We will first look at the simplified case of a photon confined in a reflecting chamber. If we had 100% reflecting walls, what is the smallest volume that would confine a single photon? Combining the transmission characteristics of waveguides with the resonance characteristics of lasers, it is possible to answer this question. In waveguides, a sharp cutoff occurs when the width of the waveguide in the polarization direction is equal to or less than $\frac{1}{2}$ wavelength. However, the width needs to only be slightly larger than $\frac{1}{2}$ wavelength to achieve good transmission. For circularly polarized electromagnetic radiation, a cylindrical waveguide slightly more than $\frac{1}{2}$ wavelength in diameter is the smallest waveguide which has good transmission. Making a waveguide into a resonator requires adding two flat and parallel reflectors separated by $\frac{1}{2}$ wavelength and oriented perpendicular to the axis of the cylinder. This cylindrical waveguide resonator is the minimum evacuated volume (maximum confinement) that we can achieve for coherent circularly polarized light of a particular wavelength. This configuration will be called the “maximum confinement resonator” and will be utilized in both calculations and a proposed experiment later.

When electromagnetic radiation is freely propagating, the electric and magnetic fields are perpendicular to each other and in phase. However, when electromagnetic radiation is confined in a resonator such as the maximum confinement waveguide resonator described here (or even in a laser resonator) the radiation forms standing waves that have the electric and magnetic fields 90° out of phase. This is easiest to see by imagining electromagnetic radiation reflecting off a metal mirror. The electric field is a minimum at the surface of each mirror but the magnetic field is at a maximum at the mirror surfaces. The electrons in the metal mirror are undergoing a motion that minimizes the electric field but this creates an oscillating magnetic field. If the reflectors are separated by $\frac{1}{2}$ wavelength, the standing wave created between the two mirrors has maximum electric field oscillations in the central plane of the $\frac{1}{2}$ wave cavity (antinode) and the minimum electric field at the mirror surfaces (nodes). Conversely, the magnetic field is at a minimum (node) in the central plane and at a maximum at the mirror surfaces (antinodes).

Displacement of Spacetime Produced by a Single Photon: Next we will calculate the displacement of the spacetime field produced by a single photon in this maximum confinement resonator. By specifying the “maximum confinement condition”, we can avoid specifying the characteristics of a freely propagating photon that will be discussed in chapter 11. Since we are ignoring numerical factors near 1, we will model the displacement required to produce a uniform oscillating electric field over the central volume of \mathcal{A}^3 and assume zero electric field in the

remainder of the maximum confinement cavity. Also we are not specifying whether we are designating the peak electric field strength or the RMS electric field strength. Therefore, ignoring these factors (assuming a volume of λ^3), the energy density of a single photon with energy $\hbar\omega$ and uniform energy density in a volume of λ^3 we have:

$$U = \hbar\omega/\lambda^3 = \hbar c/\lambda^4 = \hbar\omega^4/c^3 = (L_p/\lambda)^4 U_p.$$

To find the displacement amplitude of spacetime required to produce this energy density, we will equate $U = \hbar\omega^4/c^3$ with $U = A^2\omega^2 Z_s/c$ and solve for ΔL in $A = \Delta L/\lambda$.

$$U = \frac{\hbar\omega^4}{c^3} = \frac{H^2\omega^2 Z_s}{c} = \left(\frac{\Delta L^2\omega^2}{c^2}\right)\omega^2\left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \frac{\Delta L^2\omega^4}{G} \quad \text{solve for } \Delta L$$

$$\Delta L = \sqrt{\frac{\hbar G}{c^3}} = L_p \quad \text{displacement amplitude of a single photon in "maximum confinement"}$$

$$A = L_p/\lambda \quad \text{the strain amplitude } A \text{ of a single photon in "maximum confinement"}$$

The equation $\Delta L = L_p$ is for a single photon in volume λ^3 . Therefore this calculation presumes that ΔL is over a total path length of λ (ignoring numerical factors near 1). A total path length of $\pi\lambda$ (the diameter of the maximum confinement waveguide) is within the allowed range, especially since the electric field is maximized over the central λ . Since photons are bosons and many photons can occupy the same volume, we will next calculate the displacement of spacetime required if many coherent photons (same frequency and phase) are introduced into the volume λ^3 . In this calculation we will use " n_γ " as the number of photons occupying the volume. Therefore $U = n_\gamma\hbar\omega/\lambda^3 = n_\gamma\hbar\omega^4/c^3$.

$$U = \frac{\Delta L^2\omega^4}{G} = \frac{n_\gamma\hbar\omega^4}{c^3} \quad \text{Solve for } \Delta L$$

$$\Delta L = \sqrt{n_\gamma} L_p \quad \text{displacement amplitude of } n_\gamma \text{ photons in "maximum confinement"}$$

The equation $\Delta L = \sqrt{n_\gamma} L_p$ is the oscillating displacement of spacetime for " n_γ " photons in the maximum confinement previously discussed. This value of ΔL is over distance λ , therefore the strain in spacetime produced by n_γ coherent photons in maximum confinement is:

$$A = \frac{\Delta L}{L} = \frac{\sqrt{n_\gamma} L_p}{\lambda} \quad \text{strain produced by } n_\gamma \text{ coherent photons in maximum confinement}$$

The equation $\Delta L = \sqrt{n_\gamma} L_p$ is very revealing. First, it incorporates Planck length L_p . Previously we found that Planck length was also associated with Planck charge ($\underline{\mathbb{V}}_E = L_p/r$ and $\underline{\mathbb{E}}_E = L_p^2/r^2$)

Therefore, the fact that a photon exhibits this amplitude in maximum confinement supports the model.

Also, it is not possible to actually measure the electric field or magnetic field produced by a single photon. Now we can understand this because measuring the electric field produced by a single photon would be attempting to measure a displacement of Planck length. References in chapter 4 showed that it is fundamentally impossible (device independent) to detect a displacement of spacetime equal to or less than Planck length. It is theoretically possible to detect and measure the oscillating electric field produced by many photons ($n_\gamma \gg 1$ photons) because many coherent photons produces $\Delta L \gg L_p$. Now we can conceptually understand this effect.

Similarity to Gravitational Wave: We previously learned that Planck impedance Z_p is the same as the impedance of spacetime Z_s when we use the charge conversion constant η . This conversion constant and a wave-amplitude equation also give that n_γ photons in the maximum confinement condition gives the oscillating strain amplitude in the spacetime field A equal to $A = \sqrt{n_\gamma} L_p / \lambda$. This implies that electromagnetic waves are very similar to gravitational waves. While gravitational waves appear to be completely dissimilar to electromagnetic waves, they must be first cousins. Both are transverse waves that propagate at the speed of light through the medium of the spacetime field. They both experience the same impedance therefore electromagnetic waves must also be waves in spacetime. The quantum mechanical description of the spacetime field is vacuum fluctuations with Planck length/time displacements at all frequencies up to Planck frequency. This description of the spacetime field has a high energy density. The spacetime field has elasticity and very large impedance. Waves in the spacetime field propagate at the speed of light but the displacement of the spacetime field is very small because the spacetime field also has an incredibly large impedance and bulk modulus. A single photon in maximum confinement (volume λ^3) only affects the spacetime field by a Planck length displacement over a distance of λ .

One of the biggest differences is that positive and negative electrically charged particles are available to generate electromagnetic radiation. Gravitational waves can only be generated by particles that have a single polarity (only positive mass) therefore only quadrupole gravitational waves are possible. However, if we are attempting to understand the physics of electromagnetic radiation propagating in the spacetime field the differences in generation are not too important.

A gravitational wave is a transverse wave that causes a spherical volume to become a transverse oscillating ellipsoid. If we freeze this ellipsoid for a moment there is an axis that increases the distance between points and an orthogonal axis that decreases the distance between points. The points themselves are not accelerated and physically moved by the gravitational wave. The spatial properties of the spacetime field are affected in a way that increases or decreases proper distance as might be measured by a tape measure. With gravitational waves there is no polarization vector that distinguishes between opposite directions along either of these two

axes. The effect on the spacetime field by gravitational waves is symmetrical (reciprocal). This effect can be thought of as a difference between the coordinate speed of light and the proper speed of light along the two axes. We interpret this difference as a change in the distance between points because we assume that the proper speed of light is constant. Also, all physical objects (meter sticks, proton radius, etc.) scale their size with proper length which in turn scales with the proper speed of light. This is understandable from the proposed spacetime based model of the universe because all matter and forces are ultimately waves in the spacetime field which scale with the proper speed of light.

Proposed Model of an Electric Field: Electromagnetic radiation has transverse oscillating electric and magnetic fields. If we imagine freezing the wave, the electric field has a specific vector direction which by convention we say points away from positive and towards negative. The magnetic field by convention points from North to South. Therefore one difference between an electromagnetic wave and a gravitational wave is that the electromagnetic wave produces transverse vectors which are not reciprocal (electric and magnetic fields vectors) while the gravitational wave is a reciprocal transverse wave. Reversing direction along either the long or short axis distortion produced by a gravitational wave produces the same distance between points. We will designate the unsymmetrical (non-reciprocal) effect on the spacetime field produced by EM radiation as “polarized spacetime”. Both EM radiation and gravitational waves do not modulate either the rate of time or proper volume.

If we are going to explain electromagnetic fields using only the properties of spacetime, it is necessary to incorporate into the explanation a nonreciprocal (polarized) effect that does not produce an oscillation of either proper volume or the rate of time. Explaining an electric field (and later a magnetic field) using only the properties of spacetime has been the most difficult task (invention) of any creative new idea described in this book. In particular, it was difficult to 1) initially recognize that the solution must involve polarized spacetime, 2) to find a model that would generate the correct force 3) not modulate proper volume and 4) result in the non-reciprocal (polarized) characteristics required for an electric field. For example, there must be a physical difference between the positive electric field direction and the negative electric field direction (the opposite direction).

A gravitational wave does not produce a net change in proper volume. An increase in one dimension is offset by a decrease in the orthogonal transverse dimension to keep the total volume constant. If there was a detectable change in volume, there would also be a detectable change in the rate of time and this would create conditions where there can be a violation of the conservation of momentum (see dipole wave discussion in chapter 4). An oscillating electric field must modulate distance between points without modulating proper volume. The way this is accomplished is even simpler than the mechanism used by a gravitational wave. In an oscillating electric field the dimensional increase and decrease happens in only one dimension. One propagation direction experiences the increase while the opposite propagation dimension

experiences the decrease. The round trip propagation time (round trip distance) is unchanged therefore there is no change in proper volume.

This is the simplest possible way that produces a net polarization of the spacetime field without also producing a net change in volume or a net change in the rate of time. This proposed model of an electric field will be further supported in chapter 10 by a calculation which shows that this model produces the correct electrostatic force between rotars with elementary charge e . The calculation cannot be presented here because it requires the introduction of additional concepts.

It is proposed that an electric field is an asymmetric distortion of the spatial dimension of the spacetime field parallel to the electric field direction. This results in a slight asymmetric distance between points propagating in the positive electric field direction compared to propagating in the negative electric field direction. There is neither a net volume change nor a rate of time change because the round trip time between the points is unchanged (except for the slight gravitational effect).

The proposed model of an electric field implies that n_γ photons in maximum confinement produce an effect on space that results in a distortion of $\Delta L = \sqrt{n_\gamma} L_p$ over distance λ . The vector distortion implies that if the rotating electric is imagined as being momentarily frozen, there would be a difference in the distance of $\Delta L = \sqrt{n_\gamma} L_p$ progressing from + to - compared to progressing in the opposite direction (- to +). It is not known which polarization direction produces the longer distance, but hypothetically this is experimentally measurable.

This non-reciprocal property seems strange, but another example of a non-reciprocal effect is a Faraday rotator. When a magnetic field is imposed on any transparent material, circularly polarized light experiences a different path length depending on whether it is propagating in the North magnetic direction compared to propagating in the South magnetic direction. This difference in path length between the two opposite directions can be expressed as $\Delta L/L$. It also causes linearly polarized light to exhibit a different rotation direction when propagating in opposite directions. This effect is commonly used to form an optical isolator that only allows laser beams to propagate one direction.

Charged Particles: Since EM radiation has an oscillation at frequency ω , it is easy to imagine that that the oscillating electric field (oscillating distortion of the spacetime field) produced by EM radiation has energy density. However, the electric field produced by a charged particle appears to be static and yet it also possesses energy density. Of we insert $\omega = 0$ into the energy density equation $U = kA^2 \omega^2 Z$, we obtain that there should be no energy density if there is no oscillation. Yet we know that the electric field produced by charged particles also has energy density. It will be proposed in chapter 10 that all particles (charged and neutral) produce an oscillating disturbance in the surrounding volume of spacetime. This will be shown to be oscillating standing waves at the particle's Compton frequency. These standing waves produce not only

particle's de Broglie waves but also they are required for the production of a non-oscillating portion of the electric field and also gravitational effects.

Electric Field Produced by Charged Particles: Earlier in this chapter we derived the electrical potential for Planck charge in dimensionless Planck units as: $\underline{V}_E = L_p/r$. When we assume elementary charge e (designated with subscript "e") the equation becomes:

$$\underline{V}_e = \frac{\underline{V}_e}{\underline{V}_p} = \frac{\sqrt{\alpha}L_p}{r}$$

Therefore the voltage expressed in dimensionless Planck units is a dimensionless number that is describing the slope of the polarized strain of spacetime. As previously explained, an electric field produces polarized spacetime where there is a difference in distance progressing in opposite directions. The difference in distance is designated ΔL so the ratio $\Delta L/\Delta r$ can be thought of as a type of slope designating the difference in distance between opposite directions ΔL over radial line segment Δr . For example, we will start with a single radial vector pointing away from a charged particle. We will designate distances r_1 and r_2 along this radial vector and specify that $r_2 > r_1$. The distance between r_1 and r_2 is slightly different if a time of flight distance measurement is made progressing from r_1 to r_2 compared to progressing in the opposite direction. This difference ΔL produced by a particle with elementary charge e , is equal to:

$$\Delta L = \sqrt{\alpha}L_p \ln(r_2/r_1) \quad \text{distortion produced by the electron's charge between } r_2 \text{ and } r_1$$

For example, if $r_2 = 1$ meter and $r_1 = 10^{-12}$ meter, then $\Delta L = \sqrt{\alpha} \times L_p \times 27.6 \approx 3.26 \times 10^{-36}$ m. While this seems like a very small net distance, it must be remembered that the strain is affecting the enormously large energy density, impedance and bulk modulus of the spacetime field. Later it will be shown that this type of polarized strain of spacetime can produce the magnitude of the force we expect of an electric field acting on an electron (rotar). If there are multiple charges, the strain produced by each elementary charge is a vector which adds to the vector strains produced by all the other charges. For example, if there are a large number of electrons (n_e electrons) on a charged sphere, then the value of ΔL becomes: $\Delta L = n_e \sqrt{\alpha}L_p \ln(r_2/r_1)$.

Thus far we have dealt with the distortion produced by a spherical electric field such as is produced by a single electron of a charged sphere. However, what about the distortion of spacetime produced by a parallel plate capacitor? We will assume a vacuum capacitor made with parallel plates of dimensions $D \times D$ and separated by distance D . This is an idealized vacuum capacitor which forms a cube. We will ignore the effects of fringing electric fields in this exploratory discussion. The same way that expressing voltage (electrical potential) in dimensionless Planck units \underline{V} for a single charged particle gave strain $\Delta L/r$, so also expressing the voltage on a vacuum capacitor with separation distance D gives the strain of spacetime produced by the electric field generated by a vacuum capacitor.

$$\underline{V} = \frac{V}{V_p} = \frac{\Delta L}{D}$$

$$\Delta L = \underline{V} D$$

For example, a time of flight distance measurement along the electric field of a vacuum capacitor might be made if a small hole is provided in the center of both plates. The prediction is that the time of flight distance proceeding from positive to negative should differ by $\Delta L = \underline{V} D$ compared to proceeding the opposite direction. However, this would be hard to measure. For example, if $D = 1$ m and voltage was 1,000,000 volts, then since $V_p \approx 10^{27}$ volts, $\underline{V} \approx 10^{-22}$ and $\Delta L \approx 10^{-22}$ m. This is much smaller than current interferometer technology can measure. However, there is also another problem which will be discussed later relating to whether light can ever be used to measure the ΔL effect.

Comparison of Electric Fields: The equation $\Delta L = \underline{V} D$ for a cubic vacuum capacitor specifies the length difference in terms of \underline{V} and D . Since an electric field $\mathcal{E} = V/L$ and in the case of a vacuum capacitor $L = D$, we can also express ΔL over distance L in a uniform electric field \mathcal{E} as:

$$\Delta L = \frac{\mathcal{E} L^2}{V_p}$$

With photons we were able to specify ΔL in terms of the number of photons n_γ in maximum confinement ($\Delta L = \sqrt{n_\gamma} L_p$). Next we will calculate ΔL in a cubic vacuum capacitor in terms of the number of electrons n_e on the vacuum capacitor with dimensions $D \times D \times D$. This calculation will make use of the following substitutions:

$$V = q/C, \quad q = n_e e, \quad C = k \epsilon_0 D^2 / D = k \epsilon_0 D, \quad V = k n_e e / \epsilon_0 D, \quad V_p = \sqrt{c^4 / 4 \pi \epsilon_0 G}, \quad L_p = \sqrt{\hbar G / c^3}, \\ e = \sqrt{\alpha 4 \pi \epsilon_0 \hbar c}, \quad n_e = \text{number of electrons}$$

$$\Delta L = \underline{V} D = \frac{V D}{V_p} = \frac{n_e D \sqrt{\alpha 4 \pi \epsilon_0 \hbar c}}{\epsilon_0 D V_p} = \frac{n_e \sqrt{\alpha 4 \pi \epsilon_0 \hbar c}}{\epsilon_0} \sqrt{\frac{4 \pi \epsilon_0 G}{c^4}} = \sqrt{\alpha} 4 \pi n_e L_p$$

$$\Delta L = k \sqrt{\alpha} n_e L_p$$

The above equation will be expressed in words. The non-reciprocal distortion of spacetime ΔL produced across the width of a cubic vacuum capacitor (D) is equal to 1.38×10^{-36} meters per electron. This holds for all size cubic vacuum capacitors (all values of D).

Converting elementary charge e to coulomb, the strain of spacetime produced by a coulomb of charge on a cubic vacuum capacitor is:

$$\Delta L/q = \sqrt{\alpha} L_p / e = 8.62 \times 10^{-18} \text{ meters/coulomb} = \eta \text{ (the charge conversion constant)}$$

Therefore one of the physical interpretations of the charge conversion constant η is that this is the distortion of spacetime produced over the width (D) of a cubic vacuum capacitor by a coulomb of charge.

Previously it was calculated $\Delta L = \sqrt{n_\gamma} L_p$ for n_γ photons in the maximum confinement cavity approximately of volume λ^3 . Now we have $\Delta L = \sqrt{\alpha} n_e L_p$ for a vacuum capacitor with dimensions $D \times D \times D$ (ignoring numerical factors near 1). The electric field distortion produced by photons and electric charge become very similar if we have similar size ($\lambda \approx D$). The calculation is not shown here, but an electric field generated by photons produces the same polarized distortion of spacetime (ΔL) as an equal electric field strength produced by charged particles on a vacuum capacitor. In other words, $\Delta L = \mathbb{E} L^2 / \nabla_p$ holds for electric fields generated by either photons or electrons. The photon field is oscillating and has an associated magnetic field, so there are also differences in the value of k which is being ignored. However, the point is that even though the photon equation scales with the square root of the number of photons $\sqrt{n_\gamma}$ and the capacitor equation scales with the number of electrons n_e (no square root), still when the effect is reduced to electric field of equal strength in equal volumes, the values of ΔL are the same (ignoring k).

Experiments Using Light: In earlier versions of this book and in an earlier technical paper, I discussed possible experiments using light in an attempt to measure the predicted non-reciprocal path length difference between opposite propagating directions. However, now I doubt that light can measure this effect. The doubt has nothing to do with the fact that all practical experiments produce a value of non-reciprocal length change ΔL in the range of 10^{-20} to 10^{-18} m. The best interferometers currently can see a modulated length change on the order of 10^{-18} m. Therefore, if the effects were measurable by interferometers, they would be near the detectable limit. However, the real problem is that it now appears as if the light from an interferometer will not be able to see any value of ΔL produced by an electric field no matter the magnitude. The problem has to do with the way that light propagates through spacetime. Before I explain the problem, I want to give some history about the understanding of light.

In the late 1600's one of the biggest mysteries of science was double refraction. When light passes through a crystal known as Iceland spar (a crystal of CaCO_3), the light is broken into two beams and double images appear. Isaac Newton proposed a corpuscular theory of light but his corpuscular theory could not explain double refraction. In 1690, Christian Huygens proposed a wave-based theory of light. Huygens also derived a partial explanation of double refraction. The Huygens Principle considers each point on a wavefront to be the source of a new wave. Huygens realized that if the velocity of light varied with the direction in the crystal, then the spheres would deform into ellipsoids and be able to partially explain double refraction of Iceland spar. Even though his explanation could be reduced to an equation which corresponded to experiment, the

explanation did not give conceptual understanding of the fundamental difference between the two beams. He, and everyone else for the next 100 years, assumed that light waves were longitudinal waves like sound waves in air. The problem was that longitudinal waves could not explain double refraction.

The puzzle of double refraction was so iconic, that in 1807 the French Institute offered a cash prize to anyone who could explain this phenomena. The prize was initially awarded to a Frenchman, Etienne Malus, in 1810 and a second cash prize was awarded to a French woman, Sophie Germain, in 1816. However, these were only partial solutions. The most important insight was made by Thomas Young several years later when he showed that light is a transverse wave. The transverse waves of unpolarized light were being split into two orthogonal linear polarizations by the crystal. This gave an explanation of double refraction of light which was both conceptually understandable and mathematically rigorous. However, Thomas Young, an Englishman, was not awarded a third cash prize by the French Institute.

This story about double refraction and polarized light is told to prepare the reader for a more complex model of the distortion of spacetime produced by a photon. In earlier drafts of this book I proposed that the distortion of spacetime could be measured by an interferometer where the two beams propagate in opposite directions across the rotating electric field produced by microwave radiation in a maximum confinement cavity. One laser beam would experience a decrease in path length while the opposite propagation beam would experience an increase in path length. A half cycle later the rotating microwave electric field would have reversed polarity. If the intensity of the rotating EM radiation (probably microwaves) could be made high enough, the modulated path length might be detectable as an intensity modulation when the two laser beams are compared in an interferometer.

The problem with this experiment is that it does not properly address the transverse wave structure of light. As previously stated, a photon is not a packet of energy that propagates linearly through the empty void of spacetime. Instead, a photon is a transverse wave that is interacting with the properties of spacetime transverse to the direction of propagation. The speed of light for linearly polarized light is set by the speed of wave propagation in the plane of polarization. Therefore, light cannot be used to accurately measure distance in the direction of propagation if the medium being probed is not homogeneous. This transverse wave property creates a problem for any experiment that attempts to use light to measure the distortion of spacetime produced by an electric field.

When light propagates through homogeneous glass, it has a speed of light less than 1. The relative permittivity ϵ of the glass and the index of refraction are both homogeneous in all directions. However, suppose that the glass is stressed by a uniform compression along what we will consider to be the Z axis of the glass. The permittivity ϵ in the Z direction becomes different than the permittivity measured in the X and Y axis. Linearly polarized light with its electric field

vector along the Z axis propagates through the glass at a different speed than light of the same wavelength but polarized along any orthogonal direction. When light is propagating through a uniform medium, then we can ignore the transverse wave nature of light. However, when the medium is not uniform in all directions, we have to be careful about the actual mechanics of wave propagation through the medium when attempting to make a distance measurement.

Normally, the vacuum is considered to be perfectly homogeneous. However, the proposal is that both gravitational waves and electric fields distort the vacuum (spacetime) so that it is not homogeneous in all directions. The inhomogeneity is extremely small, but we are attempting to devise experiments to measure this effect. Therefore, the experiment is specifically designed to enhance the inhomogeneity to a measurable level. However, there is a problem that will be illustrated with an example. Suppose that a vacuum capacitor contains two small holes in the middle of each flat plate of the capacitor. Sending a laser beam through the holes would have the laser beam propagating one way along the electric field of the capacitor. The prediction is that the distance along the electric field should be different for a “time of flight measurement” proceeding in the two opposite directions (positive to negative compared to negative to positive).

However, the speed of propagation of the laser beam is determined by the properties of spacetime perpendicular to the propagation direction. Even with an extremely strong electric field, it should be impossible for a beam of EM radiation to measure any effect. Even if the beam direction is changed so that it propagates perpendicular to the electric field with the polarization direction parallel to the probed electric field, there still should be almost no detectable effect. Recall that the round trip distance in an electric field should be unchanged compared to the round trip distance with no electric field. The EM radiation has an oscillating (reversing) electric field so it is probing the round trip properties of spacetime. One complete cycle of the oscillating electric field should produce no first order effect. There would be a very small second order nonlinear effect associated with the gravity produced by the electric field, but that would be vastly smaller than the first order effect. It would also be symmetrical.

There is another hypothetical way to probe the distortion of spacetime produced by an electric field that gets around to problems of EM radiation but has its own practical problems. Suppose that a neutral particle such as a neutron or neutrino could be sent along the electric field. If the speed was accurately known, then distance could theoretically be measured by a time of flight measurement. This is not subject to the transverse wave problems of light and it should hypothetically give the one way distance. The obvious problem is that neutron or neutrino beams are completely impractical to experimentally measure distance accurately.

Implied Maximum Energy Density for Photons: Even though experimental verification appears impractical, there are other ways of checking the validity of the predictions. The following calculations test the model at the highest energy density. When I first developed the

equations for the distortion of the spacetime field produced by electromagnetic radiation, I quickly realized that there was an implied limit. The finite properties of the spacetime field implied that there should be a maximum intensity limit for EM radiation. This limit is set because EM radiation produces a distortion of the spacetime field which has finite properties. It should be impossible to exceed 100% distortion of any portion of the spacetime field if the model is correct. Initially, this prediction was counterintuitive and appeared to be revealing a flaw in the model.

This implied limit will be explained using the maximum confinement cavity but it applies even to a laser beam focused in a vacuum. For example, the equation $\Delta L = \sqrt{n_\gamma} L_p$ applies to a cavity of volume λ^3 . This equation implies that there is a maximum possible value of ΔL that can be achieved. When $\Delta L = \lambda$, then the distortion ΔL equals the size (λ) of the maximum confinement cavity (ignoring numerical factors near 1). Therefore if the model of the distortion of spacetime produced by the electric field generated by photons was correct, it should be impossible to exceed the condition where $\Delta L = \lambda$ in a volume of λ^3 because this would require 100% modulation of the properties of the spacetime field within this volume.

As you probably have guessed, experimentally testing this prediction would require a peak power that is totally beyond human capability. For example, suppose that we attempted to exceed the 100% modulation of spacetime limit using a pulsed laser with a wavelength of 10^{-6} m (1 micron). If we assume a pulse length 1 wavelength long (3×10^{-15} s pulse has a length of 1 micron) and the beam focused to a spot 1 wavelength in diameter, then the volume of the focused pulse would be about 1 micron in diameter. To exceed the ability of the spacetime field to transmit this radiation, the peak power in the pulse would have to be about 10^{53} watts. The energy in the 3×10^{-15} s pulse would have to be about 10^{38} Joules to reach this theoretical transmission limit for a 1 micron diameter volume. To put this energy requirement in perspective, this required energy is equivalent to the annihilation energy of about 10^{21} kg which is about the mass of all the oceans on earth. An experiment is obviously not possible, but it is quite easy to check this prediction theoretically.

We will return to the maximum confinement resonator previously described which had a diameter of $\frac{1}{2}$ wavelength and a length of $\frac{1}{2}$ wavelength. Since the energy density inside is not uniform and maximum near the center, we loosely defined this volume as λ^3 by ignoring numerical factors near 1. For this condition, we previously determined the displacement amplitude ΔL as: $\Delta L = \sqrt{n_\gamma} L_p$, where n_γ equals the number of photons in the resonator. We will now designate n_c as the critical number of photons at frequency ω required to theoretically achieve 100% modulation at wavelength λ . This condition occurs at $\Delta L = \lambda$. This critical number of photons in volume λ^3 has a critical amount of energy of E_c . Therefore we will analyze the critical energy E_c in volume λ^3 to see if there is any obvious reason preventing electromagnetic radiation from exceeding the implied limit that would achieve 100% modulation (achieve $\Delta L = \lambda$.)

$$n_c = \frac{E_c}{\hbar\omega} = \frac{E_c\lambda}{\hbar c} \quad \text{set } \Delta L^2 = n_c L_p^2$$

$$\Delta L^2 = n_c L_p^2 = \left(\frac{E_c\lambda}{\hbar c}\right) \left(\frac{G\hbar}{c^3}\right) \quad \text{set } \Delta L = \lambda$$

$$\lambda = \frac{GE_c}{c^4} = \frac{Gm}{c^2} = R_s \quad \text{where } R_s \equiv Gm/c^2 \text{ the Schwarzschild radius for energy of } \frac{E_c}{c^2}$$

This is a fantastic result! It is not necessary to do an experiment to prove that this prediction is correct. The intensity (energy density) that would achieve 100% modulation of spacetime would also make a black hole! The maximum confinement resonator can be considered to have a radius equal to λ . For the critical condition, $\lambda = R_s$, where $R_s \equiv Gm/c^2$ is the previously defined Schwarzschild radius of a black hole. Therefore, it is indeed impossible to exceed the implied limit that would achieve 100% modulation of spacetime because this is the condition that creates a black hole. If more energy than the transmission limit was provided, the energy density would form a black hole which would block transmission through the volume. While the calculation assumed a maximum confinement cavity, this same limit would apply if the laser beam achieved this size and energy density by merely being focused in a vacuum. This successful test has several profound implications.

- 1) The proposed quantum mechanical model of spacetime (dipole waves in the spacetime field) is strongly supported.
- 2) The concept that EM radiation is a wave propagating in the medium of spacetime is supported.
- 3) The displacement amplitude of n_γ photons in "maximum confinement" is: $\Delta L = \sqrt{n_\gamma} L_p$
- 4) The condition that creates a black hole can now be understood more completely than merely discussing vague terms such as "curved spacetime". Now the internal workings of spacetime that creates curved spacetime can be quantified.

We cannot exceed the intensity that would demand more than 100% modulation of the spacetime field. This field has all frequencies up to Planck frequency and a total energy density of about 10^{113} J/m³. However, it is not necessary to exceed 10^{113} J/m³ to achieve a black hole. That is the intensity required to achieve a black hole with wavelength equal to Planck length. To achieve a black hole using 1 micron light, it is only necessary to achieve 100% modulation of the portion of the spacetime field with frequency of about 3×10^{14} Hz in a volume about 1 micron in diameter (this example ignores numerical factors near 1).

Maximum Voltage on a Vacuum Capacitor: There is another prediction that will test the proposed model of the distortion of spacetime produced by an electric field. In the case of the cubic vacuum capacitor calculated earlier, we generated the equation $\Delta L = \nabla D$ for a vacuum capacitor with dimensions $D \times D \times D$. In other words, the distance between the parallel plates of the vacuum capacitor is D . Therefore the maximum distortion of the spacetime field occur when $\Delta L = D$. This would also be 100% distortion of the properties of the spacetime field within the vacuum

capacitor volume ($Dx Dx D$). This condition is reached when $\underline{V} = 1$. Since the definition of \underline{V} is: $\underline{V} \equiv V/V_p$, it should be impossible to exceed the condition where the voltage on the cubic vacuum capacitor equals Planck voltage $V = V_p$ because at this voltage $\underline{V} = 1$. This limit seems strange because this fixed maximum voltage applies to any size cubic vacuum capacitor. Therefore, there is not a maximum electric field but a maximum voltage. We will calculate the energy contained in a cubic vacuum capacitor when it is charged to Planck voltage. Substitutions to be used: $V_p = \sqrt{c^4/4\pi\epsilon_0 G}$, $E = kC V^2$, $C = k\epsilon_0 D^2/D = k\epsilon_0 D$ where: $C = \text{capacitance}$

$$E = kC V_p^2 = (k\epsilon_0 D) \left(\frac{c^4}{4\pi\epsilon_0 G} \right) = k \frac{c^4 D}{G}$$

$$D = \frac{GE}{c^4} = \frac{Gm}{c^2} = R_s$$

Therefore the equation $D = R_s$ says that the condition which achieves 100% modulation of the properties of spacetime within the vacuum capacitor also forms a black hole with radius R_s . It is impossible to exceed Planck voltage on a cubic vacuum capacitor because this requires energy which would form a black hole. (This statement ignores numerical factors near 1 and ignores fringing of the electric field around the edges of the plates.) Again, this analysis of the maximum voltage on any size vacuum capacitor is revealing something about the mechanics of the formation of a black hole beyond the standard gravitational explanations.

Gravitational Wave Detection: We are going to pause from the discussion of electric fields and briefly examine the implications for the detection of gravitational waves. For review, a gravitational wave is a transverse wave that propagates through the spacetime field at the speed of light. It causes a spherical volume of spacetime to become an oscillating ellipsoid. If the gravitational wave propagates in the Z axis direction, the elliptical elongation and contraction will occur perpendicular to the Z axis. We can define the X and Y axis to correspond to the transverse directions of maximum oscillation. There is no effect on the rate of time and no change in proper volume because an expansion of the X axis is offset by a contraction of the Y axis and vice versa.

The LIGO experiment will be used as an example of experiments around the world currently attempting to detect gravitational waves. This experiment is a power recycled Michelson interferometer. Massive mirrors suspended by wires are located at each of the corners of L-shaped evacuated tubes which are 4 km long. Suppose that a large gravitational wave passes with properties would produce the maximum difference in path length between the mirrors. What is physically happening? Is there a force exerted on the mirrors causing the mirrors to physically move (accelerate and decelerate)? Alternatively, does the change in the separation distance result from a change in the properties of the spacetime field with no force exerted on the mirrors (no acceleration and deceleration of the mirrors)?

This second alternative is proposed to be correct. The properties of spacetime change in way that affects the size of rotars, atoms, etc. This would make physical objects such as meter sticks and tape measured change their size. The distance between the mirrors would change according to physical measurements, but there would be no physical motion of the mirrors. There would be no force, and no acceleration of the mirrors. Here are two reasons for believing this.

- 1) Suppose that one of the two mirrors had vast mass, equivalent to the mass density of a neutron star. The force that must be exerted to achieve the required physical motion of this mirror would also have to be vast. Yet there is no offsetting mass accelerating in the opposite direction required to achieve the conservation of momentum. Assuming that the mirrors physically move is a violation of the conservation of momentum.
- 2) A gravitational wave does not affect the rate of time. If a gravitational wave achieves the acceleration of matter using gravity, the gravitational wave would have to affect the rate of time and possess a rate of time gradient. As discussed in chapter 2, all gravitational acceleration implies a rate of time gradient. Since a gravitational wave does not exert a gravitational force, is there any other force which might accelerate the mirrors?

Therefore, a gravitational wave affects the spatial properties of two of the three spatial dimensions. There is no effect on proper volume but the three orthogonal directions (X, Y and Z axis) of the spacetime field have received different distortions. Now the question is: what effect does this spatial change have on EM radiation? If you think of a photon as being a bullet-like packet of energy, then only one dimension (the propagation direction) is being probed and distance as measured by time of flight of photons in that one dimension should agree with the meter stick measurement. However, if the model of photons is a transverse wave propagating in the medium of the spacetime field, then it is not obvious what effect the two transverse dimensions might exert on the distance measurement.

To explore this question, we will temporarily shift from a gravitational wave affecting spacetime to a gravitational wave affecting a transparent cube made of a homogeneous material such as glass. The faces of the cube are aligned with the X, Y and X axis previously defined. A gravitational wave passing through this transparent cube will cause the cube to become an oscillating rectangle which exhibits both modulated birefringence and a modulation of the relative permeability ϵ .

The modulated birefringence and modulated permittivity in glass would cause a single beam of circularly polarized light propagating in any direction in the glass cube to become an oscillating elliptical polarized beam of light. The biggest effect on polarization of circularly polarized light would be for the beam propagating along the Z axis. This is the direction that does not experience any change in the time of flight path length. However, since light is a transverse wave, changes in ϵ_0 or the speed of light for light polarized in the X and Y directions convert circularly polarized light propagating in the Z direction into oscillating elliptically polarized light. If we consider the spacetime field to be a medium in which EM radiation propagates, then it should react to the

passage of a gravitational wave similar to the way that a transparent homogeneous material such as glass would react. In particular, the propagation speed (inverse index of refraction) depends on the polarization direction, not the direction of propagation. There is some uncertainty in this, but if gravitational waves turn the spacetime field into an oscillating birefringent material, then there would be simpler and more sensitive ways of detecting gravitational waves.

Presently, the biggest source of noise using interferometers is the seismic noise. Interferometers are attempting to detect very small difference in optical path length between the two arms. Anything that produces even a very small vibration is a source of noise. Even the photon pressure of the light making the measurement is a source of noise. If the spacetime field becomes a birefringent medium, then it would be possible to detect gravitational waves without using an interferometer. For example, circularly polarized light propagating in the Z direction, should encounter a birefringence (difference in ϵ) in the X and Y directions. This would cause even a single beam of circularly polarized light to become an oscillating ellipsoid of polarized light. Other experiments can also be devised but the point is that it is much easier to detect changes in a single polarized beam than changes in the path length of two beams propagating in two widely separated arms of an interferometer.

Also, this proposed birefringence can also create problems for interferometers. If the two beams of an interferometer have the same polarization direction, then this would cause the same path length change to occur in both arms of the interferometer. Even if there was a large signal, both arms would experience the same path length change. The interferometer would detect no difference in path length and there would be no signal.

Magnetic Field Analysis

Comparison between Electric and Magnetic Fields: What is the effect on spacetime produced by a magnetic field? We know that an electric field and a magnetic field are intimately connected by the speed of light ($E = cB$). A magnetic field in one frame of reference can appear to be an electric field and magnetic field in another frame of reference.

There are two common ways of producing a magnetic field 1) an electric current in a wire and 2) the magnetic field associated with the spin of subatomic particles. There is a very good explanation of a magnetic field generated by current in a wire. This explanation by Ed Lowry¹ is based on the special relativity transformation of an electric field. When current flows in a wire, the negatively charged electrons in the wire are moving relative to the positively charged

¹ <http://users.rcn.com/eslowry/elmag.htm>

protons in the wire. Therefore, the positive and negative charges in the wire are in two different average frames of reference. When an external electron moves parallel to the wire, it also is in a different frame of reference. The moving electron experiences a transverse electric field that exerts a transverse force on the electron. This force will be towards the wire if the external electron is moving in the same direction as the electrons in the wire. The force will be away from the wire if the movements are in opposite directions. While this explanation gives important insights, it does not explain the distortion of spacetime produced by a magnetic field.

The force on the external electron increases with relative speed. When the electron is traveling near the speed of light, the energy density of the magnetic field has been almost completely transformed into a transverse electric field. A photon is propagating at the speed of light, therefore if it is propagating in a transverse magnetic field the photon experiences a transverse electric field. The direction of the electric field is 90° relative to the transverse magnetic field. What effect would this have on a photon? Unfortunately, a transverse electric field produces a subtle effect. A transverse electric field is polarized spacetime exhibiting the asymmetry previously discussed. The transverse direction of the asymmetry would produce no effect on distance and no effect on the polarization of the light. Instead, I propose that the only effect would be that the direction of propagation of the light would not be precisely perpendicular to the wavefront. A converging beam of laser light would come to a focus at one spot when there is no transverse magnetic field and focus at a slightly different spot when there is a transverse magnetic field. In a typical experiment these spots would overlap to a degree that it would not be possible to measure the difference. The signal to noise ratio would be too low.

An Electron's Magnetic Field: The spin of an electron produces a magnetic field that is aligned with the spin axis. Therefore, perhaps it is possible to obtain an insight into the distortion of spacetime produced by a static magnetic field by looking at the rotar model of an electron. Since a magnetic field is closely related to an electric field, a magnetic field must also be associated with a strain of the length dimensions with no distortion of the rate of time and no change in total volume. An electron is most well-known for its electric field, but the spin of the electron also produces a magnetic field. The energy density of an electron's magnetic field decreases more quickly with distance than the electron's electric field. Therefore the electric field dominates when distance r is much greater than an electron's rotar radius λ_c . However, when $r \approx \lambda_c$, the electron's magnetic field should have a comparable energy density to the electron's electric field.

We will begin the quest to deduce the spacetime model of a magnetic field by doing some plausibility calculations to see if the rotar model of an electron can give plausible agreement with the magnetic properties of an electron. If the universe is only spacetime, then a magnetic field must be a distortion of the spacetime field. We are going to attempt to make a connection between an electrical current flowing around a loop of wire and the rotar model of a fundamental particle. We know that a current flowing around a loop of wire produces a magnetic field. If the

proper connection is made, then we should be able to see how the rotating dipole wave of the rotar model produces an electron's magnetic field.

The rotar model of a fundamental particle has a dipole wave in the spacetime field chaotically propagating at the speed of light around a volume of space. This volume can be mathematically approximated by the rotar model with a circumference equal to the particle's Compton wavelength. Therefore the radius of this volume is equal to λ_c . Even though the propagation is chaotic, there is a definable expectation rotation direction and rotation axis. Suppose that we test the postulate that the magnetic field produced by an electron is equivalent to a point particle with charge e propagating at the speed of light around a loop with radius equal to the rotar's rotar radius λ_c . This radius has a circumference equal to the rotar's Compton wavelength λ_c . Since the propagation speed equals the speed of light, the rotation frequency around the loop would be equal to the particle's Compton frequency $\nu_c = \omega_c/2\pi$. We will assume a fixed axis of rotation rather than the chaotic axis of the dipole wave.

With these assumptions, it is possible to determine the electron's circulating current (designated I_e) that would be flowing around this hypothetical loop. We will assume the constants associated with an electron. Therefore $\lambda_c = 3.86 \times 10^{-13}$ m and an electron's Compton frequency is equal to: $\nu_c = c/\lambda_c = 1.23 \times 10^{20}$ Hz. The electron's equivalent circulating current (symbol I_e) is simply elementary charge $e = 1.602 \times 10^{-19}$ Coulomb times the electron's Compton frequency $\nu_c = 1.236 \times 10^{20}$ Hz.

$$I_e = e\nu_c \approx 19.796 \text{ amps} \quad I_e = \text{electron's equivalent circulating current} \sim 19.8 \text{ amps}$$

We can check to see if this current produces the correct magnetic effects if we imagine a loop of wire with radius equal to an electron's rotar radius λ_c . Specifically, we will see if this current in this size loop of wire would produce the same magnetic moment as an electron (before QED interactions). The magnetic moment μ_m of a loop of wire with area $\mathcal{A} = \pi r^2$ and current I is: $\mu_m = \mathcal{A}I$. To simulate an electron, we will use: $\mathcal{A} = \pi\lambda_c^2$ and $I = I_e = e\nu_c$.

$$\mu_m = \pi\lambda_c^2 I_e = \pi (3.8616 \times 10^{-13} \text{ m})^2 \times 19.796 \text{ amp} = 9.274 \times 10^{-24} \text{ J/Tesla}$$

This is a successful test because 9.274×10^{-24} J/Tesla equals an electron's Bohr magneton ($\mu_B = e\hbar/2m_e = 9.274 \times 10^{-24}$ J/Tesla.) A more rigorous calculation (not shown here) incorporating λ_c , e , ν_c etc. shows that the rotar model of an electron gives $\mu_B = e\hbar/2m_e$. The term "Bohr magneton" is used to express a simplified version of an electron's magnetic dipole moment. The experimentally measured value of an electron's dipole moment differs from this Bohr magneton number by about 0.1%. This small correction factor obtained from QED (the anomalous magnetic moment) will not be discussed further because the objective here is to develop a spacetime based model of a magnetic field. To achieve this goal, we will test the postulate that the rotar model of an electron (on axis) produces the same magnetic field as if

there was a point particle with charge e propagating at the speed of light around a loop with radius equal to the electron's rotar radius λ_c . From this postulate, the electron's magnetic field calculated from I_c and λ_c will be designated \mathbb{B}_e . The equation for the magnetic field at the center of a single circular loop of wire with radius r and current I is:

$$\mathbb{B} = \mu_0 I / 2r \quad \text{set } I = I_c \text{ and } r = \lambda_c \text{ for an electron } (\lambda_c = 3.86 \times 10^{-13} \text{ m})$$

$$\mathbb{B}_e = 3.22 \times 10^7 \text{ Tesla} \quad \mathbb{B}_e = \text{electron's equivalent magnetic field}$$

This large magnetic field would have energy density of $3.22 \times 10^{22} \text{ J/m}^3$. To test the postulate, we must ask the question: Is this reasonable? How does the implied energy in the magnetic field compare to the energy in the electron's electric field external to the electron's rotar volume (external to λ_c)? The calculation is not shown here, but the energy in the electric field external to an electron's radius λ_c is $(1/2)\alpha E_i \approx 3 \times 10^{-16} \text{ J}$. We want to test whether the large magnetic field of $3.22 \times 10^7 \text{ Tesla}$ is reasonable by making a comparison to the energy in the electron's external electric field. We will make the assumption that the magnetic field fills a volume equal to the electron's rotar volume ($V_r = [4\pi/3] \lambda_c^3 \approx 2.41 \times 10^{-37} \text{ m}^3$). It also produces an external magnetic field, so this estimate should be low. Is the energy in the electron's external electric field ($\sim 3 \times 10^{-16} \text{ J}$) comparable to, but more than, the energy in a $3.22 \times 10^7 \text{ Tesla}$ magnetic field filling the electron's rotar volume?

$$E = UV_r = (B^2/2\mu_0)(4\pi/3)\lambda_c^3 \approx 10^{-16} \text{ J} \quad \text{energy in the calculated magnetic field in volume } V_r$$

Therefore this simple calculation shows that a magnetic field of $3.22 \times 10^7 \text{ Tesla}$ is reasonable. We can also perform a more exact test. Recall that for any fundamental rotar such as an electron, the slope of the strain curve at arbitrary distance was always implied a spatial displacement at the center of an electron of $\sqrt{\alpha} L_p$ which is $1.38 \times 10^{-36} \text{ m}$. Out of curiosity, we will look at the implied ΔL for a $3.22 \times 10^7 \text{ Tesla}$ magnetic field over a distance equal to the electron's rotar radius $\lambda_c = 3.86 \times 10^{-13} \text{ m}$. Even though we have not yet proposed the physical interpretation of ΔL produced by a magnetic field, it is still possible to calculate the magnitude of ΔL for this magnetic field of $3.22 \times 10^7 \text{ Tesla}$ over a distance equal to λ_c . For a uniform electric field \mathbb{E} over distance L , we previously had $\Delta L = \mathbb{E}L^2/\nabla_p$ which converts to $\underline{\Delta L} = \underline{\mathbb{E}}L^2$ (note underlines implying dimensionless Planck units). Now we will replace L with λ_c , which is the radius of the rotar model of a fundamental particle. We will not prove it here, but a Lorentz transformation of an electric field expressed in dimensionless Planck units ($\underline{\mathbb{E}} = \mathbb{E}/\mathbb{E}_p$) can be considered equivalent to a magnetic field expressed in dimensionless Planck units ($\underline{\mathbb{B}} = \mathbb{B}/\mathbb{B}_p$). In this equation \mathbb{B}_p is Planck magnetic field which is $\mathbb{B}_p = Z_s/q_p = 2.15 \times 10^{53} \text{ Tesla}$. This means that, ignoring numerical factors near 1, it is reasonable to convert $\underline{\Delta L} = \underline{\mathbb{E}}L^2$ to $\underline{\Delta L} = \underline{\mathbb{B}}\lambda_c^2$ when we are dealing with a fundamental particle with radius λ_c .

$$\underline{\Delta L} = \underline{\mathbb{B}}\lambda_c^2 \quad \text{dimensionless Planck units}$$

$$\Delta L = \mathbb{B}\lambda_c^2 / \mathbb{B}_p L_p \quad \text{converted from dimensionless Planck units to SI units}$$

$$\text{Set } \mathbb{B} = 3.22 \times 10^7 \text{ Tesla}, \mathbb{B}_p = 2.15 \times 10^{53} \text{ Tesla}, L_p = 1.6 \times 10^{-35} \text{ m}, \lambda_c = 3.86 \times 10^{-13} \text{ m}$$

$$\Delta L \approx 1.38 \times 10^{-36} \text{ m} \approx \sqrt{\alpha} L_p$$

A more general calculation (not using numbers) can be made and it gives the same answer that $\Delta L = \sqrt{\alpha} L_p$. Therefore, this is a successful plausibility calculation on two fronts. First, it says that the calculated magnetic field produces the same magnitude of ΔL over the same distance λ_c as the electric field for the rotar model of an electron. However, the physical interpretation of ΔL is different for a magnetic field than for an electric field. Secondly, it gives added assurance that we can look to the rotar model of an electron to understand the distortion of the spacetime field that produces a magnetic field.

As previously explained, the rotation of an electron's extremely small distortion of the spacetime field is chaotic because it is at the limit of causality. However for analysis, we can imagine a stabilized electron rotation with a fixed axis of rotation. Proceeding along this axis of rotation, we would experience the distortion of the spacetime field that is producing a magnetic field of about 3×10^7 Tesla. This is a very strong magnetic field compared to anything that can be generated by man. However, it is also very weak compared to Planck magnetic field of about 10^{53} Tesla. What is different about this rotar volume compared to a typical volume of the spacetime field that is not inside an electron and does not have a magnetic field? The "typical" volume of the spacetime field contains chaotic dipole waves with Planck energy density (about 10^{113} J/m³), but the dipole wave distortion averages out to being as homogeneous as quantum mechanics allows. The obvious difference is that the electron's axial volume also contains an organized spatial and temporal distortion of the spacetime field that has a small rotating component with strain amplitude equal to $A_\beta \approx 4.2 \times 10^{-23}$. For review, see figures 5-1 and 5-2 from chapter 5. This would produce a rotational path length difference that is difficult to articulate.

Recall that an electric field is proposed to be a distortion of one spatial dimension of the spacetime field (parallel to the electric field direction) that results in a slight asymmetric distance proceeding in opposite propagation directions. The round trip distance is unchanged. A magnetic field is similar except that the plane transverse to the magnetic field has a rotational distance asymmetry. The time required for a particle with known speed to proceed around the circumference of a circle proceeding clockwise in this plane would be slightly different than the time required to proceed counterclockwise. Since light is a transverse wave, it is not accurate to imply that a pulse of light propagating around a circle would be able to measure this subtle effect. Therefore terms like "speed of light" would be misleading.

However, since light is a transverse wave, the implication is that a total vacuum should exhibit a Faraday effect for light propagating parallel to the magnetic field direction. If a photon was a bullet-like energy packet, then we would not expect any effect if it propagates through a volume of space that is experiencing a rotational asymmetry of the spacetime field. However, a transverse wave propagating through a rotationally strained volume of spacetime would

experience a polarization effect. Linearly polarized light propagating along a magnetic field should experience a slight rotation of the plane of polarization. Circularly polarized light would experience a path length change. The value ΔL can be thought of as the difference in path length exhibited by opposite circular polarizations propagating in a medium with a magnetic field. This is essentially a prediction that a complete vacuum containing a magnetic field should exhibit a Faraday effect.

The magnitude of the effect is difficult to predict since it is not clear how to treat the transverse size of a photon propagating along the magnetic field. If it is possible to make an analogy to an electric field, then here is one attempt at a calculation. The magnitude of ΔL can perhaps be calculated from $\Delta L = \mathbb{B} \lambda_c^2$ which converts to $\Delta L = \mathbb{B} L^2 = \mathbb{B} L^2 / \mathbb{B}_p L_p^2$ when we set $\lambda_c = L$. Also $\mathbb{B}_p = 2.15 \times 10^{53}$ Tesla and $L_p = 1.6 \times 10^{-35}$ m.

$$\frac{\Delta L}{L_p} = \frac{\mathbb{B}}{\mathbb{B}_p} \frac{L^2}{L_p^2}$$

$$\Delta L = \frac{\mathbb{B}}{2 \times 10^{53} \text{ tesla}} \frac{L^2}{1.6 \times 10^{-35} \text{ meter}} = 3 \times 10^{-19} \mathbb{B} L^2 \text{ meter}$$

There is a special way that the length term must be calculated explained in the analogous electric field experiment calculation. Without going into the details, the experiment is marginally detectable ($\Delta L \approx 10^{-18}$ or 10^{-19} m) for some hypothetical values. There are some possible effects which might hide the proposed vacuum effect. For example, any residual gas in the vacuum would exhibit a competing Faraday effect. However, the magnitude of the effect due to residual gas could be approximately offset by changing the gas pressure and attempting to subtract out this effect.

Comparison of Models: As a parting gesture, I just want to stand back and compare the proposed spacetime based model of a static electric or magnetic field to the currently accepted standard model. In the standard model all force is conveyed by “messenger particles”. The electromagnetic force is conveyed by virtual photons which are not to be confused with virtual photon pairs (see chapter 7).

A static electric field and a static magnetic field both have energy density. This is a real effect that implies some tangible difference between a volume of spacetime that has an electric/magnetic field and a volume of spacetime that has no electric/magnetic field. The “Reissner-Nordstrom” solution to Einstein's field equation gives the gravitational effect of this energy density, but there is no theoretical model of an electric or magnetic field itself. The electromagnetic force is supposedly transferred by messenger particles. This implies that an electric or magnetic field must generate virtual photons without any contact with the matter that is generating the field. Two examples will illustrate this. First, suppose that a free neutron is stationary in a magnetic field. When it decays it generates a rapidly moving electron, a proton

and electron antineutrino. The rapidly moving electron and the slower proton immediately feel a Lorentz force exerted by the magnetic field. The force happens before speed of light communication exerts an opposing force on the source of the magnetic field. Therefore, the Lorentz force on the moving electron is being generated by virtual photons which must originate from within the magnetic field itself. Is there a limit to the amount of force that can be generated by a weak magnetic field without communication back to the source?

The second example will examine this question. Suppose that the magnetic field of a star equals the earth's magnetic field strength ($\sim 5 \times 10^{-5}$ Tesla) at a distance of 3×10^9 m from the star. Therefore, at this distance any force exerted by the magnetic field takes about 10 seconds to be communicated back to the star. Now at this distance, suppose that there is a square loop of wire that is one meter on each side. Furthermore, suppose that two of the 4 sides are parallel to the magnetic field and two of the 4 sides are perpendicular to the magnetic field. If a current flows in this wire, a Lorentz force will be exerted on the two perpendicular sections of wire (one meter each) and a net torque will be exerted on the loop of wire.

Theoretically, any current can be made to flow in the loop of wire up to Planck current which is about 3.5×10^{25} amps. For example, a current of 2 million amps would exert a 100 Newton force on each of the two wire sections that are perpendicular to the magnetic field. If the current flow is started quickly, then all the torque exerted on the wire loop comes from an interaction with a limited volume of the magnetic field. The energy density of a 5×10^{-5} Tesla magnetic field is only about 10^{-3} J/m³ and it takes 10 seconds to transfer this torque to the star. Therefore, if the current started over 3×10^{-8} seconds, the maximum volume that could be accessed at speed of light communication would be about 1,000 m³. This limited volume has only about 1 Joule of energy in its magnetic field. While no energy is being extracted from the star's magnetic field, it would take 3×10^{10} watts of real photons to generate a 100 N force if this force was generated by photon pressure. A 100 Newton force lasting 10^{-8} s would require about 300 Joules if it was generated by deflecting real photons. How do virtual photons with no real energy accomplish this?

This example does not imply a violation of the conservation of momentum. A powerful magnetic field is being established and the star's weak magnetic field is distorting the formation of the new magnetic field. However, the question remains: How exactly does the virtual photon model explain the force magnitude (100 N) and force vectors exerted on these wires? Carrying this thought experiment to an extreme; Planck current would generate a force of about 10^{21} N on each of the two wire sections without communicating any torque back to the star.

There is no commonly accepted explanation in the standard model for an electric/magnetic field in terms of something more fundamental. On the other hand, the spacetime based model of the universe can easily explain an electric/magnetic field in terms of a distortion of the spacetime field. Even the instantaneous generation of a 10^{21} Newton force can be explained. The magnetic

field is a distortion of the spacetime field with its sea of dipole waves. The maximum force that the spacetime field can exert is equal to Planck force which is about 10^{44} N. The spacetime model of the universe has the ability to explain many of the mysteries of quantum mechanics.

Spacetime Units

In chapter 10 we will try to combine the insights gained from charged particles and from electromagnetic radiation to give a conceptually understandable model of the external volume of charged rotars. The last step in this chapter is to build on the insights that were gained in the exercise that eliminated charge as a unit. Eliminating charge and replacing this with a strain in spacetime is a step towards developing units based on the properties of spacetime. However, this step does not take the real plunge. It is necessary to eliminate mass as the fundamental unit and develop units based only on the properties of spacetime. Even though length and time are related to spacetime, the meter and second are human constructs. Planck units have always been considered the most fundamental of units since they are not human constructs. It has been said that if aliens attempted to communicate with us, they would use Planck units because these units are derived from the constants of nature. What could be more fundamental than a system of units based on \hbar , G and c ?

If the universe is only spacetime, it should be possible to express constants and units such as kilogram, Newton and Coulomb using only the fundamental properties of spacetime. This spacetime conversion is not particularly convenient to use, and it is closely related to Planck units. However, it is very informative to see how common units can be constructed out of the properties of spacetime. In particular, it is important to grasp the idea that mass is not a fundamental unit when we look at the universe from the standpoint of spacetime being fundamental. Mass is a measurement of inertia and inertia is a characteristic of energy traveling at the speed of light in a confined volume. Deflecting energy traveling at the speed of light causes momentum transfer. This is the source of all forces including the pseudo-force of inertia. The goal is to express everything, including mass, in terms of the properties of spacetime.

We will start the search for spacetime units by looking at one of the 5 wave-amplitude equations previously described.

$U = A^2 \omega^2 Z/c$ equation giving the energy density in a wave

When we apply this wave-amplitude equation to spacetime, it should be easy to express this equation if we use the fundamental properties of spacetime. The first obvious candidate for a fundamental property of spacetime is “ Z ” the impedance of spacetime ($Z_s = c^3/G$). Another candidate is “ c ”, the speed of light, but this is not as certain as Z_s .

Other candidates for being fundamental units of spacetime must be contained in the amplitude term A . We know that a general expression of the maximum permitted dipole wave in spacetime is: $A_{max} = L_p/\lambda = T_p\omega$. This is the maximum strain amplitude which in turn is dictated by the maximum displacement amplitude of spacetime: dynamic Planck length L_p and dynamic Planck time T_p . It is proposed that dynamic Planck length L_p and dynamic Planck time T_p are both fundamental properties of spacetime. They are added to our list making a total of four candidates. Therefore, the four candidates are Z_s , L_p , T_p and c . We really only need three terms to express everything in the universe, therefore there are three possible combinations of three terms that could serve as the basic units of spacetime. These are: 1) T_p , L_p , Z_s ; 2) c , L_p , Z_s ; and 3) c , T_p , Z_s

All of these combinations have advantages and disadvantages. I will use the combination of: c , T_p , Z_s , as the units of spacetime. After working with the different combinations I find this combination the most intuitive. For example, the speed of light and the impedance of spacetime seem to belong together. The unit of Planck time becomes the quantized heartbeat of the universe. While working to develop the model of electric field and charge, this combination is somehow easier to visualize. Recall that the impedance of spacetime is Planck mass divided by Planck time. ($Z_s = M_p/T_p$). Therefore all conventional units can be expressed using these 3 properties of spacetime. However, the use of c , T_p , and Z_s gives answers that correspond to Planck units which are not convenient for everyday use. To illustrate how these spacetime units work, the unit of force has dimensional analysis units of ML/T^2 and conventional units of $kg\ m/s^2$. The spacetime units of force are cZ_s . However, these units specify Planck force ($\sim 1.2 \times 10^{44}$ N) which is the largest force spacetime can exert. For another example, to specify the gravitational constant G using conventional units it is necessary to include a constant (6.673×10^{-11}) and the units of $m^3/kg\ s^2$. With spacetime units the gravitational constant is equal to 1 and the units of the gravitational constant are c^3/Z_s . The spacetime units on the next page treat charge as a strain of spacetime with units of length. Recall that the charge conversion constant η is:

We have long ago found the optimum ways of expressing conversion constants that simplify calculations. Instead, this exercise is intended to illustrate how the properties of spacetime can be manipulated to produce familiar constants and units of physics. It may be difficult for the reader to imagine physics without mass or energy being a fundamental unit. However, the maximum force that spacetime can support is cT_p and the maximum quantized mass is T_pZ_s . Mass and energy are a quantification of properties of spacetime. This change in perspective has a great deal of appeal once it is internalized.

On the following table:

$$\eta \equiv \frac{L_p}{q_p} = \frac{\sqrt{\alpha}L_p}{e} = \sqrt{\frac{G}{4\pi\epsilon_0 c^4}} = 8.617 \times 10^{-18} \text{ meter/Coulomb}$$

Spacetime Units

Name	Spacetime Conversion
elementary charge	$e = (1/\eta) \sqrt{\alpha} c T_p$
impedance of free space	$Z_o = \eta^2 4\pi Z_s$
speed of light	$c = c$
Planck's constant	$\hbar = c^2 T_p^2 Z_s$
gravitational constant	$G = c^3 / Z_s$
Coulomb force constant	$(1/4\pi\epsilon_o) = \eta^2 c Z_s$
permeability of free space	$(\mu_o/4\pi) = \eta^2 Z_s / c$

Transformation of Planck Units into Spacetime Units

Planck Units	Standard Conversion	Spacetime Conversion
Planck length	$L_p = \sqrt{\hbar G / c^3}$	$L_p = c T_p$
Planck mass	$m_p = \sqrt{\hbar c / G}$	$m_p = T_p Z_s$
Planck frequency	$\omega_p = \sqrt{c^5 / \hbar G}$	$\omega_p = 1 / T_p$
Planck energy	$E_p = \sqrt{\hbar c^5 / G}$	$E_p = c^2 T_p Z_s$
Planck force	$F_p = c^4 / G$	$F_p = c Z_s$
Planck power	$P_p = c^5 / G$	$P_p = c^2 Z_s$
Planck energy density	$U_p = c^7 / \hbar G^2$	$U_p = Z_s / c T_p^2$
Planck impedance	$Z_p = 1 / 4\pi\epsilon_o c$	$Z_p = \eta^2 Z_s$
Planck charge	$q_p = \sqrt{4\pi\epsilon_o \hbar c}$	$q_p = (1/\eta) c T_p$
Planck electric field	$\mathbb{E}_p = c^4 / G \sqrt{4\pi\epsilon_o \hbar c}$	$\mathbb{E}_p = \eta Z_s / T_p$
Planck magnetic field	$\mathbb{B}_p = c^3 / G \sqrt{4\pi\epsilon_o \hbar c}$	$\mathbb{B}_p = \eta Z_s / c T_p$
Planck voltage	$\mathbb{V}_p = \sqrt{c^4 / 4\pi\epsilon_o G}$	$\mathbb{V}_p = \eta c Z_s$

While it is possible to express all the units of physics using only the properties of spacetime (c , T_p and Z_s), it will be shown in chapter 14 that it is necessary to add one additional dimensionless designation (Γ_u) to quantify the changing properties of spacetime. As will be explained in chapter 14, the spacetime field is undergoing a transformation that is changing all the units of physics relative to an absolute standard that is unchanged since the Big Bang.

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Chapter 10

Rotar's External Volume

External Volume of an Electron (Conventional Model): Before presenting the spacetime based model of the external volume of a fundamental particle, we will first look at the competition. The conventional model of an electron is a point particle (or vibrating string with no volume) surrounded by an electric and magnetic field. The energy density of a macroscopic electric field from elementary charge e is: $U = (1/8\pi)(\alpha\hbar c/r^4)$. The energy in the electric field external to a given radial distance r is: $E_{ext} = (1/8\pi\epsilon_0)(e^2/r) = 1/2(\alpha\hbar c/r)$. When $r = \lambda_c$, then the electric field energy external to the quantum radius λ_c is $E_{ext} = 1/2(\alpha E_i)$ where E_i is the internal energy of the electron. This energy density shows that an electron's electric field is a real physical entity. An interaction with an electron's electric field does not exhibit any delay that would occur if messenger particles had to be sent out by an electron. In chapter 9 an example was given involving the magnetic field of a star. This example clearly illustrates the inadequacy of the exchange of virtual photon messenger particles to explain the electromagnetic force. In this chapter we will develop further the spacetime based explanation of electric and magnetic fields.

If the electron's radius is less than the classical radius of an electron ($\sim 10^{-15}$ m) then there is an additional problem with the point particle model because a smaller radius makes the energy in the electric field exceed the total energy of the electron. For example, if a particle or the vibrating string was considered to be contained in a volume with a radius of Planck length, then the energy in the surrounding electric field would be about 10^{20} times larger than the electron's internal energy (10^7 J compared to $\sim 10^{-13}$ J). This problem is usually ignored by saying that the electron has an "intrinsic" electric field associated with elementary charge e . If we are attempting to give conceptually understandable explanations of quantum mechanics using the properties of spacetime, then we do not have the luxury of being able to ignore such problems. It is even necessary to describe charge and electric field in terms of the properties of spacetime.

External Volume of a Rotar: We will now look at the spacetime model of the "fields" associated with a fundamental particle. A rotar has previously been described as a unit of quantized angular momentum in a sea of vacuum fluctuations. These vacuum fluctuations have superfluid properties as previously described. The vacuum fluctuations cannot possess angular momentum and therefore any angular momentum must be isolated into quantized units just like superfluid liquid helium isolates angular momentum into quantized vortices. The "rotar volume" of a rotar possesses angular momentum so this volume is in a different state than the surrounding spacetime field. While the vacuum fluctuations surrounding a rotar avoid possessing angular momentum, the surrounding volume is still affected by the presence of a rotar (quantized angular momentum) in its midst. The rotar produces disturbances in the volume external to the

rotar which slightly affect the sea of vacuum fluctuations that surround a rotar. This chapter will examine the standing waves and static strain produced in the volume surrounding a rotar. These effects are responsible for not only the rotar's gravitational and electromagnetic fields but also numerous other effects including de Broglie waves and Compton scattering.

The probability of interacting with a rotar (finding a particle) does not end at the edge of the rotar volume. The edge of the rotar volume is mathematically significant because it allows us to characterize properties and dimensions, but the proposed quantum mechanical nature of a rotar is not bound by our convention. There is part of a rotar that extends far beyond the rotar radius λ_c . These external effects will be shown to be both oscillating standing waves and static strains distributed across the sea of vacuum fluctuations that are part of spacetime. The volume beyond the rotar radius will be called the "external volume". This external volume still possesses part of the rotar's quantized angular momentum. Therefore the external volume is still considered to be part of the rotar but the external volume has different characteristics than the rotar's quantum volume.

The dipole wave in spacetime responsible for a rotar has previously been described as rotating at its Compton angular frequency and possessing amplitude of: $A_\beta = L_p/\lambda_c = T_p\omega_c$. It was also proposed that the rotar is attempting to radiate away its energy into the external volume (the sea of vacuum fluctuations). The amplitude of this attempted radiation has been designated the "fundamental amplitude" A_f . This fundamental amplitude decreases with distance r such that the hypothetical amplitude would be: $A_f = L_p/r = cT_p/r$. If there were no offsetting effects, this amplitude would radiate away a rotar's full energy in a time of $1/\omega_c$ which is typically in the range of 10^{-21} to 10^{-25} s. This is the same as having no stability. The few rotar frequencies that are stable or semi-stable must produce an interaction with vacuum energy that generates a new wave that cancels energy loss but leaves oscillating standing waves. For example, an electron has long term stability therefore the probability of energy loss is zero. However, this does not mean that all of the energy of an electron is confined to its rotar's quantum volume. There is a battle going on in the external volume between the attempted emission and the cancelation waves. The residual effects that exist in the electron's external volume are responsible for the electron's gravity, the electron's electric/magnetic fields and the electron's de Broglie waves.

Gravitational and Electromagnetic Strain Amplitudes: In chapters 6 and 8 it was shown that gravity is the result of spacetime being a nonlinear medium for dipole waves in spacetime. While there is cancelation of the fundamental wave emission, the nonlinear effects remain from the battle. This results in a non-oscillating strain in spacetime which has previously been designated "gravitational magnitude β ". In this chapter we are dealing with the various amplitudes associated with rotars. Therefore, the gravitational non-oscillating strain amplitude in spacetime produced by a rotar will be designated by the symbol $A_G = \beta = Gm/c^2r = A_\beta^2/\mathcal{N}$ where \mathcal{N} has previously been designated as the number of reduced Compton wavelengths: $\mathcal{N} = r/\lambda_c$.

There was also a proposed oscillating component of gravity with strain amplitude designated A_g . It will be shown that this oscillating gravitational component in the external volume results in energy external to λ_c that is in the range of 10^{40} times smaller than a rotar's internal energy therefore it is undetectable when dealing with individual rotars. However, the implication is that the gravitational field of massive bodies has an oscillating component that can achieve substantial energy density. This will be discussed at the end of this chapter.

As before, the simplest example used for illustration in this chapter is a single isolated fundamental particle with elementary charge e . Only electrons, muons and tauons meet this criterion. To further simplify the semantics it is easiest to use electrons in examples. Therefore, this chapter will attempt to describe the external volume of an electron. Once this is done there will be some discussion of the external volume of protons, neutrons, etc.

As previously stated, understanding the connection between electric fields (magnetic fields) and dipole waves in spacetime has been the most difficult task in developing the spacetime based model of the universe. Furthermore, the most difficult component of this explanation has been modeling the electric field of a rotar. In chapter 9 we concluded that an electron and other charged leptons with charge e produce a non-oscillating strain in spacetime. At distance r this strain corresponds to the dimensionless Planck electrical potential $\mathcal{V} = \sqrt{\alpha} L_p / r$. So far it has not been explained how this non-oscillating strain is produced. The breakthrough occurred with the realization that gravity has an oscillating component (figure 8-1) and a static component. On close examination it was found that the electric field produced by a charged particle such as an electron must also have an oscillating component and a static component. Therefore a gravitational field has two strain components (one oscillating and one static) while the electric/magnetic field also has two strain components (one oscillating and one static). The static component of a gravitational field has already been discussed in chapters 6 and 8. This chapter will concentrate on the remaining three components

The model assumes that the electric field produced by an isolated electron possesses the classical energy density external to the rotar volume where $r > \lambda_c$. There is no continuous loss of the electron's energy, so these external oscillations must be standing waves that remain after the proposed cancelation that must take place to eliminate emission of energy at frequency ω_c and amplitude $A_r = L_p / r$. In order for the standing waves to achieve the energy density of the electric field, it is necessary for some part of the electron's energy to reside outside distance λ_c . We will calculate the oscillating "standing wave" amplitude distribution required to achieve this energy density.

$$U = (\frac{1}{2}) \epsilon_0 \mathcal{E}^2 \quad \text{energy density in an electric field } \mathcal{E} \text{ of a single electron}$$

$$\mathcal{E} = (1/4\pi\epsilon_0) e/r^2 \quad \text{electric field produced by a particle with charge } e$$

$$U = \frac{\alpha \hbar c}{8\pi r^4} \quad \text{substitution including } \alpha \hbar c = \left(\frac{e^2}{4\pi \epsilon_0} \right)$$

We also have $U = A^2 \omega^2 Z_s/c$ from the 5 wave-amplitude equations. Therefore we can set these two energy density equations equal to each other and ignore dimensionless constants.

$$A^2 \omega^2 Z_s/c = \alpha \hbar c/r^4 \quad \text{substitute } Z_s = c^3/G \text{ and } \omega = c/\lambda_c, \text{ then solve for } A$$

$$A^2 = \alpha (\hbar G/c^3) \lambda_c^2/r^4 \quad \text{set } \hbar G/c^3 = L_p^2; \quad A = A_e \quad \text{and } \mathcal{N} = r/\lambda_c$$

$$A_e = \frac{\sqrt{\alpha} L_p R_q}{r^2} = \left(\frac{\sqrt{\alpha} L_p}{\lambda_c} \right) \left(\frac{\lambda_c}{r} \right)^2 = \sqrt{\alpha} \frac{A_\beta}{\mathcal{N}^2}$$

A_e = oscillating (standing wave) amplitude component of the electric field at frequency ω_c

Note that the different Compton frequencies of an electron and a muon are absorbed into the A_β and \mathcal{N} terms which both have a frequency dependence ($A_\beta = L_p/\lambda_c = \omega_c/\omega_p$ and $\mathcal{N} = r/\lambda_c = r\omega_c/c$) While this oscillating amplitude A_e gives the correct energy density, these standing waves do not directly convey force between charged rotars. If the oscillating component was responsible for electrostatic force, this would imply that oscillating energy in the external volume was propagating and energy would be continuously radiated. The standing waves in a rotar's external volume do not directly generate forces. However, they are indirectly responsible for the forces between rotars. Here is the picture that has emerged after lengthy examination.

A rotar is attempting to radiate away its energy to the surrounding sea of vacuum energy. The few fundamental particles that are stable exist at one of the few special frequencies that generate canceling waves in vacuum energy eliminating the loss of energy. Even though the loss of energy is eliminated, there are four residual effects that show that a battle has taken place. These 4 residual effects are really combined into a distortion of spacetime with oscillating and non-oscillating components, but for analysis it is convenient to separate them into component parts.

- 1) There is non-oscillating strain in spacetime responsible for gravity and previously discussed in chapters 6 and 8. This strain has been designated as the gravitational magnitude β , but to make a designation A_G in keeping with other amplitude terms we will also designate the non-oscillating term as $A_G = \beta = A_\beta^2/\mathcal{N}$.
- 2) There is an oscillating nonlinear effect associated with gravity and illustrated in figure 8-3 as the small amplitude waves on the line designated "nonlinear component". This oscillating component of gravity has previously been shown to have amplitude of A_β^2 at distance λ_c . It will be proposed that this gravitational oscillating term external to λ_c has amplitude $A_g = A_\beta^2/\mathcal{N}^2$. This gives energy density to a gravitational field (calculated later)

- 3) There are standing waves (associated with the electric field) remaining in the vacuum energy that surrounds the rotar. These standing waves are at the rotar's Compton frequency ω_c and have the oscillating amplitude $A_e = \sqrt{\alpha}A_\beta/\mathcal{N}^2$.
- 4) It is proposed that there is a non-oscillating term associated with the electric field with amplitude $A_E = \sqrt{\alpha}A_\beta/\mathcal{N} = \underline{\mathbb{V}}$. This non-oscillating component is what we usually consider to be an electron's electric field. Here is the reasoning.

The following is a summary of the electromagnetic and gravitational amplitudes generated by a fundamental particle with charge e . For example, an electron has energy $E_i = 8.2 \times 10^{-14}$ J. This means that it has dimensionless strain amplitude $A_\beta \approx 4.18 \times 10^{-23}$ and reduced Compton wavelength $\lambda_c = 3.86 \times 10^{-13}$ m. Distance from the electron is specified as the number \mathcal{N} of reduced Compton wavelengths.

$$A_e = \sqrt{\alpha} \frac{A_\beta}{\mathcal{N}^2} = \sqrt{\alpha} \frac{L_p \lambda_c}{r^2} = \text{electromagnetic standing wave amplitude oscillating at } \omega_c \text{ (charge } e)$$

$$A_E = \sqrt{\alpha} \frac{A_\beta}{\mathcal{N}} = \sqrt{\alpha} \frac{L_p}{r} = \text{electromagnetic non-oscillating strain amplitude (charge } e)$$

$$A_g = \frac{A_\beta^2}{\mathcal{N}^2} = \frac{L_p^2}{r^2} = \text{gravitational standing wave amplitude oscillating at } 2\omega_c$$

$$A_G = \frac{A_\beta^2}{\mathcal{N}} = \frac{Gm}{c^2 r} = \beta = \text{gravitational non-oscillating strain amplitude (spacetime curvature)}$$

The introduction of A_e , A_E , A_g and A_G is merely a case of giving new symbol designations to the concepts previously discussed. We just derived $A_e = \sqrt{\alpha}A_\beta/\mathcal{N}^2$ as the amplitude required to produce the energy density of an electric field associated with energy density $U = (\frac{1}{2}) \epsilon_0 \mathbb{E}^2$ (numerical constant $\frac{1}{2}$ is ignored). $A_G = A_\beta^2/\mathcal{N} = \beta$ is the non-oscillating amplitude required to produce the gravitational field of a rotar. A_E is the symbol given to the non-oscillating strain developed in chapter 9. A_g is the symbol given to the oscillating component of gravity previously discussed and depicted in figures 8-1 and 8-3. The oscillating component of gravity A_g will be examined in more detail at the end of this chapter and shown to give energy density to a gravitational field. The picture that emerges is that both the electric/magnetic field and the gravitational field of a rotar such as an electron possess an oscillating component and a non-oscillating component. The oscillating components give energy density to these fields but the Planck amplitude oscillations are undetectable. However, the oscillating components are essential because they create the non-oscillating strains that we easily detect.

Non-Oscillating Strain Amplitude A_E : The proposed electromagnetic non-oscillating strain amplitude A_E is responsible for what we consider to be the electric field of charged leptons such as an electron or muon. The strain $A_E = \sqrt{\alpha} A_\beta/\mathcal{N}$ looks similar to the fundamental amplitude $A_f = A_\beta/\mathcal{N}$ which is the theoretical oscillating strain amplitude that is being canceled in the rotars that are stable enough to be considered fundamental particles. However, there are several key

differences. First is the obvious difference of $\sqrt{\alpha}$ which reduces the amplitude by a factor of about 11.7 at any given value of \mathcal{N} . Second, A_E is a non-oscillating strain while A_f is a hypothetical oscillating amplitude at frequency ω_c that is attempting to radiate away the rotar's energy. Third, the type of displacement of spacetime produced by an electric field is different from the type of displacement of spacetime produced by dipole waves in spacetime. Recall that dipole waves modulate the rate of time and the distance between points as well as having the Planck length/time amplitude limitation. The electric field component designated A_E is the non-oscillating strain which produces the non-reciprocal characteristic previously discussed (difference in the one way travel time for a time of flight). The magnitude of this effect can greatly exceed the Planck length limitation of oscillating components.

Electrostatic Force Calculation: We will next check to see if the non-oscillating strain amplitude A_E gives the correct electrostatic force between two charged leptons (two electrons). When we calculated the gravitational force on a rotar produced by another rotar creating the non-oscillating strain $A_G = A_\beta^2/\mathcal{N}$, we calculated the implied difference in the rate of time across the radius of a rotar and converted this to the difference in gravitational magnitude $\Delta\beta$ across the rotar. This was necessary because for force generation, it is only the gradient in β or Γ that is important, not the absolute value.

The proposed characteristic of an electric field is different in the sense that the difference is between opposite directions, not the gradient across a rotar. In fact, the difference across the width of a rotar is insignificant compared to the difference between opposite directions at the average location of the rotar feeling the force. Imagine the rotar model presented in chapter 5 rotating in otherwise homogeneous spacetime. Now imagine this rotar rotating in polarized spacetime where there is a difference in the time required for speed of light propagation in opposite directions across the rotar. The strain in spacetime producing this effect is static, but the interaction with the rotar is dynamic. The interaction occurs at a frequency equal to ω_c and the interaction modulates the rotar at amplitude of $A_E = \sqrt{\alpha}A_\beta/\mathcal{N} = \mathcal{V}$. This in turn affects the interaction with vacuum energy/pressure surrounding the rotar. This creates a pressure imbalance that can appear to be either attraction or repulsion. The magnitude of the force is:

$$F = \frac{A^2 \omega^2 Z_s \mathcal{A}}{c}$$

$$\text{set } A^2 = \alpha \frac{A_\beta^2}{\mathcal{N}^2} = \alpha \left(\frac{L_p^2}{\lambda_c^2} \right) \left(\frac{\lambda_c^2}{r^2} \right) = \alpha \left(\frac{\hbar G}{c^3 r^2} \right); \quad \omega = \frac{c}{\lambda_c}; \quad Z_s = \frac{c^3}{G}; \quad \mathcal{A} = \lambda_c^2; \quad \alpha = \frac{e^2}{4\pi\epsilon_0 \hbar c}$$

$$F = \alpha \left(\frac{\hbar G}{c^3 r^2} \right) \left(\frac{c^2}{\lambda_c^2} \right) \left(\frac{c^3}{G} \right) \left(\frac{\lambda_c^2}{c} \right) = \alpha \left(\frac{\hbar c}{r^2} \right) = \left(\frac{e^2}{4\pi\epsilon_0 \hbar c} \right) \left(\frac{\hbar c}{r^2} \right) = \frac{e^2}{4\pi\epsilon_0 r^2} \quad \text{Success!}$$

This explanation is far from complete. For example, there is no explanation for the difference between a force of attraction and repulsion. Also, there is no explanation for the difference between an electron and a positron. However, the explanations offered here do make a first step

towards developing a physically understandable explanation of electric fields and electrostatic force. The standard approach is to merely accept the existence of mysterious “fields” with no attempt to find an underlying causality.

Electric Field Cancellation: The non-oscillating component of the electric field produced by an electron does not have any inherent energy density. Only the oscillating component producing standing waves oscillating at ω_e possess energy density. These two components of the electric field are connected so it is not possible to have an electric field (the measurable non-oscillating component) without also having the energy density provided by the oscillating component. The oscillating component produces the non-oscillating effect.

It is possible to cancel out the non-oscillating strain of an electric field when two opposite charges are brought together. However, exactly what happens to the oscillating portion when opposite charges are brought together has not been exactly determined. For example, bringing an electron and proton together to form a hydrogen atom in its lowest energy state releases 13.6 eV of energy. This energy probably came from a reduction in the Compton frequencies of the fundamental particles. However, there might have also been a reduction in the amplitudes A_e for each particle compared to the value of A_e if each oppositely charged particle was isolated. This is part of the unknown.

However, even a neutron still has de Broglie waves as demonstrated by a double slit experiment using neutrons. Therefore, not all the oscillating portion of energy in the external volume has been eliminated. Also, there has clearly been some additional change because the 3 quarks that form a neutron have lost their individual Compton frequencies and instead a neutron with rest energy of 939.6 MeV exhibits de Broglie wave characteristics of the composite frequency. Therefore the bonding process must include some unknown mechanism for frequency addition of component parts. We will not speculate on this any further since this chapter is primarily about the external volume of the 3 charged leptons and about the electron’s external volume in particular. This is a subject that needs further analysis.

Energy in the External Volume: As previously calculated, the energy in a charged lepton’s external volume caused by the oscillating component of the electric field is equal to $\alpha/2$ (roughly 0.4%) of the charged lepton’s total energy. Hadrons do not have a fixed percentage of their energy external to their radius but even a neutron has some of its energy external to its radius. The three quarks that form a neutron have addition/subtraction of the static strain components of the quark’s electric fields. A short distance from the neutron there is effectively charge cancellation. However, this is the non-oscillating component of the electric field that results in vector addition or subtraction. The oscillating part is proposed to remain and produce standing waves in the neutron’s external volume. These standing waves become the neutron’s de Broglie waves when the neutron is observed in a moving frame of reference. For example, a neutron produces a diffraction pattern when it is passed through a double slit experiment. The implied

frequency is equal to the sum of the frequencies of the three quarks. No effort has been expended to develop a model of frequency addition in hadrons and other composite particles.

A muon and an electron both have the same charge and same fraction of their total energy in their external volumes. However, a muon has about 200 total times more energy and 200 times smaller radius. Almost all of the muon's extra external energy is contained in the small difference between the rotar volume of a muon and the rotar volume of an electron. At a distance larger than the electron's rotar radius, they both generate the same electrostatic force because they both generate the same non oscillating strain in space. This can be shown by the following:

$$A_E = \sqrt{\alpha} \frac{A_\beta}{\mathcal{N}} = \sqrt{\alpha} \left(\frac{L_p}{\lambda_c} \right) \left(\frac{\lambda_c}{r} \right) = \sqrt{\alpha} \frac{L_p}{r} \quad \text{this is the same for all rotars with charge } e.$$

The equation $A_E = \sqrt{\alpha} L_p / r$ has lost all terms which relate to a specific Compton frequency or a specific rotar radius size. Therefore the non-oscillating strain (the detectable electric field) produced by a muon is exactly the same as the non-oscillating strain produced by an electron. The oscillating components of an electron and muon retain their frequency dependence but these oscillating components are only detectable as de Broglie waves and other quantum mechanical wave characteristics.

Internal Electric Field: Even though this chapter is about the external volume of a rotar, we are going to take a brief diversion and talk about the extension of the non-oscillating strain of the electric field into the interior of a lepton's rotar volume. If rotars are slight distortions of spacetime that can partially overlap, does the electric field (the non-oscillating strain) continue to increase inside the rotar's rotar radius? The problem is that when two electrons collide relativistically, the repulsion force exceeds the force that could be generated if the electric field ended at the surface of the rotar volume. In chapter 9 it was determined that the strain in spacetime produced by charge e at distance r is: $\Delta L/L = \underline{V} = \sqrt{\alpha} L_p / r$. I suspect that this equation changes gradually when $r < \lambda_c$ if only because of the uncertainty of designating the location to specify as the central location to serve as the point where $r = 0$. However, the point is that the strain can continue to increase into the internal volume of a rotar such as an electron. Therefore, there is no reason why colliding two electrons together should reveal any internal structure. The strain in spacetime, and therefore the repulsive force continues to increase as the two electrons overlap. Furthermore, the collision of two rotars causes both rotars to convert the kinetic energy to internal energy. For example, colliding two electrons with kinetic energy of 50 GeV causes both electrons to momentarily gain 100,000 times their original energy and shrink by a factor of 100,000 at the point of closest approach. This decrease in size combined with the strain equation ($\Delta L/L = \underline{V} = \sqrt{\alpha} L_p / r$), permits an electron to appear to be a point particle in relativistic collisions.

Accelerating Charged Leptons: We will now return to the external volume discussion and focus on the electromagnetic properties, temporarily ignoring the gravitational effects. The

external volume of a non-accelerating, isolated electron is a combination of standing waves at frequency ω_c with oscillating amplitude $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2$ and a non-oscillating strain of spacetime with amplitude $A_E = \sqrt{\alpha} A_\beta / \mathcal{N}$. Previously the electric field energy in a rotar's external volume was calculated at $E_{ext} = \frac{1}{2} \alpha E_i$. To be precise, this is the limiting case of an isolated rotar that has not interacted with anything for an infinitely long time. In this idealized case a rotar's external volume has had sufficient time at speed of light communication to become fully established. In practice, the extent of a rotar's external volume (its undisturbed electric field) is limited by the length of time an isolated electron has remained undisturbed in a condition that does not radiate electromagnetic radiation.

Therefore what is commonly considered to be the electric field of a particle can be considered part of the rotar's external volume. However, in a larger sense both the electric "field" produced by the rotar and indeed the rotar itself are just strains in the sea of vacuum energy of spacetime. In chapter 4 it was said that there was only one truly fundamental field since all fields are just different distortions of vacuum energy/fluctuations. Keeping this in mind, we will use the term "electric field" to indicate the disturbance in vacuum energy that results in electromagnetism. The part of a rotar's external volume that produces the electromagnetic disturbance has speed of light communication back to the rotar's rotar volume. In chapter 9 a thought experiment involving the magnetic field of a star illustrated the fact that a magnetic field has the ability to exert a force before communication is established back to the source of the field (the star). Similarly, an electron's electric field (spacetime disturbance) can interact "before" communication is established back to the electron (frame of reference dependent).

There is an obvious objection to the concept that an electron's external volume can extend many meters from the rotar volume. This objection is that accelerating an electron would break contact (at speed of light) with a distant part of the external volume thereby abandoning a small part of an electron's structure and energy. However, rather than being a defect, this is actually a strength of this concept because it provides a mechanism for the emission of electromagnetic radiation (a photon with a quantized unit of angular momentum) when an electron is accelerated. The acceleration introduces a modulation ($\omega > 0$) into what was previously a static strain ($\omega = 0$). Also, a portion of the standing wave energy in the external volume loses contact when the rotar volume. The energy abandoned by the acceleration is converted to the energy of the photon that is formed when an electron is accelerated. The acceleration initially introduces a distortion into the waves of the rotar's external volume. This distortion both launches a photon and gives energy to reestablish the lost portion of the external volume. Chapter 11 will discuss freely propagating photons in more detail.

Another test of an electron's distributed energy is whether a test can be devised that distinguishes between the rotar model with its distributed energy and the currently accepted model of a charged point particle. It takes time to measure energy or inertia. The more accurate the measurement needs to be, the more time is required. This allows time for the energy in the

external volume to communicate its presence at the speed of light and add to the total energy or inertia of the electron. It is possible to do a plausibility calculation to see if it would ever be possible to do an experiment that would give a different answer for the rotar model of an electron compared to a point particle model of an electron which has all of its energy localized but also experiences a retardation as part of the emission of a photon.

The energy in an electron's electric field external to radius r is: $E_{ext} = \alpha\hbar c/2r$. This is energy that is in the form of standing waves external to the electron's rotar volume. From the uncertainty principle ($\hbar/2 = \Delta E \Delta t$), it is possible to calculate the integration time Δt that would be required to detect an energy uncertainty of $\Delta E = E_{ext}$.

$$E_{ext} = \frac{\alpha\hbar c}{2r} \quad \text{set } \frac{\hbar}{2} = \Delta E \Delta t$$

$$E_{ext} = \left(\frac{\alpha c}{r}\right) \Delta E \Delta t \quad \text{set } E_{ext} = \Delta E$$

$$\Delta t = \frac{r}{\alpha c} \approx 137 \frac{r}{c}$$

Therefore, it would take an integration time 137 times longer than the time r/c to detect this energy discrepancy. However, this is 137 times longer than it takes for the discrepancy to be corrected to a degree that is undetectable. Therefore, a model of an electron with the proposed distribution of energy in the external volume is indistinguishable from a point particle.

Chaotic Waves: The transition from the rotar volume to the external volume of a rotar is actually ill defined because the rotar volume has a chaotic, probabilistic quality. The rotating dipole in spacetime is at the limit of causality. The rotar volume is attempting to radiate its full energy in a time of $1/\omega_c$. A fundamental amplitude of $A_f = \lambda_c/r$ is actually attempting to carrying away the full energy. It is only the return wave generated in vacuum energy that is somehow canceling this emission. However, the chaotic process at the limit of causality can reconstruct the rotar (reconstruct the quantized angular momentum) at a different location described by the uncertainty principle. Also a double slit experiment can interfere with the normal reconstruction and result in the rotar being reconstructed on the other side of the double slit. This will be discussed later.

The point is that all of the quantum mechanical properties which seem mysterious for a point particle become conceptually understandable if a particle is a vortex of quantized angular momentum in a sea of vacuum fluctuations.

We have previously discussed that all rotars must satisfy a soliton condition in spacetime. This means that the few fundamental particles that exist must exhibit a combination of characteristics that offset the tremendous emission of dipole waves in spacetime that leave the vicinity of the rotar volume. The few leptons and hadrons that exist somehow achieve a soliton condition

where the emission is offset by the generation of waves in vacuum energy that effectively cancel the emission from the rotar's rotating dipole core.

Model of the External Volume: Figure 10-1 is a simplified representation of the standing dipole waves that surround a rotar. Recall that the rotar is attempting to radiate away its energy and emits dipole waves with frequency ω_c and amplitude $A_r = L_p/r$. The few rotars that are stable or semi-stable must form a resonance with the surrounding vacuum energy that eliminates the energy loss but leaves both standing waves and non-oscillating strains in spacetime as previously discussed. All the figures in this chapter deal with the standing waves associated with the oscillating part of the electric field. These standing waves have amplitude $A_e = L_p/\mathcal{N}^2$ and angular frequency ω_c . Figure 10-1 is the first in this series of figures and this figure has been greatly simplified compared to an actual rotar. The rotating dipole has been replaced by a simple monopole source of waves. In fact, we will use a monopole emitter for the first series of figures because the initial illustrations are easier to understand without the added complexity of a rotating dipole source. The figures will later be illustrated using a dipole source when this source becomes important to the illustration.

Initially we will imagine that figure 10-1 represents sound waves being emitted by a monopole emitter of sound waves at the center circle and being reflected by a spherical reflector outside of the area shown in the figure. The interaction between the emitted and reflected waves forms the standing waves depicted in figure 10-1 and subsequent figures. An acoustic monopole emitter can be thought of as a sphere that expands and contracts its radius at an acoustic frequency.

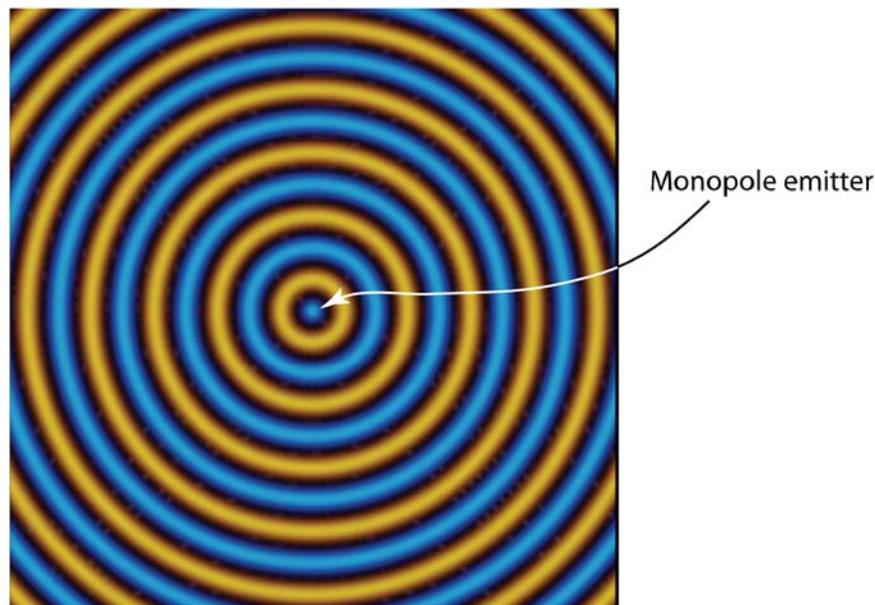


FIGURE 10-1 Monopole emission pattern

Figure 10-1 shows standing waves in an acoustic medium depicted at a moment in time. The blue regions can represent regions of maximum acoustic pressure and the yellow regions can represent regions of minimum acoustic pressure. A half cycle later the standing waves will reverse and regions that previously had maximum pressure will have minimum pressure. The black regions between the yellow and blue regions would be the wave nulls in this representation, but there is another way of depicting this standing sound wave.

The black regions have the maximum pressure gradient. This means that the black regions have the maximum kinetic energy of the acoustic medium. Therefore, there is another way of representing the standing acoustic wave where we emphasize the kinetic energy of molecules. In this type of representation the black regions would be depicted as regions of maximum kinetic energy, not the nulls shown above. In fact the energy in the standing acoustic wave is just being transferred between energy in compression/rarefaction and kinetic energy.

We will now switch to considering figure 10-1 as representing standing waves in spacetime. The vacuum fluctuations that form spacetime have a vastly larger energy density than the energy density of a rotar. As previously discussed, the pressure of vacuum energy is stabilizing the rotar and exerting the necessary pressure to confine the energy density of the rotar. Figure 10-1 represents a moment in time where the disturbance caused by the presence of the rotar results in standing waves in the surrounding vacuum energy. These standing waves fluctuate both the rate of time and proper volume. Regions of fast time are shown in blue and regions of slow time are shown in yellow. A half cycle later the fast and slow time regions will reverse. The black regions between yellow and blue have the maximum gradient in the rate of time. These regions are equivalent to the grav field previously explained. Just like the standing sound wave, there really are no nulls in the standing wave in spacetime. The regions of fluctuating rate of time have the same energy density as the regions of maximum grav field (maximum rate of time gradient). The total wave energy is constant ($\sin^2\theta + \cos^2\theta = 1$).

Wavelets: All dipole waves in spacetime are proposed to have propagation characteristics that are similar to the Huygens Principle in optics. The Huygens principle assumes that every point on an advancing wavefront of an electromagnetic wave is the source of a new disturbance. The electromagnetic wave may be regarded as the sum of these secondary waves (called “wavelets”). Reflection, diffraction and refraction are explained by assuming that all parts of an electromagnetic wave are the source of these new wavelets. The surface that is tangent to any locus of constant phase of wavelets can be used to determine the future position of the wave.

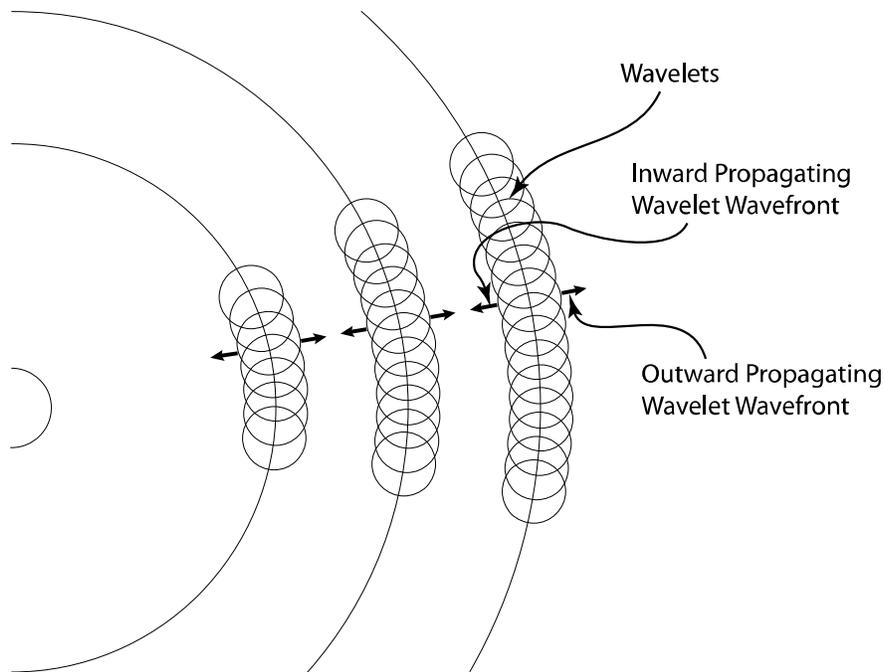


FIGURE 10-2 Simplified representation of waves propagating in spacetime. Each component becomes the source of a new wavelet.

As originally formulated by Christiaan Huygens, the Huygens Principle requires that the wavelets are hemispherical and only radiate into the forward hemispherical direction of the propagation vector. A modification of this was made by Gustav Kirchhoff where the wavelets emit into an amplitude distribution of $\cos^2(\theta/2)$. This distribution has maximum amplitude in the forward direction and zero amplitude in the reverse direction. The result is the classical Huygens-Fresnel-Kirchhoff principle that accurately describes diffraction, reflection and refraction. This will be discussed in more detail in chapter 11.

It is proposed that the few frequencies that form rotars interact with vacuum energy in a way that allows them to emit wavelets that propagate into a complete spherical pattern as shown in Figure 10-2. With this hypothesis the $\cos^2(\theta/2)$ amplitude distribution of the wavelets of light is not shared by the wavelets of vacuum energy that stabilizes rotars. The conditions that stabilize rotars require that both a forward propagating wave and an equal backwards propagating wave be formed in the external volume. This is accomplished if each wavelet propagates into a spherical disturbance pattern as shown in figure 10-2. These spherical wavelets add together to produce the next generation of dipole waves in spacetime. This results in wavefronts propagating in both the forward and backward radial directions. These new wavefronts are labeled inward propagating and outward propagating. In the tangential direction there is incoherent addition that produces cancellation. If the energy flow is equal in both directions, the result is standing waves in the external volume of a rotar. Standing waves are oscillating waves

that have fixed regions of nodes and antinodes. They possess energy, but there is no continuous energy drain.

Path Integral: A key point here is that the wavelets of dipole waves in spacetime explore all possible paths between two points. Furthermore, the amplitude at any point is the coherent sum (amplitude and phase) of these waves. The intensity at any point is the square of the amplitude sum. This concept gives a physical interpretation to the path integral operation of quantum electrodynamics. It is a stretch to explain how point particles explore all possible paths between events, but waves in spacetime that form new wavelets intrinsically accomplish this task. Again, this proposed spacetime based explanation makes quantum mechanical operations conceptually understandable while the point particle model has numerous mysteries.

This explanation that involves backwards propagating waves sounds good, but there is a problem. If this was the only mechanism stabilizing a rotar, the residual standing waves would be much larger than the calculated amplitude of $A_e = \sqrt{\alpha} L_p / \mathcal{N}^2$ required for the standing wave part of the electric field. There appears to be an additional unknown mechanism generated in vacuum energy that forms a wave that provides additional cancelation. These standing waves remain even when the non-oscillating component of the electric field has been canceled. If others choose to model these standing waves, it should be noted that accurate modeling of the Huygens Principle in optics requires that the modeling must be done in three spatial dimensions¹. If the Huygens's Principle is modeled in only 2 spatial dimensions, there is incomplete cancelation of waves that do not contribute to a wavefront.

de Broglie Waves: In chapter 1 it was shown that a laser contains light traveling in opposite directions. When the waves in this laser are observed from a stationary frame of reference, the bidirectional light forms standing waves. In other words, the standing waves are stationary relative to the laser mirrors. When the laser is translated relative to an observer, the standing light waves are still stationary relative to the moving mirrors, but the moving frame of reference means that the observer sees the light being Doppler shifted up in frequency in the direction of travel and being Doppler shifted down in frequency in the opposite direction. The superposition of these two Doppler shifted beams of light produces what appears to be a moving envelope of waves.

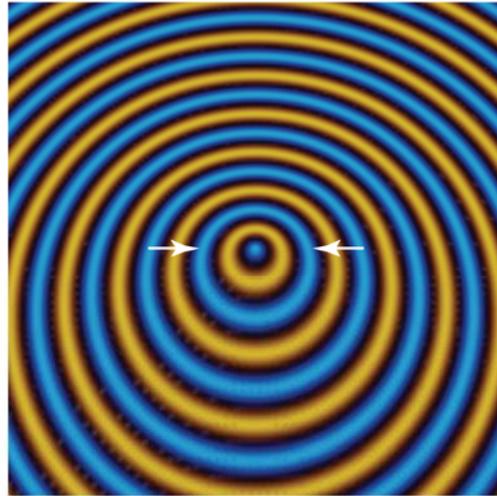
¹ <http://www.mathpages.com/home/kmath242/kmath242.htm>

Outward propagating waves



FIGURE 10-3 Doppler shift on outward propagating waves.

Inward propagating waves



↓
Direction
of Relative
Motion

FIGURE 10-4 Doppler shift on inward propagating waves.

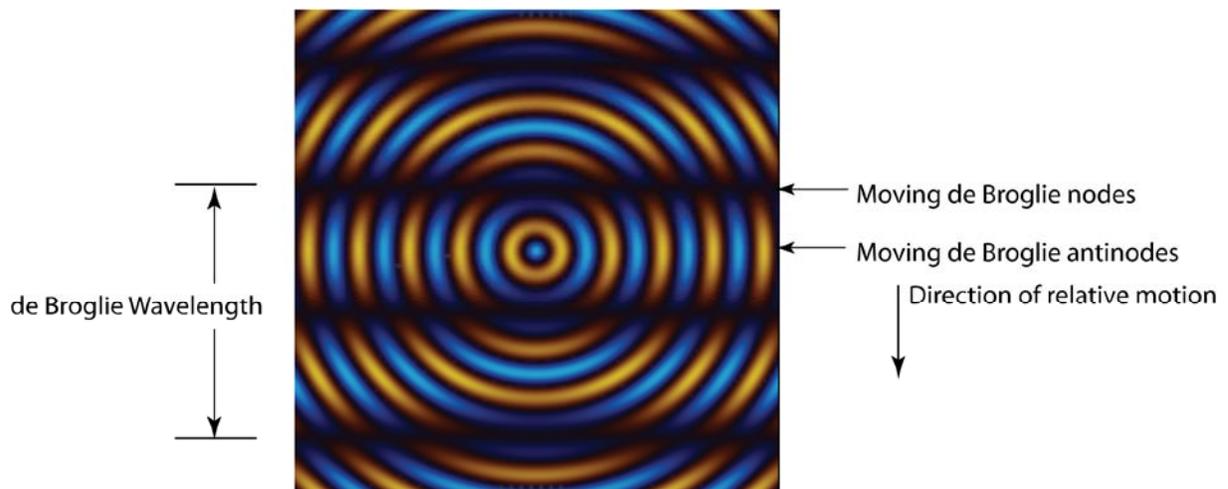


FIGURE 10-5 Linear de Broglie waves obtained from the translation of the rotar model (except monopole source)

Figure 1-1 shows the moving envelope of waves and moving laser mirrors. An analogy is proposed to be present when a rotar is observed in a moving frame of reference. It is desirable to examine the de Broglie waves of a rotar in greater detail. Figure 10-3 is similar to Figure 10 - 1, but there are two differences. First, Figure 10-3 shows waves propagating only away from the monopole source (arrows pointing away from the source). Second, Figure 10-3 shows the monopole source moving downward relative to the observer. The combination of these two factors produces the Doppler wave pattern shown. Figure 10-4 also has a downwards moving

frame of reference, but the difference is that only waves propagating towards the source (inward propagation) are shown with arrows pointing towards the source.

The wavelets previously shown in figure 10-2 means that waves are simultaneously propagating both towards the source and away from the source. This means that a moving source will produce a wave pattern that is a superposition of figures 10-3 and 10-4. When we add these two patterns together we obtain the result shown in Figure 10-5. It is surprising to see that we obtain a linear wave pattern from the superposition of spherical waves in a moving frame of reference. These are the rotar's de Broglie waves. They have all the correct characteristics – correct de Broglie wavelength, correct de Broglie phase velocity and the correct de Broglie group velocity. Moving the rotar model produces the rotar equivalent of de Broglie waves.

This figure is not static. Not only is there translation relative to the observer, but the dark interference fringes are moving at a speed faster than the speed of light. For example, if the rotar model is moving at 1% of the speed of light relative to an observer, then the interference pattern is moving in the same direction as the relative motion, but at 100 times the speed of light ($w_d = c^2/v$). Also notice that there is a phase shift going across the dark interference pattern. This is represented by a reversal of color following a wave across the dark de Broglie null.

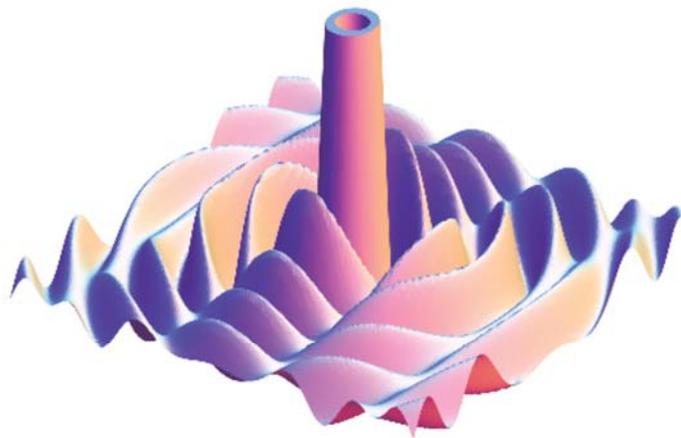


FIGURE 10-6 Three Dimensional Wave Plot Showing DeBroglie Waves and a Radial Amplitude Dependence

Figure 10-5 makes no attempt to show that the amplitude decreases with radial distance from the source. Figure 10-6 is a 3-dimensional graphical representation of Figure 10-5 with the

added feature of a $1/r$ amplitude dependence. The actual amplitude should fall off proportional to $1/r^2$, but this sharp decrease in amplitude makes it difficult to see the de Broglie modulation wave.

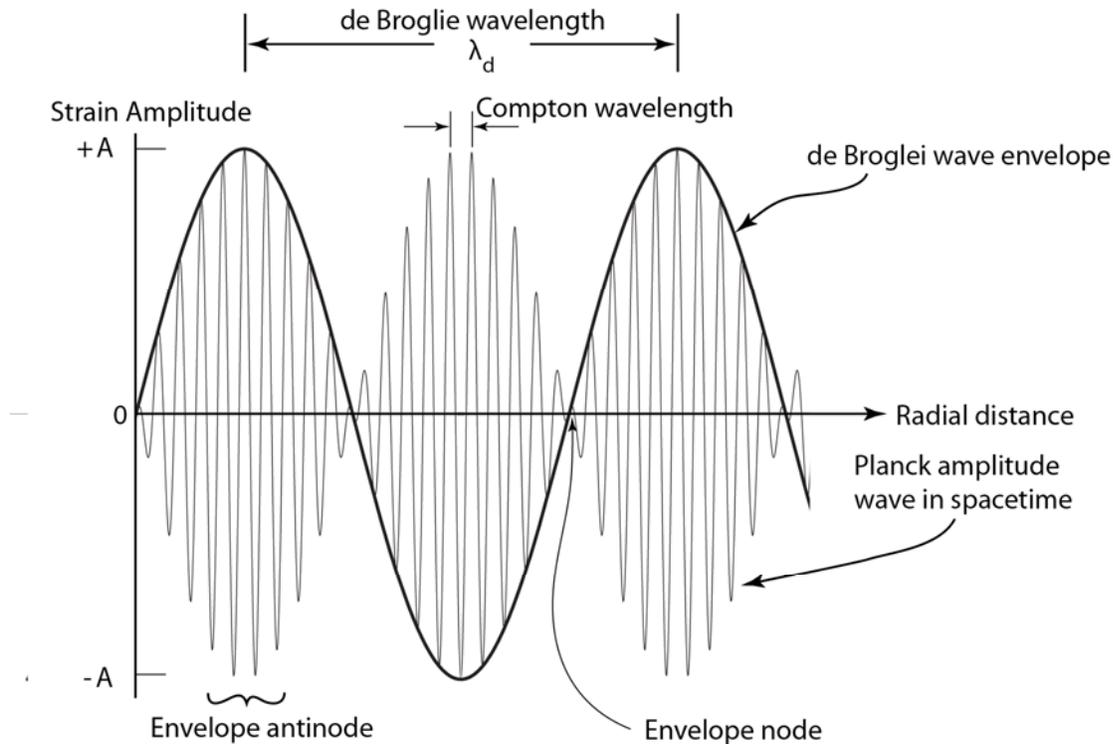


FIGURE 10-7 Graphical representation of a portion of the spacetime waves that form the external volume of a moving rotar.

Strain Amplitude Graph: It is easiest to explain the de Broglie modulation wave using Figure 10-7. This figure is a graph of the waves in figure 10-5 (radial cross-section). In figure 10-7, the high frequency waves are designated as “dipole waves in spacetime”. When a rotar is stationary relative to the observer, then all the dipole waves in spacetime have equal amplitude. At this stationary condition the frequency of these waves is the rotar’s Compton frequency ($\sim 10^{20}$ Hz for an electron) and the wavelength of these waves is the rotar’s Compton wavelength λ_c . When the rotar is moving relative to the observer, then the rotar’s de Broglie wave appears. This is just the modulation envelope that results from the different Doppler shift for waves propagating away from the rotar’s rotar volume and towards the rotar volume.

Figure 10-7 shows a graphical representation of the rotar’s de Broglie wavelength λ_d . This graph plots strain amplitude versus radial distance r . Only a short radial segment is shown. There should be a radial decrease in amplitude, but the short radial distance depicted does not show this decrease in amplitude. In the external volume of a rotar the fundamental traveling wave with amplitude L_p/r has been canceled leaving behind the standing wave responsible for the

rotar's electric charge with amplitude of $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2$. The nonlinear effect responsible for the oscillating portion of gravity is too small to be shown. Therefore, the Y axis of this graph is the strain amplitude A_e . The maximum value of A_e is the value given by the equation $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2 = \sqrt{\alpha} L_p \lambda_c / r^2$.

To give an idea of scale, the approximate Compton wavelength λ_c is shown. An electron's Compton wavelength is about 2.43×10^{-12} m. The de Broglie wavelength λ_d depends on relative velocity (v) and is illustrated as being approximately 20 times longer than the Compton wavelength in this example. Therefore, the de Broglie wavelength would be approximately 5×10^{-11} m in this example. The Compton wavelength λ_c and the de Broglie wavelength λ_d are related as follows: $\lambda_c = (v/c)\lambda_d$ (approximation $v \ll c$). Therefore, this figure illustrates the de Broglie wave pattern if an electron is traveling at about 5% the speed of light ($\lambda_d \approx 20\lambda_c$ in this figure).

The Y axis of this graph is strain amplitude which can be expressed either as a spatial strain (meters/meter) or as a temporal strain (seconds/second). Both ways of expressing this give the same dimensionless number for a specific point in space and instant in time. Suppose our observation point at a particular instant is one micrometer (10^{-6} meters) from an electron that is moving past us at 5% the speed of light. We can then quantify the strain amplitude depicted in Figure 10-7. Using $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2 = \sqrt{\alpha} L_p \lambda_c / r^2$ and substituting $r = 10^{-6}$ m and $\lambda_c = 3.86 \times 10^{-13}$ m for an electron, we obtain: $A_e = 5.3 \times 10^{-37}$. This is the maximum value of A_e above and below the zero strain line (the "x" axis).

It is possible to calculate the displacement of spacetime required to produce this amount of dimensionless strain. This strain exists over approximately one radian of the wave which is a distance equal to λ_c . For an electron $\lambda_c = 3.86 \times 10^{-13}$ m therefore $A_e \times \lambda_c \approx 2 \times 10^{-49}$ m. Therefore, the spatial displacement of spacetime (displacement amplitude) which causes the strain amplitude illustrated here is smaller than Planck length by a factor of about 10^{14} . If we would have chosen to work in the temporal domain we would obtain the same dimensionless strain which could be thought of as seconds/second. The temporal displacement amplitude causing this strain would then be $A_e / \omega_c \approx 6.8 \times 10^{-58}$ s. This is smaller than Planck time and the difference is again a factor of about 10^{14} .

Ψ Function: It is not obvious in figure 10-7 but there is a 180 degree (π radian) phase shift between each de Broglie lobe. Therefore one complete de Broglie wavelength includes two lobes as shown. This 180 degree phase shift between lobes is a fundamental property of standing waves viewed from a moving frame of reference. This phase shift gives rise to the de Broglie wave interpretation shown in figure 10-7. Perhaps most important, **the wave designated de Broglie wave envelope is really the moving rotar's Ψ function.** It is sometimes said that the Ψ function has no physical interpretation. However, figure 10-7 is the proposed physical interpretation of the quantum mechanical Ψ function. This is another example of how the

proposed spacetime based model makes quantum mechanical mysteries conceptually understandable.

Relativistic Contraction: Above it was stated that λ_c illustrated in figure 10-7 is “approximately” equal to the rotar’s Compton wavelength. The reason that this is not exact is that this figure depicts a moving rotar and there is relativistic length contraction in the Compton wavelength. If the rotar was stationary, there would be no de Broglie wave modulation envelope and the dipole waves would be exactly equal to the Compton wavelength.

The reason for bringing up this point is that it is possible to see the physical cause of relativistic length contraction when there is relative motion. A moving rotar has waves that are Doppler shifted up in frequency and Doppler shifted down in frequency as previously explained. When these Doppler shifted waves are combined, the resultant wave has a shorter wavelength than the original wavelength without Doppler shifts. This was proven mathematically in Appendix A at the end of chapter 1. This analysis applies equally to standing waves in a moving laser cavity or to standing waves in the external volume of a rotar. The combination of the two Doppler shifts in the two oppositely propagating waves produces a net decrease in the Compton wavelength by a factor of: $\sqrt{1 - v^2/c^2}$. This is proposed to be the source of relativistic contraction. A moving meter stick will appear to decrease in length because all the waves that make up the meter stick decrease their wavelength because of this effect.

Rotating Dipole Model: We will now attempt to give a crude model of the standing waves present in the external volume of rotating spacetime dipoles. An accurate model of this requires high level computer modeling. It involves modeling a large number of wavelets that are added together and then become the source of new wavelets that form the next generation. This process is repeated a large number of times. This task is beyond the scope of this book. Furthermore, the simplest modeling would probably make no distinction between the infinite number of frequencies that do not form stable rotars and the few frequencies with the unusual characteristics that combine to form stable rotars. Also, how do we handle the chaotic spin distribution characteristics of spin $\frac{1}{2}$ particles? The following modeling is a best guess model of the external volume of an electron. This can then serve as a starting point for others that can improve on this model.

Before attempting to model the external volume of rotars, it is desirable to first describe the chaotic spin properties exhibited by isolated rotars. Because a rotar is at the limit of causality, it should not be a surprise that a rotar has probabilistic characteristics. The displacement of spacetime is so small that dipole waves in spacetime do not violate the conservation of momentum. Recall the examples given previously comparing the minute volume and rate of time changes required to form an electron’s spacetime dipole. (expanding the radius of Jupiter’s orbit by a hydrogen atom or slowing the rate of time by several microseconds over the age of the universe.)

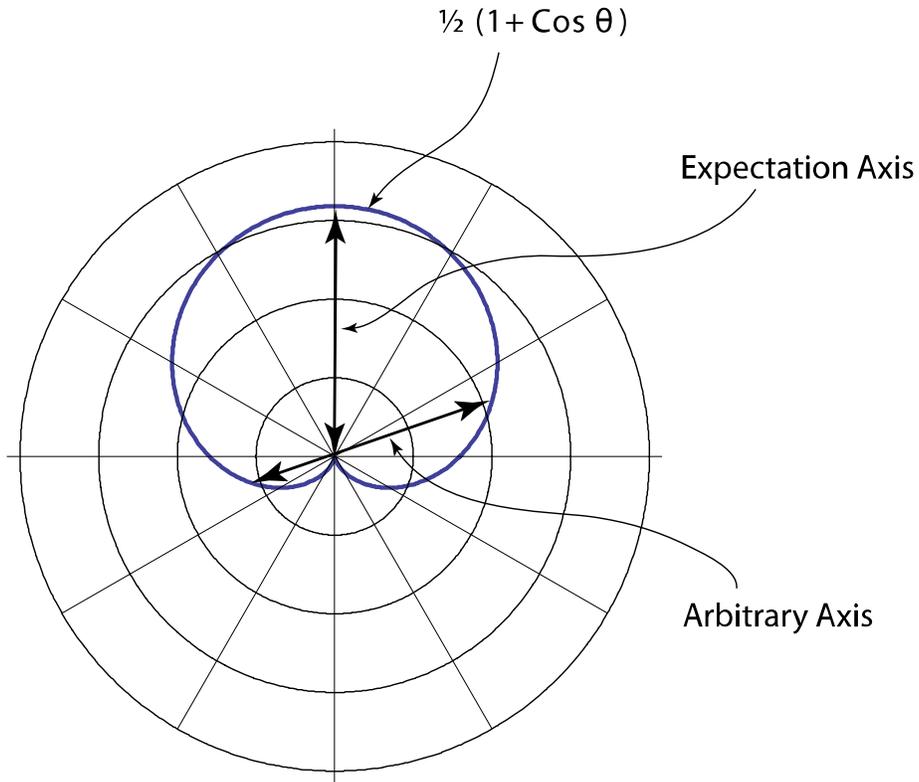


FIGURE 10-8 Probability of Spin Direction

Figure 10-8 shows a plot in spherical coordinates of the probability of spin being oriented in the direction θ . This spin direction probability is proportional to $\cos^2(\theta/2)$. Suppose that we concentrate not on the spin direction, but on the axis of spin. Figure 10-8 specifies the expectation axis and an arbitrary axis. The point of this is to show that a rotar can have a spherical distribution averaged over time even though the rotar has an expectation spin direction. The rotating dipole shown in figure 5-1 would not have a spherical distribution if the axis of rotation were fixed. However, figure 10-8 shows that the probability of spin direction is such that all axis orientations are equally probable. In other words, the expectation axis shown in figure 10-8 is the same length as the arbitrary axis when opposite spin probabilities are added together. If we consider the length of the spin axis probability as ζ , then we have:

$$\zeta = \cos^2(\theta/2) + \cos^2[(\theta + \pi)/2] = \cos^2(\theta/2) + \sin^2(\theta/2) = 1$$

With this being said, we will simplify the modeling by looking at the equatorial plane of the expectation rotation axis. For example, the expectation axis can be set by placing an electron in a magnetic field. This is the simplest to model and one step better than assuming a monopole emitter.

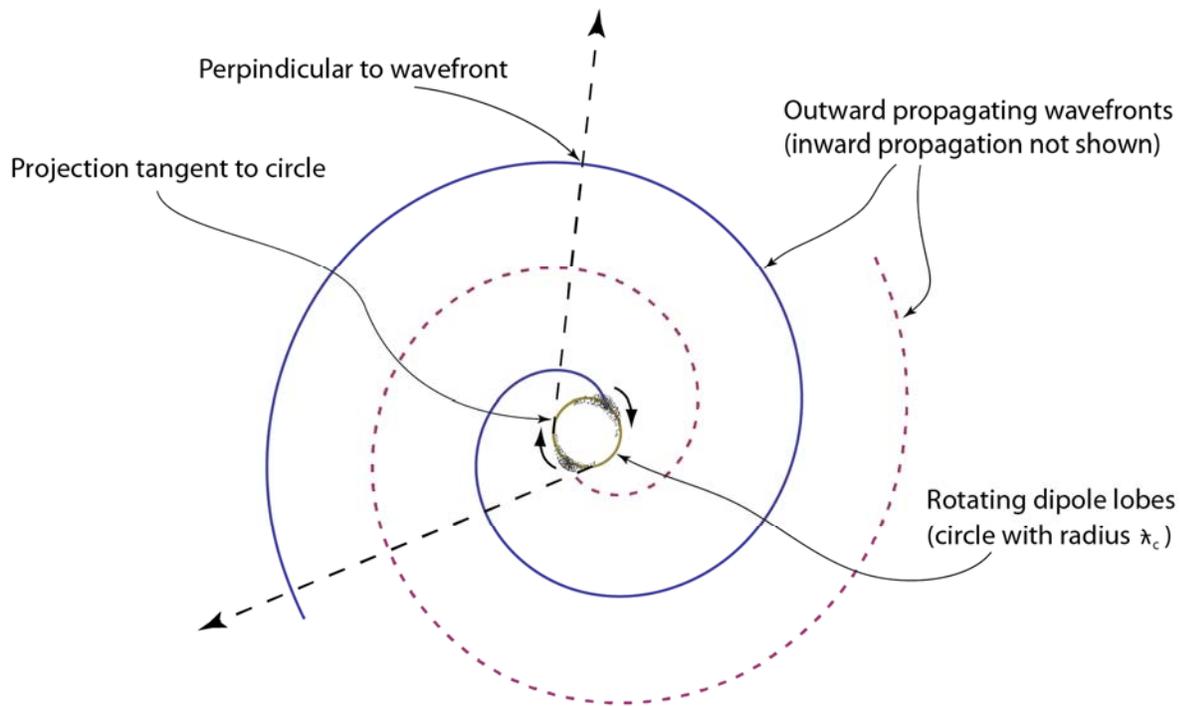


FIGURE 10-9 Rotating dipole and Archimedes Spiral dipole wave

Figure 10-9 shows a rotating dipole designated “rotating dipole lobes”. The two lobes depicted represent the two dipole lobes discussed and depicted in chapter 5. When the lobes move around the imaginary circle at the speed of light, any disturbance propagates away from these lobes at the speed of light and forms the outward propagating Archimedes spirals shown. This simplified description does ignore the fact that every part of the wave forms new wavelets, but we will proceed with this description and attempt to include wavelets later.

For discussion, we will initially assume that the solid lines represent regions where the rate of time is faster than normal and the dashed lines represent regions where the rate of time is slower than normal. Since the rate of time affects all 3 spatial directions equally, these waves are neither longitudinal nor transverse. They are simply time waves. Besides affecting the rate of time, these waves also represent a spatial distortion.

So far, we have ignored the fact that the model calls for every point on the wavefront to be the source of a new wavelet. An extremely simplified model takes the outgoing wave pattern shown in figure 10-9 and generate the backwards propagating waves by assuming that the outward propagating waves are reflected off a concentric spherical reflector. These reflected waves then propagate back towards the rotating dipole. This makes another pair of Archimedes spirals that in a static image are the mirror image of figure 10-9. They have the same rotational direction when viewed from the perspective of figure 10-9, but they are propagating inward.

When the outgoing waves and incoming waves are added together we obtain an interference pattern shown in Figure 10-10. This is a cross-section view of the equatorial plane of the external volume of a rotar. This also depicts an instant in time. The actual pattern is rotating at the same rate as the rotating dipole (the Compton frequency). For an electron, this image would rotate about 1.24×10^{20} revolutions per second. This is currently the best representation of an isolated rotar such as an isolated electron. We are assuming a stationary frame of reference for Figure 10-10 (no de Broglie waves superimposed). Note that there is a 180 degree phase change at the destructive interference bar (black bar) that goes across the center of this figure. This phase change can be seen because there is a reversal of color (yellow to blue or blue to yellow) at this region of destructive interference.

Even though this figure was made using some questionable simplifications, it is a reasonable first attempt. The amplitude of the waves should drop off with a $1/r^2$ decrease in amplitude from the center. For illustration purposes, this figure depicts uniform radial wave amplitude. The reader should mentally adjust for the radial decrease in amplitude.

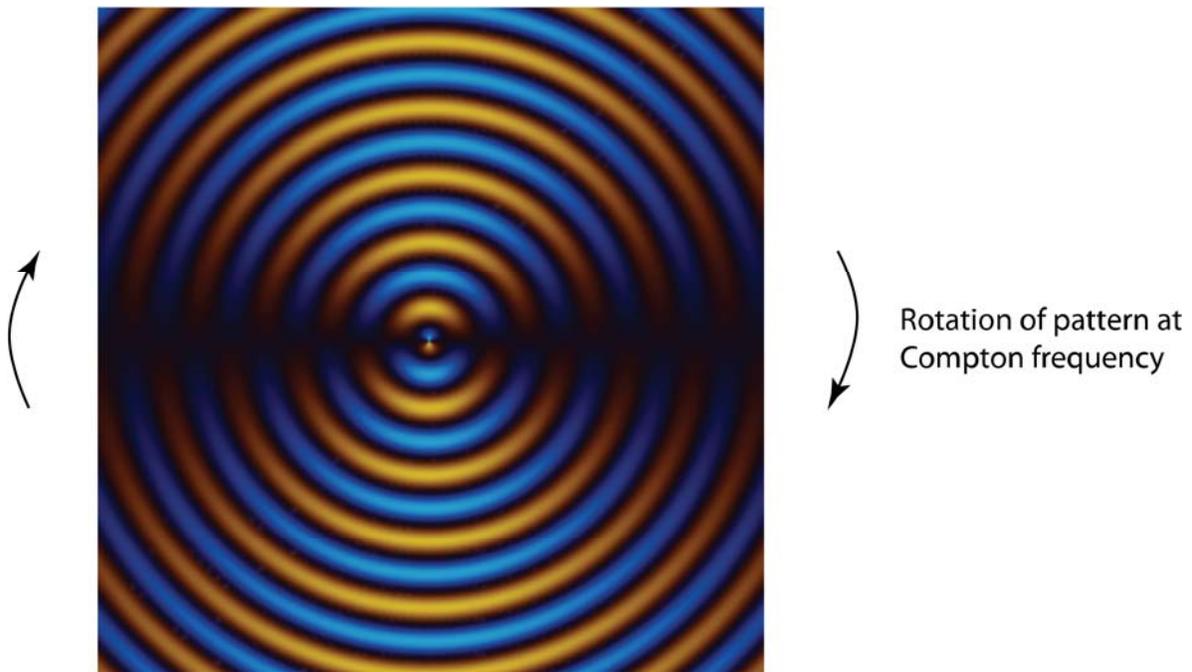


FIGURE 10-10 Interference pattern obtained by adding outward and inward propagating Archimedes spiral waves. (stationary frame of reference)

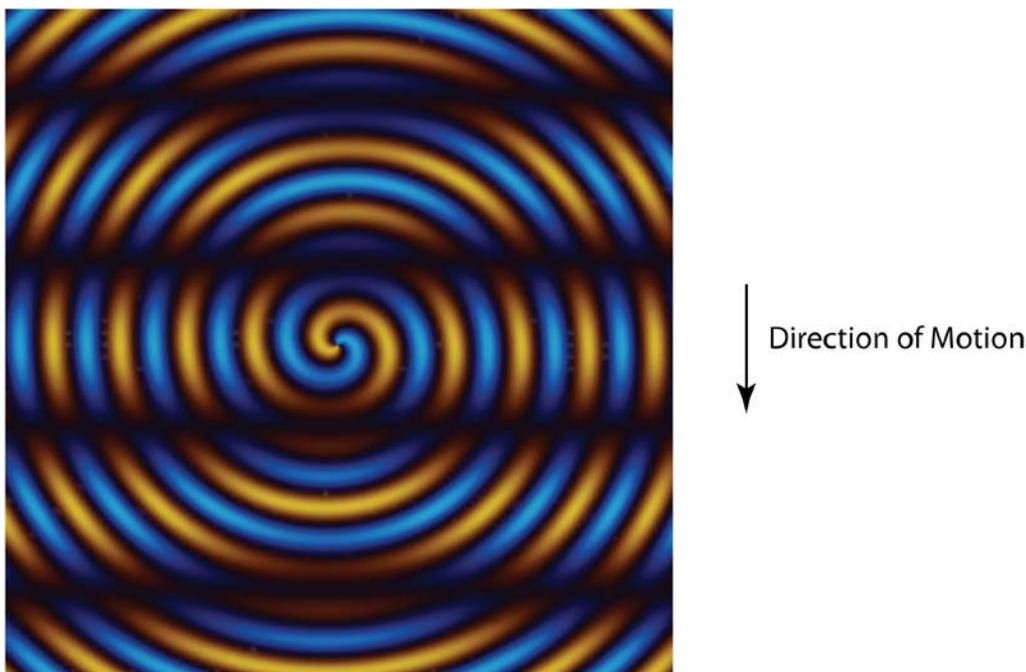


FIGURE 10-11 Interference pattern obtained by viewing Fig 10-10 from moving frame of reference

Conservation of Angular Momentum: Figure 10-10 looks similar to a rotating disk, but this is the wrong interpretation. There is no violation of the conservation of angular momentum as this pattern enlarges. This is best explained by returning to figure 10-9. We will assume that all of the energy and angular momentum starts off in the region designated “rotating dipole lobes”. If some energy leaves this region, its outward propagation follows the Archimedes spiral pattern shown in figure 10-9. This is the pattern that maintains constant total angular momentum.

Proving this statement would represent a substantial diversion, but one brief point supports this contention. Figure 10-9 shows an arrow drawn perpendicular to the Archimedes spiral in the far field of the spiral pattern. In the limit of the far field the projection of this perpendicular line back towards the center results in the projected line being tangent to the imaginary circle with radius of λ_c . This implies a conservation of the angular momentum for energy that leaves this circle. The pattern shown in figure 10-10 is a super position of two Archimedes spiral patterns, both of which can be shown to individually exhibit conservation of angular momentum. The rotating pattern in figure 10-10 has a tangential speed faster than the speed of light for any radial distance greater than $r = \lambda_c$. This is permitted because this is just an interference effect that can move faster than the speed of light.

In Figure 10-11 we are looking at this same pattern of figure 10-10 from a moving frame of reference. To obtain this picture we added together the Doppler shifter outgoing and incoming wave patterns. This is similar to adding together Figures 10-3 and 10-4 to get figure 10-5. To obtain figure 10-11 we added together Doppler shifted outgoing and incoming Archimedes

spirals rather than the concentric circles. Like figure 10-5, Figure 10-11 is a snap-shot of a moving interference pattern. The interference pattern would be moving faster than the speed of light as previously explained for Figure 10-5. In fact, the de Broglie wavelength and translation speed is the same whether we model a monopole source or a dipole source provided that we assume the same Compton frequency.

Figure 10-11 is actually a large spiral pattern, but the spiral characteristic is only obvious near the center of the figure. The exact center of figure 10-11 that is the initiation of the spiral is not an accurate illustration of the pattern that would be produced by a rotar. Figure 10-9 illustrates that the spiral does not extend to the exact center. Instead, there is a transition to the rotar volume that is represented by a circle with radius λ_c . Figure 10-11 was drawn with the two spirals (inward and outward propagating) extending all the way to the center. Therefore, a more realistic version of figure 10-11 would have a transition to black over the center $\sim 1/\pi$ wavelength.

Compton Scattering: In 1905 Albert Einstein's published a paper on the photoelectric effect. This paper suggested that light exhibits particle-like properties. At the time light was considered to be only a wave phenomenon. In the early 1920's, the particle-like properties of light was still being debated. However, debate effectively ended with the observation by Arthur Compton of the scattering of x-ray photons by electrons (called Compton scattering). The scattered x-ray photons exhibit a decrease in frequency that is a function of scattering angle. The individual electrons also exhibit recoil when they scatter an x-ray photon. The decrease in the frequency of the scattered photon corresponds to the energy transferred to the recoiling electron. A simple Doppler shift of waves reflecting off the moving electron does not correspond to the correct frequency shift. All of this is perfectly explained by the model that assumes that photons are particles with energy that is a function of frequency. When a photon (point particle) collides with an electron (point particle) there is momentum transfer and energy transfer between these particles. The interaction is nicely described by Compton's equations and he received the 1927 Nobel Prize in physics for this work.

The physics community has universally adopted the wave-particle photon model. Photons clearly have wave properties, but Compton scattering, the photoelectric effect and other experiments also seem to require a particle explanation. The wave-particle description of both photons and particles works well, but the conceptual understanding of this has puzzled generations of physics students.

Schrodinger Article on the Compton Effect: Since this book proposes that fundamental particles are dipole waves in spacetime, it would be helpful to support this contention by offering a plausible explanation for Compton scattering using the proposed spacetime based model of both electrons and photons. As I was working on this explanation, I assumed that no one had been successful in proposing a purely wave based explanation for Compton scattering. To my

surprise, I discovered that in 1927 Erwin Schrodinger had published a technical paper titled “The Compton Effect”². This article is available in Schrodinger’s book “Wave Mechanics” which has had multiple editions in English. Schrodinger did not conceive of waves in spacetime or a rotar model, but he did propose a plausible wave explanation for Compton scattering. His proposed explanation involved an electron’s de Broglie waves interacting with light waves to produce the correct scatter characteristics for both the light and the electron. In this article, Schrodinger used some antiquated terminology such as the phrase “an aether wave” to describe light, but his point is valid. A brief description of his concept will be given here.

Schrodinger looked at the collision as if it was a continuous process. In this case four waves are present and continuously interacting. These four waves are 1) the electron’s de Broglie wave before the interaction 2) the electron’s de Broglie wave after the interaction 3) the light wave before the interaction and 4) the light wave after the interaction. Schrodinger found that the two superimposed de Broglie waves combined to make a wave that he called a “wave of electrical density”. This combined wave had the perfect periodicity to reflect the incident light beam and create a reflected beam with the correct frequency shift and scatter angle. The two superimposed light waves (incident and scattered) produce an interference pattern that matches the interference pattern produced by the two superimposed de Broglie waves.

Schrodinger made an analogy between Compton scattering and light interacting with sound waves (Brillouin scattering). Sound waves produce a periodic change in the index of refraction of an acoustic medium. Light waves propagating in an acoustic medium can reflect off the sound wave which produces periodic changes in the index of refraction. The maximum reflection is obtained if the following equation is satisfied: $\lambda \approx 2\Lambda \sin \theta$

Where: λ = light wavelength, Λ = acoustic wavelength and θ = the angle between the light propagation direction and a plane parallel to the acoustic waves.

This equation would be exact if the acoustic wave was stationary. Since the acoustic wave has a speed much less than the speed of light, the condition of a stationary acoustic wave is approximately met. However, relativistic corrections would be required if the sound wave propagated at a significant fraction of the speed of light. The equation corresponds to the Bragg law (first order) and becomes exact when the acoustic waves are stationary. When the acoustic speed of sound is taken into consideration, then it appears as if the light waves are reflecting off a moving multi layer dielectric mirror. There is a frequency shift in the reflected light and the angle of incidence does not equal the angle of reflection because the mirror is moving.

Schrodinger considered the superposition of the two sets of an electron’s de Broglie waves (before and after the interaction) to result in a “wave of electrical density” that could interact with light. Here are Schrodinger’s translated words:

² Annalen der Physik (4), vol 82

“According to the hypothesis of wave mechanics, which up to now has proven trustworthy, it is not the ψ -function itself, but the square of the absolute value that is given a physical meaning, namely, density of electricity. A single ψ -wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,... we see that a ‘wave of electrical density’ arises from the combination...”

Now it is this density wave that takes the place of the sound wave of Brillouin’s paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg’s law) then we shall show that our four waves (two ψ -waves and the incident and reflected light waves) stand exactly in the Compton relationship....

As all the four waves are invariant with respect to Lorentz transformation, we can bring the density wave to rest by means of such a transformation.... Bragg’s relationship holds exactly if λ denotes the wavelength of the light wave, Λ that of the density wave and θ the glancing angle. It can be put in the form: $2h\lambda/\sin\theta = h/\Lambda$ ”

Vector Diagrams: I will elaborate on Schrodinger’s point that it is possible to bring the two interacting de Broglie waves into a stationary frame of reference by a Lorentz transformation. Normally Compton scattering involves an incident photon striking a stationary electron. The momentum transfer produces a recoiling (moving) electron and reduces the energy of the scattered photon compared to the incident photon.

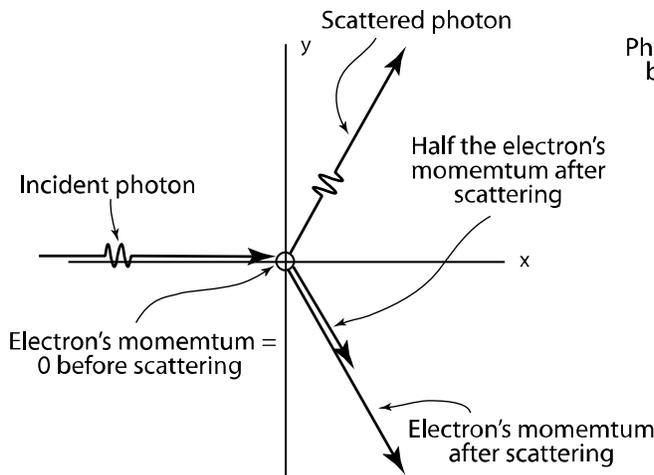


FIGURE 10-12 Compton scattering vector diagram (stationary electron before scattering)

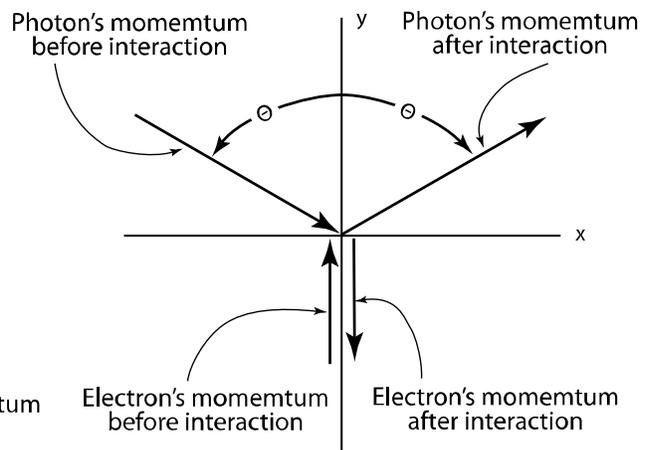


FIGURE 10-13 Compton scattering vector diagram in the frame of reference that gives zero energy transfer (moving electron before scattering)

Figure 10-12 shows a vector diagram that depicts this normal Compton scattering condition. This diagram shows the momentum vector of both the incident and the scattered photons. It also shows the electron's momentum vector after the Compton scattering. All of these are commonly included in Compton scattering diagrams, but figure 10-12 includes two additional features. First, the electron's momentum before scattering is designated (momentum = 0). Secondly, there is a momentum vector designated "half the electron's momentum after scattering". This vector should be superimposed on the parallel vector but it has been displaced slightly for clarity.

The reason for the additional designations of the electron's momentum before scattering and half the electron's momentum after scattering is that these designations will help explain the frame of reference used for Figure 10-13. In figure 10-13, we adopt a frame of reference that is required to have the electron moving with the opposite momentum as the vector designated "half the electron's momentum after scattering". If the scattered electron's velocity is non relativistic, then the moving frame of reference is simply half the scattered electron's speed and the opposite vector direction as shown in figure 10-13. In this frame of reference, the electron is moving at velocity $+v$ before scattering and is moving at velocity $-v$ after the scattering (the same speed but opposite direction). This is the frame of reference described by Schrodinger as the Lorentz transformation that "brings the density wave to rest". The superposition of the electron's de Broglie waves before and after the interaction results in a stationary (but oscillating) de Broglie wave pattern.

It is very easy to analyze Compton scattering from this frame of reference. There is momentum transfer between the photon and the electron, but there is no energy transferred. In this zero energy transfer frame of reference, the electron momentum moving towards the origin (before scattering the photon) is the same magnitude but opposite direction as the electron momentum moving away from the origin (after scattering the photon). The reversal in direction is the momentum transferred to the photon. The superposition of the two sets of the electron's de Broglie waves produces a stationary standing wave pattern (density wave) with periodicity of $\Lambda_d = \hbar/mv$. This stationary wave pattern effectively reflects a photon without any change in frequency. Also, the angle of incidence equals the angle of reflection – just like reflection from a stationary mirror.

All Compton scattering events involving an initially stationary electron can be looked at as a special case of the zero energy transfer Compton scattering where the frame of reference has been adjusted (Lorentz transformation) so that the electron is initially stationary. Once we understand a scattering event in this simplest frame of reference, we can easily switch back to the commonly used frame of reference depicted in figure 10-12. The frequency shift and angle change is simply the result of reflecting off a moving multi-layer dielectric mirror.

Figure 10-5 shows a rotar model in a moving frame of reference. This figure depicts an instant in time. The large black horizontal fringes are moving in the direction of translation at a velocity of $w_d = c^2/v$. This says that the interference fringes are always moving faster than the speed of light. When we superimpose two rotar models moving at the same speed but in opposite directions, we again obtain an instantaneous picture similar to figure 10-5. However, the superposition of opposite moving waves results in the de Broglie waves becoming stationary. This can be visualized as the high frequency waves (yellow and blue waves) in figure 10-5 being standing waves which are oscillating at a frequency of approximately 10^{20} Hz.

ψ Function: The envelope of these waves is a wave that is proposed to be Schrodinger's ψ function. Squaring this gives the probability of finding the electron in areas of greatest oscillation amplitude. Schrodinger calls these areas of greatest oscillation "waves of electrical density". Since these waves are proposed to be dipole waves in spacetime oscillating at the electron's Compton frequency, it is easy to see why the square of these waves represents the probability of "finding" an electron.

Schrodinger argues that when light interacts with stationary ψ -waves (de Broglie waves) they represent the equivalent of a density variation that can reflect light. Once again, his translated words are:

"A single ψ -wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,... we see that a 'wave of electrical density' arises from the combination..."

Now it is this density wave that takes the place of the sound wave of Brillouin's paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg's law) then we shall show that our four waves (two ψ -waves and the incident and reflected light waves) stand exactly in the Compton relationship."

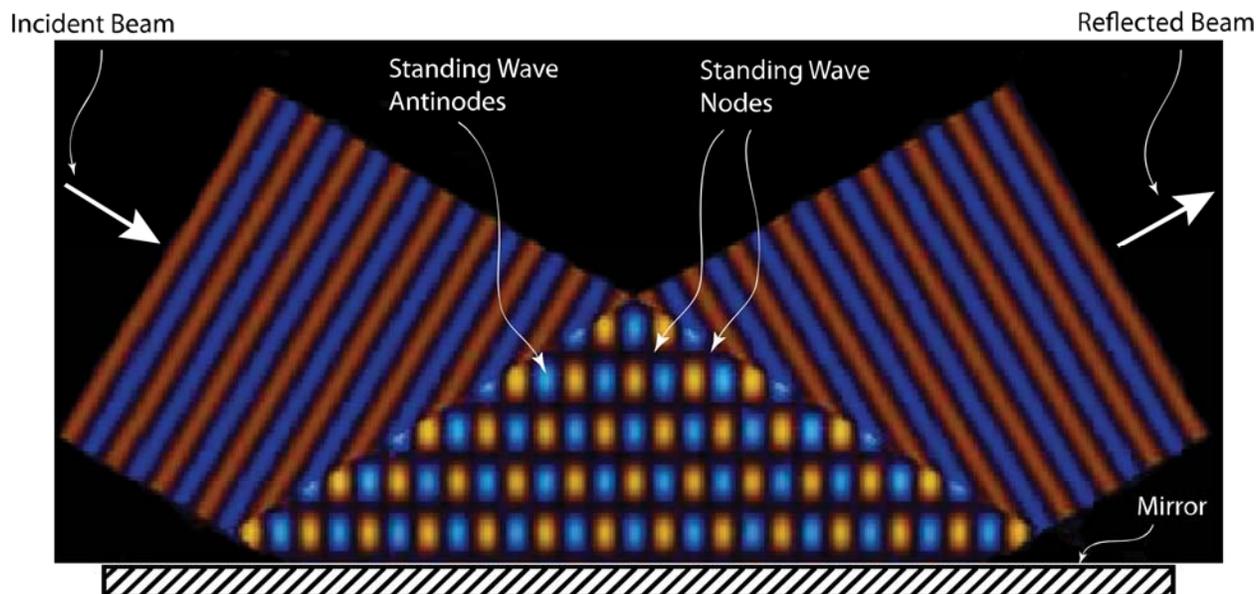


FIGURE 10-14 Standing wave pattern produced by the reflection of a beam of light off a mirror

More will be said about the physical explanation of the Ψ function in chapter 12. For now we will attempt to illustrate Schrodinger's idea of Compton scattering with the next two figures. Figure 10-14 sets the stage by illustrating the wave properties of light reflecting off a mirror (frozen in time). The beam of waves enters from the left, reflects off the mirror and leaves to the right. The area of overlap between the incident and reflected beams is the area where a standing wave pattern is created. This standing wave pattern has standing wave nulls which in this figure are horizontal bands parallel to the mirror surface where there is no electric field oscillation. The antinode bands are also illustrated and these are regions of maximum electric field oscillation. For example, if the light wave is linearly polarized with the electric field vector oscillating perpendicular to the plane of the illustration, then the blue regions might be considered regions where the electric field momentarily is pointing towards the reader and the yellow regions might be considered regions where the electric field vector is momentarily pointing away from the reader. If time was allowed to progress forward, these blue and yellow regions in the standing wave would move from left to right. The node planes would remain unchanged.

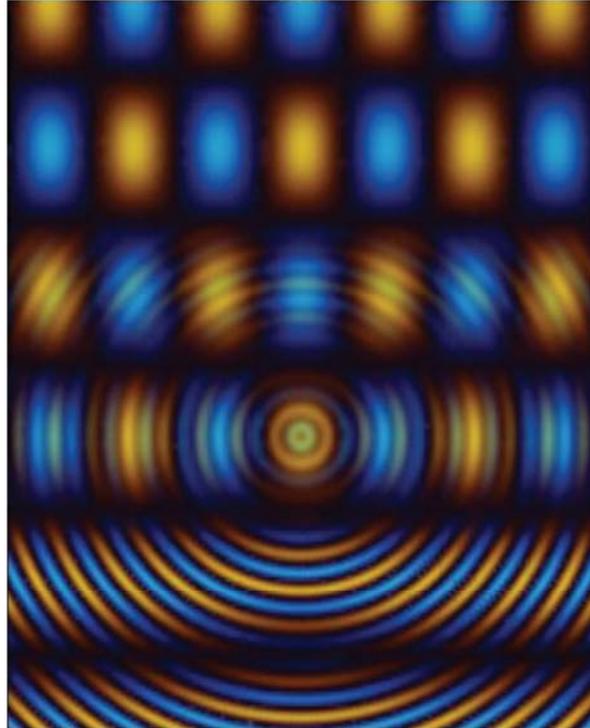


FIGURE 10-15 The superposition of 4 wave patterns produce this representation of Compton scattering. These 4 wave patterns are: 1) the incident light, 2) the scattered light, 3) the electron wave pattern before interaction, 4) the electron wave pattern after interaction.

Now figure 10-15 represents the combination of figures 10-14 and 10-5. In this case only the standing wave portion of figure 10-14 is illustrated, so the reader must imagine that the incident beam is coming in from the upper left and the reflected beam is leaving to the upper right. Also the lower portion of figure 10-15 represents the superposition of an electron before and after the scattering. We are using the zero energy transfer frame of reference, so the de Broglie wave pattern would appear stationary. The conditions that produce Compton scattering result in a perfect match between the spacing of the standing wave antinodes of the light beam and the standing wave antinodes of the electron. It is as if the light beam is reflecting off a multi layer dielectric reflector.

If we moved to a different frame of reference where we would perceive some energy transfer between the light and the electron, then the angle of incidence would not equal the angle of reflection and the wavelength of the reflected beam would be different than the wavelength of the incident beam. In the above description, some artistic license has been taken both in the illustration and the choice of words. We should really be talking about the scatter of a single photon from a single electron. The wave amplitude should not be uniform and numerous other corrections.

This spacetime wave explanation of Compton scattering is proposed to actually be better than the particle based explanation because several quantum mechanical mysteries are also explained by the spacetime wave explanation. For example, the spacetime wave explanation has the wave model of an electron going from its initial velocity to its final velocity without accelerating through all the intermediate velocities. An explanation of Compton scattering involving the standard point particle model of an electron would seem to imply that the electron undergoes acceleration as it transitions through intermediate velocities. This concept of intermediate velocities is not consistent with the quantum mechanical description.

Also, Schrodinger indicated that his ψ function had no physical meaning; it only gained physical meaning when it was squared to give the probability of finding a particle. I have given a proposed physical meaning to the ψ function. It is the wave envelope shown in figure 10-7 and depicted in figure 10-5. The envelope (ψ function) is undetectable because it is an interference effect with nodes and antinodes of dipole waves in spacetime with an interference pattern that propagates faster than the speed of light. Only when there is an interaction between two such envelopes of waves does the propagation slow down to a speed less than the speed of light (as depicted in figure 10-15). Squaring this then gives the probability of “finding the particle”.

Plausibility, Not Proof: To successfully complete this Compton scattering analysis, it would be necessary to show that this superposition of the electron’s waves in spacetime (two different velocities) produces a periodic change in the proper speed of light. Furthermore, it would also be necessary to characterize a photon using waves in spacetime and show that the combination of these models produces the correct scatter probability.

While I have proposed explanations that contain the elements required in this explanation, I cannot conclusively show that the effects on the speed of light are sufficient to accomplish Compton scattering. It is hoped that others might be able to complete this task. Schrodinger has shown that a wave explanation of Compton scattering is plausible. I show that the rotar model in a moving frame of reference is plausibly equivalent to Schrodinger’s ψ -function waves. Therefore, this will be declared a successful plausibility test even though it is a long way from being conclusively proven.

Double Slit Experiment: Another plausibility test of the rotar model is to see if this model produces a diffraction pattern characteristic of sending an electron (or other particle) through a double slit. The diffraction pattern produced by sending a stream of electrons through a double slit has long been offered as proof that an electron exhibits wave-particle duality. Even before working on the ideas expressed in this book, I always found the implications of the double slit diffraction experiment to be a problem for the wave-particle duality “explanation”. If an electron is also a point particle, then the point particle must have passed through only one of the two slits. Even if some wave properties of the particle explored the other slit, it seems as if the diffraction pattern should imply an unequal illumination of the two slits. A large inequality of illumination

should greatly reduce the visibility of the diffraction nulls. Instead, the diffraction pattern produced by electrons implies that the electron possesses only wave properties as it passes through both slits equally and simultaneously. I find it far easier to conceptually understand how the rotar model of an electron can possess particle-like properties than understand the contradictions of wave-particle duality. Imagine an electron as a unit of quantized angular momentum with a specific rotational frequency existing in a sea of vacuum energy. With this model it is possible to see how this quantized angular momentum could possibly reassemble itself on the other side of a double slit. It would have passed through both slits and would exhibit the double slit diffraction pattern.

The following explanation will continue to use an electron as an example, but this also applies to composite particles such as neutrons or molecules. The reasoning about neutrons and other composite particles will be discussed later in the chapter about hadrons.

The diffraction pattern produced by light of wavelength λ passing through a single slit of width d_1 produces a well-known single slit diffraction pattern. The single slit intensity profile can be calculated from the Fraunhofer diffraction integral. In general, the double slit diffraction pattern can be thought of as a superposition of the single slit diffraction pattern on the diffraction pattern for two coherent narrow ($< \lambda$) line sources of light separated by the double slit separation distance d_2 .

Here we are only going to do a greatly simplified version that can illustrate some interpretations of the wave patterns that will be obtained in a double slit simulation. In this simplification, we start with the model of a moving rotar such as shown in figure 10-5. Symmetrical portions of the external volume of a rotar are presumed to pass through both slits symmetrically and become two new sources of waves. For simplification the emission pattern from each slit is spherical. An actual slit width would introduce an additional intensity distribution superimposed on this spherical emission pattern. The key difference between this model and a standard double slit experiment with light is that the waves emanating from both slits in this model have the bidirectional propagation characteristics (de Broglie waves) of a moving rotar. This means that we are interfering 4 sets of waves (2 counter propagating waves from each slit).

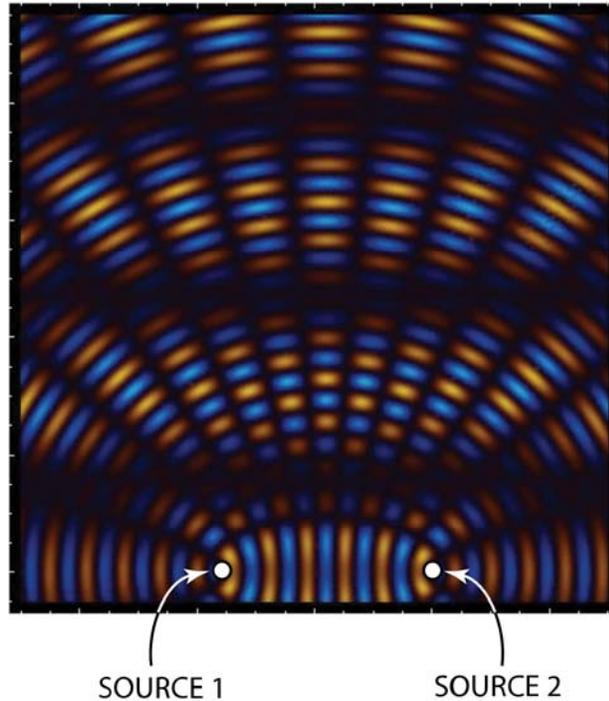


FIGURE 10-16 Illustration used to explain effects produced when a rotar encounters a double slit

Figure 10-16 shows the result of the coherent interaction of these 4 waves. The two slits are identified as “source 1” and “source 2”. The resultant interference pattern is similar to what might be expected from light passing through double slits, but there are some key differences. First, the three dark horizontal bands are the result of the de Broglie waves and are similar to the bands shown in figure 10-5. These bands would be moving at faster than the speed of light ($w_m = c^2/v$) and would not be in the pattern produced by light. Secondly, the blue and yellow wave representations would be alternating color (dipole polarity) at the electron’s Compton frequency. Third, these blue and yellow wave representations would be propagating away from the slits at the electron’s propagation speed ($u_d = v$) and not at the speed of light as would occur with light. Fourth, it is impossible to detect the fine wave pattern represented by the blue and yellow waves. These have displacement amplitudes less than Planck length/time and are undetectable as discrete waves. They are at the electron’s Compton frequency and the square of the time averaged waves represent the probability of “finding” the electron.

When a moving electron encounters a double slit, it no longer is an isolated electron. The model must change to reflect the changed boundary conditions. Parts of the quantized wave that is the electron pass through both slits and parts of the electron encounter the matter (other waves in spacetime) that forms the blocking areas. Whether or not the electron (rotar) reforms on the other side of the double slit is a probability. Even though most of the dipole wave is blocked (perhaps 99%), apparently the remaining 1% has a probability of reconstructing the entire

dipole wave on the other side of the double slit. If it does reform, it has new characteristics imposed by the interaction with the matter (waves) that surrounds the double slit openings. There are new boundary conditions that are expressed as the radial interference pattern shown in Figure 10-16.

Energy Density of a Gravitational Field: In chapter 8 we calculated the energy density in the center of the rotar model of a fundamental particle. This is a rapidly rotating time gradient ($> 10^{20}$ Hz) which is equivalent to a rotating gravitational field. If a rotating “grav field” at the center of a fundamental particle has energy density, does the gravitational field external to the particle (external to \mathcal{A}_c) also have energy density? The wave-amplitude energy density equation $U = A^2\omega^2 Z/c$ seems to imply that an oscillating wave is required for there to be any energy density because if $\omega_c = 0$ then $U_g = 0$. This is reasonable because it is not possible to extract energy from the static strain component of a gravitational field. However, as previously discussed, a gravitational field has both a static component which we can easily detect and an oscillating component which we cannot detect. In figure 8-3 the sloping line with small undulations is made up of a DC-like component that does not oscillate and an AC-like component that does oscillate. The AC-like component implies an energy density to a gravitational field. It may be impossible to ever extract energy from the AC-like component of gravity the same way that it is impossible to extract energy from vacuum energy, but on the quantum mechanical level a gravitational field does appear to have energy density. If so, what are the equations? How much of a black hole’s energy is in the gravitational field external to its event horizon? Is it possible to derive the curvature of spacetime at a point if we know the gravitational field energy density and interactive energy density at that point?

Gravitational Energy Density: The Oscillating Component of Gravity: Most of this chapter was spent describing the part of the external volume associated with the oscillating and non-oscillating components associated with the electric field. While there has previously been some discussion of the oscillating component of gravity, there is still several important points on this subject which have not been previously mentioned. Earlier in this chapter the two amplitude terms associated with a rotar’s gravity were given as:

$$A_g = \frac{A_\beta^2}{\mathcal{N}^2} = \frac{L_p^2}{r^2} = \text{gravitational standing wave amplitude oscillating at } 2\omega_c$$

$$A_G = \frac{A_\beta^2}{\mathcal{N}} = \frac{Gm}{c^2 r} = \beta = \text{gravitational non-oscillating strain amplitude}$$

For a single particle such as an electron, this oscillating term associated with gravity is an extremely weak effect because the amplitude of this oscillating component is $A_g = A_\beta^2/\mathcal{N}^2 = L_p^2/r^2$. Furthermore, this amplitude is squared again in the energy density equation so $A_g^2 = L_p^4/r^4$ where $L_p^4 \approx 10^{-140} \text{ m}^4$. However, the implication is that a gravitational field does have energy density since it has frequency, amplitude and the impedance of spacetime.

Therefore, we will calculate the implied energy density of a gravitational field using $U = A^2 \omega^2 Z / c$ and setting $A = A_g = A_{\beta^2} / \mathcal{N} = L_p^2 / r^2$ and $Z = Z_s = c^3 / G$

$$U_g = \left(\frac{L_p^2}{r^2}\right)^2 \omega^2 \left(\frac{c^3}{G}\right) \left(\frac{1}{c}\right) = \left(\frac{\hbar^2 G^2}{c^6}\right) \left(\frac{\omega^2}{r^4}\right) \left(\frac{c^2}{G}\right) = (\hbar\omega)^2 \left(\frac{G}{c^4}\right) \frac{1}{r^4} = (mc^2)^2 \frac{G}{c^4 r^4}$$

$$U_g = \frac{Gm^2}{r^4} \quad \text{This equation ignores a numerical constant near 1}$$

Total Energy in a Gravitational Field: Usually I have avoided including constants near 1 since even Planck length and Planck time might have a constant associated with it when exact calculations are required. However, in the case of the energy density of a gravitational field I can make an educated guess about the value of the constant. Einstein's field equation is essentially an equation of energy density equals pressure as shown in chapter 4. The constant associated with that energy density is $1/8\pi$. Also the energy density of the electric field produced by a Planck charge is $U_e = (1/8\pi)(\hbar c/r^4)$. I see an analogy between both of these equations and the equation for the energy density of a gravitational field $U_g = Gm^2/r^4$. In both of these equations the constant is $1/8\pi$. Therefore, I am going to restate this equation including this constant.

$$U_g = \left(\frac{1}{8\pi}\right) \frac{Gm^2}{r^4} = \left(\frac{1}{8\pi}\right) \frac{g^2}{G} \quad \text{where gravitational acceleration is } g = \frac{Gm}{r^2}$$

This calculation used the assumption that we were dealing with individual rotars. All other calculations in this book that involving fundamental particles apply even to a hypothetical Planck mass particle which would be a black hole with Schwarzschild radius (defined as $R_s \equiv Gm/c^2$) of $\mathcal{A}_c = L_p = R_s$ and $\omega = \omega_p$. Now the question is: Can we switch from individual particles and assume that the mass term m in the above equation can apply to massive objects with many particles such as planets, stars and black holes? The unknown is: How does the oscillating component of the gravitational fields produced by many individual particles add together? Since all other gravitational effects scale with total mass with no indication of a difference in the type or number of particles, I will assume that the above equation applies to the total mass and proceed with the analysis.

The implication is that gravity is producing a strain on the homogeneous vacuum energy that forms the spacetime field. If gravity has an oscillating component, then the indication is that we should be able to calculate the magnitude of the energy density produced by a mass at known radius r . Out of curiosity, what is the energy density produced by the earth's gravity at the surface of the earth? The earth's mass is about 6×10^{24} Kg and its radius is about 6.38×10^6 m. This works out to about $U_g \approx 5.8 \times 10^{10}$ J/m³ at the surface. Converting this to the equivalent mass density (dividing by c^2) this is about 6.4×10^{-7} kg/m³. This calculation

includes the constant $1/8\pi$. To test this further, we will calculate the total energy outside of a specific radius r . Obviously for a black hole, “ r ” must be interpreted as circumferential radius. If we integrate the above equation to find the total energy (or mass equivalent) external to circumferential radius r (integration limits r to infinity) we obtain:

$$E_{\text{ext}} = \frac{Gm^2}{2r} = \frac{E^2}{2F_p r}$$

Set $E = E_{\text{bh}} =$ energy of a Black hole and set $r = R_s \equiv Gm/c^2$, the Schwarzschild radius

$$E_{\text{ext}} = \frac{E_{\text{bh}}^2}{2F_p R_s} = \frac{E_{\text{bh}}^2}{2E_{\text{bh}}} = \frac{E_{\text{bh}}}{2}$$

Therefore, we obtain the result that, ignoring numerical constants near 1, about half (perhaps all) of the energy of a black hole is contained in the gravitational field external to the event horizon³. After I independently derived the above equations, I found that others have reached the same conclusion about the energy density of a gravitational field.^{4,5} However, this is not a generally accepted idea among physicists. My approach arrived at this implied energy density of a gravitational field using the model of gravity that has both an oscillating component and a non-oscillating component. This appears to be a totally new concept. The fact that a gravitational field has energy density also implies that there should be frame dragging if the mass is rotating. The predicted magnitude of the frame dragging will have to be developed.

The oscillating component of gravity is also very important in cosmology. Chapters 13 and 14 describe how the Big Bang and the expansion of the universe can be explained as a transformation of the properties of the spacetime field. A key part of this transformation involves the oscillating component of gravity transforming the observable energy density in the early universe into the situation we have today where only about 1 part in 10^{120} is observable energy in the form of fermions and bosons.

Flat spacetime is the homogeneous energy density of the dipole waves in spacetime predominately at Planck frequency previously described. Matter experiences “interactive energy density” of spacetime $U_i = \omega^2/G$ as previously described. Introducing oscillating

³ **Note:** The term “event horizon” of a black hole is used because this is the easiest way to explain a concept. However, I doubt that a black hole has a true “event horizon” where the rate of time is truly stopped. It is possible to have the rate of time slowed down by a vast amount such as 10^{20} times, but having it truly stopped rate of time presents problems for spacetime particles which cannot survive having the rate of time stopped.

⁴ http://www.grc.nasa.gov/WWW/k-12/Numbers/Math/Mathematical_Thinking/possible_scalar_terms.htm

⁵ Lynden-Bell, D. R Astro. Soc. **213**, (1985) pp 21-25, <http://adsabs.harvard.edu/full/1985MNRAS.213P..21L>

standing waves into this homogeneous energy density of dipole waves produces a distortion of the energetic vacuum characteristics. We call this distortion curved spacetime.

Insight into the Creation of Curved Spacetime: We interact with the non-oscillation component of the gravitational field. However it is the oscillating component of the standing waves which create the energy density of both an electric field and the energy density of the gravitational field. Now that we have the energy density contained in a rotar's gravitational field, can we gain a new insight into the curvature of spacetime produced by a gravitational field? To understand this, recall that the interactive energy density of the spacetime field at distance r from a mass is given by $U_i = F_p/r^2$. Therefore, the gravitational field is introducing organized energy density into what was previously flat spacetime possessing energy density without quantized angular momentum.

We know that matter curves spacetime. Now that we have been able to quantify both the energy density of a gravitational field U_g and the "interactive energy density U_i " of the spacetime field, we will see if it is possible to connect the ratio U_g/U_i to the curvature of spacetime. In chapter 2 we defined $\Gamma \equiv dt/d\tau = 1/(1 - \beta)$. Where β has been named the "gravitational magnitude". For fundamental particles the weak gravity approximation is $\beta \approx Gm/c^2r$. This definition of the curvature of spacetime is accurate to better than about 1 part in 10^{40} for the weak gravity produced by known fundamental particles. Since U_i ignores numerical constants near 1, the calculation of the ratio of U_g/U_i will also ignore the numerical constant associated with U_g . Therefore we will set:

$$U_g = \frac{Gm^2}{r^4} \quad \text{and} \quad U_i = \frac{F_p}{r^2} = \left(\frac{c^4}{Gr^2}\right)$$

$$\frac{U_g}{U_i} = \left(\frac{Gm^2}{r^4}\right) \left(\frac{Gr^2}{c^4}\right) = \frac{G^2m^2}{c^4r^2} \approx \beta^2$$

$$\sqrt{\frac{U_g}{U_i}} = \frac{Gm}{c^2r} \approx 1 - \frac{d\tau}{dt} \quad \text{the curvature of spacetime (weak gravity approximation)}$$

This is a wonderful result! The distortion produced by introducing a gravitational field's energy density into flat spacetime creates a curvature of spacetime associated with the weak field gravity. I believe that a more rigorous treatment will yield general relativity since nonlinearities are being ignored in this simplified calculation.

I initially found the square in $U_g/U_i = (Gm/c^2r)^2 = \beta^2$ a bit surprising. Before I made this calculation, I was expecting the ratio to equal the gravitational beta ($\beta = Gm/c^2r$). However, I can now see that since gravity is a nonlinear effect that scales with amplitude squared, there is also a square effect that extends to U_g/U_i . I find the connection between U_g/U_i and the curvature of spacetime is so reasonable that it confirms three things. 1) It confirms that gravitational fields have energy density $U_g = k Gm^2/r^4 = k g^2/G$. 2) It confirms the accuracy of the interactive energy density of spacetime $U_i = k c^2\omega^2/G = kF_p/\lambda^2 = k(\omega/\omega_p)^2 U_p$. 3) It confirms that we have

found the key to understanding the mechanism by which matter interacts with the spacetime field to produce curved spacetime.

The calculation that shows that gravity has energy density also implies that gravity is a real force. A variation of the equivalence principle is often cited to support the idea that gravity is not a true force because an inertial frame of reference can make a gravitational field disappear. However, an inertial frame of reference is really an accelerating frame of reference in a gravitational field. The opposing argument in favor of a gravity being a true force is as follows: A body in free fall in a gravitational field is just experiencing offsetting forces. The gravitational force is still present but the accelerating frame of reference causes an opposite inertial “pseudo-force” on every particle. The two opposing forces exactly offset each other creating the impression that the gravitational force has been eliminated. However, to draw this conclusion, it is necessary to assume that the “force” of inertia has also been eliminated even though acceleration is taking place. The acceleration also produces an offsetting rate of time gradient and an offsetting spatial effect. The conclusive way to resolve this argument is the proof that gravity possess energy density.

Chapter 11

Photons

Photons: In chapter 9 we examined the simplified case of photons confined to a reflecting cavity. When we reduced the dimensions of the cavity to the minimum size that would support electromagnetic radiation of a particular wavelength, we called this condition “maximum confinement”. Equations for the electric and magnetic field were developed for this maximum confinement condition. In this chapter we will develop a model of a freely propagating photon. This model will be incomplete, but hopefully this attempt at developing such a model will encourage others to improve on this model.

It is commonly argued that photons cannot just be waves because the photo-electric effect demonstrates that all the energy of a photon is transferred to a single electron in an absorbing atom. This concentration of energy can eject an electron from the surface of the photo-electric material. The reasoning is that if a photon was a wave, then the wave would distribute the photon’s energy evenly over a surface and no single electron would receive the energy required to eject an electron from a surface. This reasoning assumes that the waves of a photon are similar to either a sound wave or perhaps a wave in the aether. A sound wave in air for example produces an oscillating displacement of many molecules. When a sound wave in air strikes a solid surface, it is really many individual molecules striking the surface independently. The energy of the sound wave is distributed over the surface. Similarly, if light is imagined as a wave in an omnipresent fluid called the aether, then waves in the aether would be evenly distributed over a surface and an electron would not be ejected from the surface.

A photon possesses quantized angular momentum, not quantized energy. It is the quantized angular momentum that gives a photon its particle-like properties.

Recall that a photon is an \hbar unit of angular momentum propagating as a wave in the spacetime field. However, this wave is also quarantined in some way by the superfluid properties of the spacetime field. This results in a photon having quantized angular momentum. It is impossible to distribute quantized angular momentum to multiple locations. All the quantized angular momentum (and all the energy) is deposited as a single unit at a single location. This effect gives a photon particle-like properties when it interacts with matter. However, this does not require that a photon is an actual particle; it only requires quantization of angular momentum. Furthermore, the photo-electric effect is low energy Compton scattering. In chapter 10 it was shown that Compton scattering has a plausible wave explanation. Even though the photoelectric material has a surface work function, the basic Compton scatter wave interaction is the same. The quantized wave characteristics of the photon and the electron can eject the electron from the surface.

In Compton scattering the photon usually transfers some of its energy to the scattered electron (Fig. 10-12 shows the rare example of a photon transferring linear momentum but not energy). Even when a photon is reflected off a “moving” mirror, the reflected photon is Doppler shifted and therefore has different energy than it had before it reflected off the mirror. The point is that photons do not possess quantized energy. When a photon is emitted or absorbed, there is a transfer of \hbar quantized angular momentum. Energy is also transferred, but the transfer of energy is just a byproduct of the transfer of quantized angular momentum.

This chapter will show a proposed model of a photon and explain how a photon can possess quantized angular momentum. Usually the angular momentum of a photon is an abstract concept that is dealt with mathematically. It is easy to write an equation that incorporates angular momentum but the hard part is to develop a physical model of a photon which incorporates angular momentum. Why is angular momentum quantized? What enforces this quantization of angular momentum? Answering these questions are another test of the proposed spacetime-based model of the universe.

How Big Is a Photon? The standard explanation for a photon’s properties is to claim that a photon exhibits “wave-particle duality”. Of course, this is not a conceptually understandable explanation; it is merely a name. In a double slit experiment, a photon seems to have the ability to pass through both slits simultaneously. This implies that a photon has a physical width. A photon also seems to have a physical length that is a function of the photon’s spectral width. For example, a rubidium atom has a spectral line called the D₁ transition. When a rubidium atom goes through this transition, it emits a photon over about 26 ns. This implies that this photon is extends over a distance of about 8 meters. Furthermore, the spectral line width of this rubidium transition has a bandwidth that also implies a wave packet with this physical length using a Fourier transform. This is not just an 8 meter uncertainty in the location of the photon; it is an actual wave train that is 8 meters long at a wavelength of about 795 nm. The hyper fine transition of cesium 133 that is used in atomic clocks emits at a microwave frequency of about 9.2×10^9 Hz. This emission frequency is stable to better than one part in 10^{13} . This extremely narrow bandwidth implies that the emitted photon is continuously emitted over about 1000 seconds and the length of the photon wave train is about 3×10^{11} m. At the opposite extreme, the record for the shortest pulse of laser light (in terms of approaching the theoretical limit) is a mere 1.3 cycles per pulse. The current record for the shortest pulse of laser light is about 8×10^{-17} seconds but that pulse contained several cycles and harmonics of a short wavelength.

The emission of a photon by an atom is often depicted as if it is an instantaneous event. However, this is known to be incorrect¹ because there is a time dependence of the wave function in a quantum transition. Experimental measurements have been made of samples undergoing spectroscopic transitions. These experiments confirm that there are no instantaneous quantum

¹ Macomber, J. D. *The Dynamics of Spectroscopic Transition*; John Wiley and Sons: New York, 1976.

jumps. Instead, the electric and magnetic properties undergo a smooth and continuous transition occurring over the emission time period which usually corresponds to the lifetime of the excited state.

There is a very good paper titled “How a Photon is Created or Absorbed”² that is also available online³. This online version has two good animations showing the oscillations of a hydrogen atom during the emission of a photon. This paper shows that there is an often ignored transition period required for the emission or absorption of energy in a transition between energy levels. There are numerous experimental observations that confirm that photons are emitted or absorbed over a time period corresponding to the inverse bandwidth. Quoting from the above article:

The first experimental measurements of bulk samples undergoing spectroscopic transitions were obtained from nuclear magnetic resonance observations of the transition nutation effect⁴ and spin echoes^{5,6} using coherent radiation produced by a single radio frequency oscillator. More recently, the analogous transition nutation effect^{7,8} and so called “photon echoes”^{9,10,11} have been observed in molecular spectra using pulsed coherent laser radiation. These experiments confirm that there is no “quantum jumps” in the non-stationary state; rather there are smooth, continuous periodic changes in the magnetic and electrical properties of the system undergoing a transition.

An electron bound in an atom possesses less energy than an isolated electron. For example, 13.6 eV of energy is released when an isolated electron combines with a proton to form a hydrogen atom in the ground state. The binding energy can be considered to be a negative form of energy which means that binding releases energy and breaking a bond requires energy. The rotar model of fundamental particles says that an isolated electron is a rotating dipole in the spacetime field with a rotational frequency of about 1.24×10^{20} Hz. When an electron and proton combine to form a hydrogen atom in the ground state, a photon is released with a frequency of about 3.3×10^{15} Hz (~ 13.6 eV). According to the rotar model, the energy released when a hydrogen atom forms comes primarily from the electron losing energy and reducing its Compton frequency by about 3.3×10^{15} Hz. The oscillations of the electron cloud shown in the above animation can be thought of as the interaction between the electron in two different energy

² Henderson, G. *J. Chem. Educ.* **1979**, *56*, 631-634

³ <http://www3.uji.es/~planelle/APUNTS/ESPECTROS/jce/JCEphoto.html>

⁴ Torrey, H. C. *Phys. Rev.* **76**, 1059 (1949).

⁵ Hahn, E. L. *Phys. Rev.* **77**, 297 (1950).

⁶ Hahn, E. L. *Phys. Rev.* **30**, 580 (1950).

⁷ Tang, C. L.; Statz, H. *Appl. Phys. Lett.* **10**, 145 (1967).

⁸ Hocker, G. B.; Tang, C. L. *Phys. Rev.* **184**, 356 (1969).

⁹ Kurnit, N. A.; Abella, I. D.; Hartmann, S. R. *Phys. Rev. Lett.* **13**, 567 (1964).

¹⁰ Abella, I. D.; Kurnit, N. A.; Hartmann, S. R. *Phys. Rev.* **141**, 391 (1966).

¹¹ Hartmann, S. A. *Sci. Amer.* **218**, 32 (1968).

states (two different frequencies) interfering with itself. These oscillations create waves in the spacetime field that remove this energy at the frequency of the oscillations. These waves are proposed to be the photon.

In chapter 9 it was shown that a photon was not an energy packet traveling THROUGH the spacetime field, but a wave traveling IN the medium of the spacetime field. Now we will develop the model of a photon further based on waves propagating within the vacuum fluctuations of the spacetime field. These waves will be shown to be distributed over a substantial volume of the spacetime field. Clearly such a structure cannot be visualized as a point particle. It only exhibits particle-like properties because it possesses quantized angular momentum combined with the property of unity. This combination gives waves in the spacetime field with quantized spin the ability to act as a unit and transfer their energy and quantized spin to a single rotar. The name “photon” is not really appropriate since the suffix “on” was coined specifically to imply particle properties. However, the name “photon” is flexible enough that it can adjust to a quantized wave explanation. Therefore no attempt will be made to replace the word “photon”.

Vacuum Energy Versus the Aether: The aether was once believed to be an omnipresent fluid with a single frame of reference that served as the propagation medium for light waves. The concept of the aether implied that it should be possible to detect evidence of the earth’s motion relative to the aether. For example, if this model of the aether was correct, there should be a detectable shift in interference fringes in the Michelson Morley experiment. This and numerous more recent experiments have confirmed that there is no evidence that any such relative motion exists. With this experimental evidence, the concept of the aether has been abandoned. This background makes the following seem like a radical proposal:

A photon is a wave disturbance possessing quantized angular momentum that propagates in the medium of the vacuum fluctuations of the spacetime field.

This concept was first introduced in chapter 9 but it is repeated here since any discussion of photons must be based on this concept. This sounds like I am merely substituting the term “vacuum fluctuations” for aether. However, there is a big difference. The properties of the vacuum fluctuations are such that it is impossible to detect any motion relative to these fluctuations (ignoring hypothetical experiments which probe the Planck frequency limits). Recall that vacuum energy (vacuum fluctuations) is a sea of dipole waves in the spacetime field that lack angular momentum. These waves are already propagating at the speed of light. Every part of a wave becomes the source of a new wavelet so the spacetime field becomes a sea of dipole wave distortions that are rearranging themselves at the speed of light. As previously explained, these chaotic waves that lack angular momentum make the quantum mechanical version of a vacuum. They are responsible for the appearance of virtual particle pairs, the uncertainty principle, the Casimir effect, the Lamb shift, etc.

Gravitational waves also propagate in the medium of the spacetime field. It is known that gravitational waves propagate at the speed of light in any frame of reference. If it was possible to do a Michelson-Morley experiment using gravitational waves, it would be impossible to detect motion relative to the medium of the spacetime field. Therefore the spacetime field possesses the ability to propagate waves at the speed of light as seen from any frame of reference.

It is also impossible to detect motion relative to the dipole waves that are an essential part of the spacetime field. Chapter 7 discussed the subject of spectral energy density in vacuum energy. That discussion is repeated here because it takes on new meaning when applied to detecting motion relative to vacuum energy.

In quantum field theory, spacetime is visualized as consisting of fields. Every point in spacetime is treated like a quantized harmonic oscillator. The lowest quantum mechanical energy level of each oscillator is $E = \frac{1}{2} \hbar\omega$. This concept leads to a spectral energy density $\rho(\omega)d\omega$ that is:

$$\rho(\omega)d\omega = k \left(\frac{\hbar\omega^3}{c^3} \right) d\omega$$

This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift. It should also be noted that neither cosmological expansion nor gravity alters this spectrum.¹²

Therefore, vacuum energy has completely different properties than the aether which is thought of as an omnipresent fluid which has a specific frame of reference. Normally we would say that it is impossible to detect motion relative to the vacuum energy. However, in chapter 14 we will examine the implications of the vacuum fluctuations having a maximum frequency equal to Planck frequency. Since it is impossible for the spacetime field to propagate a wave with a Doppler shifted frequency higher than Planck frequency or a wavelength shorter than Planck length, it is possible to imagine extreme frames of reference where the laws of physics are not covariant. However, since these are vastly outside of any experimental condition, this exception will be ignored until chapter 14.

¹² Puthoff, H.E. Phys. Rev. A Volume 40, p.4857, 1989 Errata in Phys. Rev A volume 44, p. 3385, 1991 See also New Scientist, volume 124, p.36, Dec. 2, 1989

The bosons such as photons have angular momentum of \hbar . These quantized angular momentum disturbances in the spacetime field, are not confined to a specific location like the rotar model. Instead the quantized angular momentum of a photon is distributed into an expanding wave that will be described in this chapter. When a photon is absorbed, the disturbance with quantized angular momentum would collapse and transfer all the quantized \hbar angular momentum to the absorbing body (rotars).

A Photon Is Not a Dipole Wave in the Spacetime Field: A photon cannot be a quantized dipole wave in the spacetime field. A dipole wave creates an oscillating rate of time gradient. A rate of time gradient is capable of accelerating any matter, even a neutral particle such as a neutron. To prevent a violation of the conservation of momentum, dipole waves in the spacetime field are limited to a maximum displacement of spacetime of Planck length and Planck time as previously described. If a photon was a dipole wave, a focused laser beam would easily violate this restriction. Recall that rotars have this quantum mechanical limit of Planck length and Planck time. Therefore, the maximum energy density for a dipole wave in the spacetime field is equal to the energy density of the rotar volume of a rotar (U_q). This knowledge can be converted to a maximum intensity (\mathcal{J}) for a dipole wave in the spacetime field with reduced wavelength λ since $\mathcal{J} = Uc$ for radiation propagating at the speed of light. From previous calculations of rotars, we know that the energy density in the rotar volume of a rotar is: $U_q = \hbar c / \lambda^4$. This energy density then sets an upper limit to the maximum intensity that could be achieved at the focus of a laser beam if photons were dipole waves in the spacetime field. Using $\mathcal{J} = Uc$, the maximum intensity of electromagnetic radiation that would violate the conservation of momentum if photons were dipole waves in the spacetime field is: $\mathcal{J}_{\max} = \hbar c^2 / \lambda^4$.

If photons were dipole waves in the spacetime field, then the maximum intensity allowable for a laser beam with a wavelength of about 10^{-6} m (reduced wavelength $\lambda \approx 1.6 \times 10^{-7}$ m) would be about 10^{10} w/m² (10^4 w/cm²). Intensities in excess of 10^{20} w/cm² have been achieved at the focus of a pulsed laser at this approximate wavelength, so a photon is definitely not a propagating dipole wave in the spacetime field. A model will be developed that is a wave in the space dimensions of the spacetime field without affecting the rate of time. Gravitational waves can also have displacement amplitude that exceeds dynamic Planck length L_p because they also do not cause a displacement of the rate of time. (They also are not dipole waves in the spacetime field.)

Waves in Vacuum Energy: So far we have talked about waves in the abstract. What are the waves of a photon made of? Photons are not propagating dipole waves in the spacetime field but the proposed answer is that they are a propagating polarization in the dipole waves that form the spacetime field (vacuum energy). In chapter 9 the proposal was made that an electric field is a polarized strain in the spacetime field. This produces the unsymmetrical effects associated with propagation of a neutral particle in the positive or negative electric field direction. This results in the one way time of flight distance between points being slightly different for opposite polarity directions. For example, if there is an electric field present, then the time required to go

from point A to point B is longer than the time required to go from point B to point A. However, the round trip time is the same as expected from the speed of light and no electric field. This means that there is no change in proper volume and no change in the rate of time. A single photon with reduced wavelength λ in maximum confinement had a difference in path length over a distance of λ of L_p and n photons in maximum confinement produced a path length difference of: $\sqrt{n}L_p$. Since it is theoretically impossible to measure a distance accurate to Planck length, this explains why it is impossible to measure the wave properties of a single photon but it is possible to measure the wave properties of many photons (for example, the electric field of a radio wave).

The model of a single photon would be a wave possessing quantized angular momentum that propagates in vacuum energy. The dipole waves that form vacuum energy cannot possess angular momentum, so a disturbance carrying quantized angular momentum would be like a propagating phase transition that causes a small amount of dipole waves (the photon's energy and volume) to momentarily lose its superfluid properties. Such a wave would momentarily be giving a distributed angular momentum to vacuum energy. Apparently this disturbance is a transverse wave that possesses the polarization characteristics we normally associate with a photon. Such a wave in vacuum energy would propagate at the speed of light for all frames of reference. Furthermore, the impedance of free space (Z_o) associated with electromagnetic radiation was found in chapter 9 to be equal to the impedance of spacetime $Z_o/\eta^2 = 4\pi Z_s = 4\pi c^3/G$.

Electron-Positron Annihilation Thought Experiment: We are going to develop the photon model further using a thought experiment. In this thought experiment we will look at the two entangled photons produced by annihilation of an electron-positron pair. This might seem like an exotic way of producing a pair of photons, but it actually is the simplest case to examine because unlike atomic emission or Compton scattering, no particles remain after the annihilation to carry away momentum.

We are assuming that we start with an electron-positron pair with antiparallel spin. This form of positronium typically has a lifetime of about 10^{-10} seconds and usually decays into two entangled photons with antiparallel spins. We will assume this normal two photon decay. These two gamma ray photons have opposite spins and opposite momentum vectors. However, the spins and momentum vectors are only defined when the first photon is detected. Each photon has 511,000 eV of energy, so the frequency and wavelength of each photon matches the Compton frequency and Compton wavelength of the annihilated rotars.

The conventional picture of this annihilation is the emission of two photons which have both particle and wave properties. The particle properties imply a packet of energy that can be found somewhere within the uncertainty volume defined by the decay time and spin orientation of the electron-positron pair. This conventional picture has the two entangled photons with opposite momentum, but the momentum directions are not set until the first photon is absorbed. At that

moment the momentum and polarization of the second entangled photon has been determined. One counter intuitive part of this model is that the information about momentum and polarization must somehow be communicated to the surviving photon when the first of the two entangled photons is absorbed.

Even if the two entangled photons are separated by a distance of one light-year, they still somehow are in instantaneous communication. If one of the photons happens to interact with a polarizer of any orientation or ellipticity, the other photon instantly becomes the orthogonal polarization. Many logical questions arise from this picture. How do the two photons keep track of each other? What type of communication signal is sent out when one photon encounters a polarizer? How does this communication happen faster than the speed of light? I propose that the reason that this explanation is impossible to conceptually understand is because it is the wrong picture of a photon.

Electron-Positron Annihilation – The Quantized Wave Model: We will now restate this interaction using the photon and rotar models that incorporate distributed waves in the spacetime field. Suppose that we use the rotar model of an electron and a positron with opposite (antiparallel) spins that are initially far apart compared to distance λ_c . Both rotars have a Compton angular frequency of about $7.76 \times 10^{20} \text{ s}^{-1}$ or a frequency of $1.23 \times 10^{20} \text{ Hz}$. If these two rotars move towards each other, it means that they would both perceive the other to be Doppler shifted and the two frequencies would not be exactly the same. Since these two rotars are going to eventually emit two entangled photons of the same frequency, we will presume that the formation of positronium includes some type of synchronization of these two frequencies.

What will happen when we bring together an electron and a positron? It appears as if this interaction destabilizes both rotars. The rotar model of an isolated electron proposes that an electron is stable because there is a type of resonance between the electron's rotating dipole wave and the surrounding vacuum energy. Recall that the electron has a quantum amplitude of $A_\beta \approx 4.18 \times 10^{-23}$. This dimensionless number is also the electron's frequency, energy, mass, inverse rotar radius, etc. in Planck units. This frequency and amplitude achieves a resonance in vacuum energy that cancels the loss of power and produces constructive interference with the rotating dipole core.

The lifetime of positronium with antiparallel spins has been calculated¹³ from QED as: $\tau = 2\hbar/m_e c^2 \alpha^5 = 2/\omega_c \alpha^5 \approx 1.25 \times 10^{-10} \text{ s}$. This calculated lifetime agrees with experimentally measured lifetime. The annihilation of positronium with antiparallel spins usually produces two entangled gamma ray photons. These two photons have the same frequency, wavelength and energy as the electron and positron in the rest frame. Since the electron-positron pair had antiparallel spins, the two entangled photons also have a combined spin of zero.

¹³http://arxiv.org/PS_cache/hep-ph/pdf/0310/0310099v1.pdf

Photon Model of Annihilation: Now the model of this annihilation using waves in the spacetime field will be presented. The electron and positron both have a Compton angular frequency of $7.76 \times 10^{20} \text{ s}^{-1}$. When these two rotars annihilate each other the stabilization mechanism with vacuum energy is destroyed. The cancellation wave formed in vacuum energy no longer prevents the dissipation of the electron's and positron's energy. Waves in spacetime at the electron/positron Compton frequency propagate away from the site of the annihilation at the speed of light. These propagating waves are two entangled photons that result from the annihilation. The waves are propagating in the medium of the vacuum fluctuations that are an essential characteristic of the spacetime field. As previously determined, the impedance and bulk modulus encountered by these waves corresponds to the impedance of spacetime ($Z_s = c^3/G$) and the bulk modulus of spacetime $K_s = F_p/\lambda^2$. The speed of this wave propagation is equal to c which was previously calculated from the interactive energy density of the spacetime field and the impedance of spacetime.

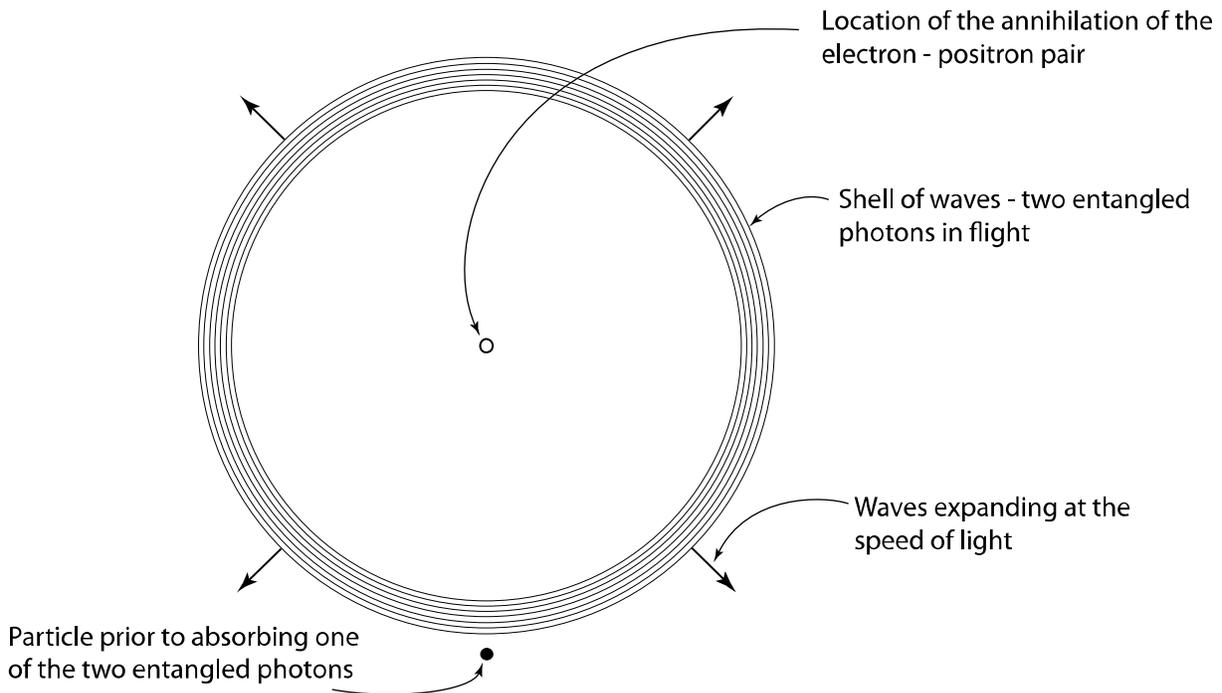


FIGURE 11-1 Concentric circles represent the waves in spacetime that form the two entangled photons produced by the annihilation of an electron-positron pair.

Figure 11-1 shows this annihilation event. At the center of this figure, a small volume of space is labeled as the location of the annihilation of the electron-positron pair. This figure shows the results of this annihilation sometime after the annihilation takes place. This is a cross-sectional view of the waves in the spacetime field that are the two entangled photons. There is now a spherical shell of waves in the spacetime field around the annihilation volume with the radius increasing at the speed of light.

The waves in this shell have an angular frequency of $7.76 \times 10^{20} \text{ s}^{-1}$ which is also the electron's Compton angular frequency. Since there is no frequency change between the electron/positron and the photons emitted, the annihilation event can be considered merely the destabilization of the vacuum energy cancelation waves that were keeping the electron's energy confined. The time required for annihilation was $1.25 \times 10^{-10} \text{ s}$ so this amounts to about 1.5×10^{10} cycles (wavelengths) forming a shell of waves with a thickness of about 3.8 cm. Figure 11-1 shows multiple concentric circles to convey the idea that the expanding shell contains many wavelengths. Also the entangled spherical shell of waves has zero net spin since this example assumed that the electron and positron had antiparallel spin.

Entanglement: Suppose that the spherical shell of two entangled photons (propagating in the vacuum fluctuations of the spacetime field) expands into what might be called "empty space" to a radius of one light-year. Really this space is filled with a sea of vacuum energy and the waves are a disturbance in this vacuum energy. At this point, suppose that a small portion of the wave shell encounters an absorbing object that we will generically call an absorbing particle. It could be an atom or other group of rotars. To make the absorption interesting, we will presume that the absorbing material has a strong absorption preference for clockwise circular polarization at the frequency of the two entangled photons. This absorbing material is illustrated in figure 11-1 as a point labeled "particle prior to absorbing one of the two entangled photons". The absorbing particle (or group of rotars) is capable of absorbing quantized angular momentum of \hbar . However, the spherical shell of waves is two entangled photons that were generated when the electron and positron (both spacetime dipoles) were annihilated. The absorbing material cannot interact with only a small percentage of the quantized wave. The quantized angular momentum transferred must be either \hbar or nothing.

Now it gets interesting. Any interaction must be with a complete photon (quantized energy and angular momentum). In this case, this means that the interaction is between the absorbing material and one of the two entangled photons that together made up the entire spherical wavefront, one light-year in radius. The interaction cannot be with both photons because the two photons have a total spin of zero. There appears to be a prohibition against energy transfer without an accompanying spin transfer.

If there is absorption, then the proposed property of unity causes one of the two entangled photons to collapse. All of the energy (511,000 eV), all the angular momentum (\hbar of clockwise circular polarization) and all the momentum ($\sim 2.7 \times 10^{-22} \text{ kg m/s}$) of the single photon is deposited into the absorbing material. Even if the absorption happens over a finite absorption time that is comparable to a finite emission time (for example, several nanoseconds), the entire quantized wave energy, distributed over one light-year radius, must collapse in this short time.

The details of how photons are proposed to collapse will be discussed later when we deal with the eventual absorption of the second of the two entangled photons. The collapse of the first of the two entangled photons removes from the spherical shell all of the wave characteristics necessary to make a circularly polarized photon with clockwise angular momentum. This includes not only spin and energy, but the collapse also imparts momentum of $\sim 2.7 \times 10^{-22}$ kg m/s. with an accurately defined momentum vector that will be discussed later.

What remains in the spherical shell of waves are proposed to be all the characteristics required to make a photon with the orthogonal polarization (counterclockwise spin) and the opposite momentum vector which is not quite precisely defined. This implies that the second photon can only impart the opposite momentum and opposite circular polarization when it is eventually absorbed. The photon that was absorbed must be the inverse of the photon that remains since the two entangled photons originally formed a uniform amplitude shell of waves. Therefore, to obtain a description of both photons we will examine the remaining photon.

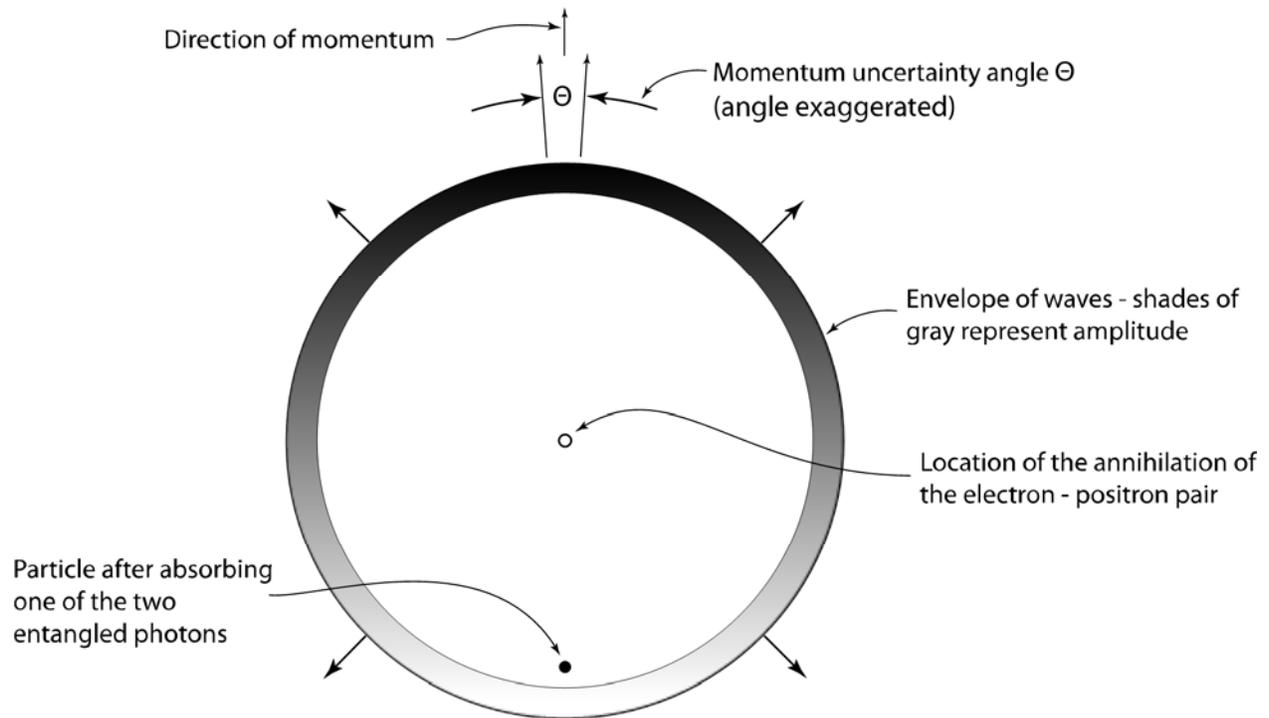


FIGURE 11-2 Amplitude distribution (shades of gray) of the surviving photon. This is a picture shortly after the other entangled photon was absorbed by the particle shown.

Single Photon Model: Figure 11-2 shows the proposed model of the surviving photon after the other entangled photon previously discussed was absorbed and collapsed into the absorbing particle. In other words, figure 11-2 shows a slightly later time than figure 11-1. In figure 11-2 the envelope of waves has expanded past the particle that absorbed the other entangled photon. This particle is shown near the bottom of the figure. Compare the placement of this particle to the placement shown in figure 11-1.

The major visible difference between figures 11-1 and 11-2 is that the circle representing the envelope of waves is now shown with different shading ranging from black (highest amplitude) at the top of the figure through shades of gray to white (lowest amplitude) at the bottom of the figure. The waves are still present but the waves are not shown in figure 11-2 because the emphasis in 11-2 is the amplitude of these waves.

The amplitude distribution for the waves in the remaining photon is proposed to be the same as the amplitude distribution of the wavelets in the Huygens-Fresnel-Kirchhoff principle. Recall that the Huygens-Fresnel principle accurately models diffraction of an optical wave by assuming that all points on an advancing wavefront become the source of a new wave called a wavelet. A new wavefront is formed by coherently adding together these secondary waves, including their phases. This principle was perfected by Gustav Kirchhoff when he added an amplitude distribution to the waves that formed each new wavelet that prevented backwards propagation towards the source and improved the accuracy. Previously the wavelets were merely considered to be limited to the forward hemisphere. This arbitrary limitation worked well for most applications, but Kirchhoff's addition perfected the principle for all cases. The amplitude distribution formulated by Kirchhoff is called the obliquity factor $K(\theta)$. It can be expressed either in Cartesian or spherical coordinates. The spherical coordinate representation is: $K(\theta) = \cos^2(\theta/2)$.

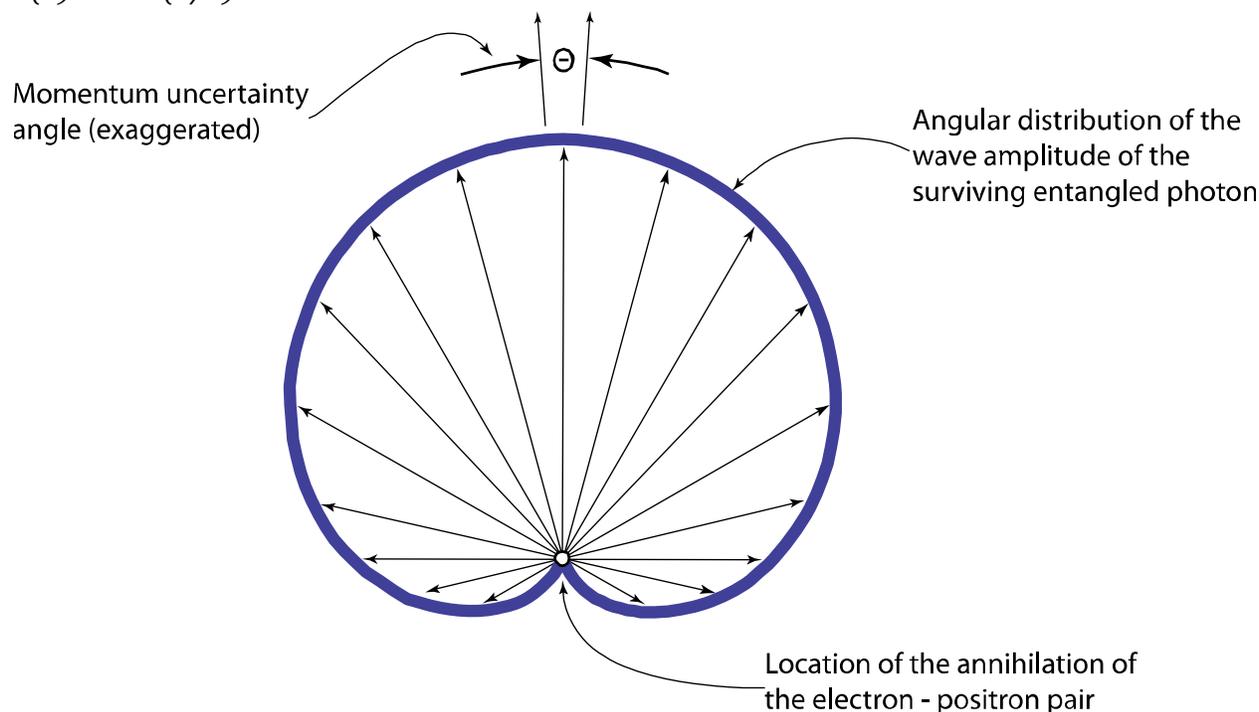


FIGURE 11-3 Amplitude distribution (graphical representation) of the surviving photon

A single photon is proposed to have the same amplitude distribution as the wavelets required for the Huygens-Fresnel-Kirchhoff principle. The shading of the envelope of waves in figure 11-2 has this distribution. However, figure 11-3 is a graphical representation of the amplitude distribution of the surviving photon. The absorbed photon would have had the inverse of this amplitude distribution which is the same as inverting figure 11-3. Adding these two distributions together produces the uniform distribution of the original entangled pair of photons ($\sin^2(\theta/2) + \cos^2(\theta/2) = 1$).

Photon's Momentum: We are now going to return to figure 11-2 to address the question of the momentum of a single photon. Recall that the thought experiment that generated this figure presumed that the two entangled photons expanded in a vacuum to the radius of one light year when finally one of the two photons was absorbed by the particle shown in figure 11-2. These assumptions mean that the momentum vector for the surviving photon must be very well defined. The original annihilation of the electron/positron pair had an uncertainty volume that can be calculated knowing the mass of the electron/positron pair ($\sim 1.82 \times 10^{-30}$ kg) and the lifetime ($\sim 1.25 \times 10^{-10}$ s) to give an emission uncertainty radius $\Delta x = \sqrt{\hbar t / 2m} \approx 6 \times 10^{-8}$ m. Also the particle that absorbed the first photon could have been part of a detector that could specify the location of the absorption to a radius much smaller than the 6×10^{-8} m uncertainty of the emission. Therefore the uncertainty in the emission dominates and we can ignore the uncertainty in defining the absorption location.

Since these two uncertainty volumes are separated by one light year ($\sim 10^{16}$ m), this means that the momentum vector uncertainty angle of the single photon in this example is about 6×10^{-24} radians (6×10^{-8} m / 10^{16} m). The surviving photon must have the opposite momentum, so at the moment the first photon is absorbed, we know a great deal about the allowed volume where the second photon can possibly be absorbed in the future. The reason for this exercise is that the model of a single photon must be capable of this momentum accuracy.

In figure 11-2 the envelope of waves should be pictured as being one light year in radius. This figure also shows an angular spread designated "momentum uncertainty angle" which for this example is about 6×10^{-24} radians. How is it possible for this wave structure to possess this narrow a momentum uncertainty? Just looking at the figure, it seems as if the surviving single photon could be absorbed by an absorbing particle located in almost any direction around the expanding shell of waves (except perhaps the zero amplitude direction). The requirement of a well defined momentum helps us define the model and helps to define the way that photons collapse.

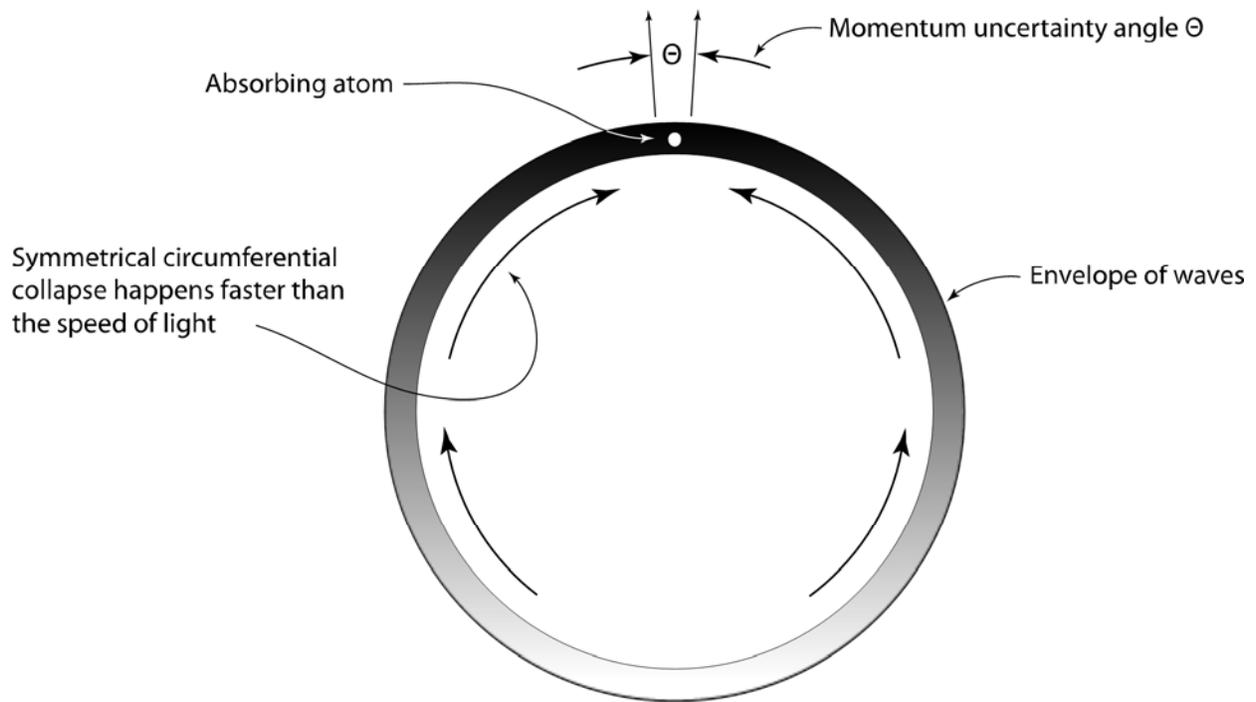


FIGURE 11-4 The collapse of a photon on an atom

Collapse of a Single Photon: Figure 11-4 shows the eventual absorption of the surviving photon. The absorbing body is designated and it must lie within the volume limited in width by the momentum uncertainty angle. Also the absorbing body must be located within the thickness of the envelope of waves during the absorption. The collapse of the single photon's energy and angular momentum is depicted by the arrows shown in figure 11-4. These arrows indicate that the collapse proceeds along the circumferential route defined by the envelope of waves.

This has a great deal of appeal. The momentum transferred to the absorbing body can only have a radial vector relative to the emission uncertainty volume. It would be a violation of the conservation of momentum for there to be a tangential vector component that is larger than the uncertainty limit. This means that the only volume of the photon's wave structure capable of interacting with matter is restricted to the small volume bounded by the momentum uncertainty angle. This is the only volume where the collapse is sufficiently symmetrical to prevent the transfer of substantial transverse momentum. There must be offsetting transverse momentum components on either side of the absorbing body so that the collapse is balanced and results in the correct net momentum.

Next, we are going to examine whether the photon structure proposed here is capable of collapsing to a volume as small as would be required to satisfy the momentum uncertainty angle which is about 6×10^{-24} radians. If the second photon was absorbed shortly after the time of the first photon absorption, then the shell of waves would be about the same size which was

postulated to be 1 light year in radius ($\sim 10^{16}$ m in radius). The waves are distributed over a diameter of about 2 light years ($\sim 2 \times 10^{16}$ m) and the wavelength produced by the annihilation of an electron/positron pair is $\lambda \approx 2.4 \times 10^{-12}$ m. If we merely calculate the diffraction limit of this combination of aperture size and wavelength we obtain a λ/D uncertainty angle (divergence angle) of 2.4×10^{-28} radians. Therefore this wave structure can easily satisfy the requirement of collapsing to a volume equivalent to 6×10^{-24} radians uncertainty. In fact, this photon model should always collapse to an area about one wavelength in circumference. At this point, quantized angular momentum takes over and the collapse into a single atom is possible.

Popper's Thought Experiment: Before proceeding with the description, we will pause and mention that the thought experiment described in figures 11-1 and 11-2 have some similarity to Popper's experiment proposed by Karl Popper and published in 1982. The Copenhagen interpretation of quantum mechanics implies that making an experimental measurement increases uncertainty. Popper wrote: "I wish to suggest a crucial experiment to *test* whether knowledge alone is sufficient to create 'uncertainty' and, with it, scatter (as is contended under the Copenhagen interpretation), or whether it is the physical situation that is responsible for the scatter". He suggested an experiment incorporating entangled particles, slits and detectors described elsewhere^{14 15}. The contention was that detecting one of the entangled particles should introduce scatter instantly communicated to the other particle if the Copenhagen interpretation was correct. An actual experiment was performed by Kim and Shia in 1999 using entangled photons¹⁶. The conclusion was that the second of the two photons actually had a much smaller scatter (smaller uncertainty) than would be expected from the Copenhagen interpretation¹⁷. This experimental result supports the model of two entangled photons proposed here. As proposed in figure 11-2, the "momentum uncertainty angle" defines the uncertainty of the allowed interaction volume for the second photon. Gaining knowledge of the location of the first photon to be absorbed decreases the uncertainty about the location where the second photon will be absorbed.

Limits on Absorption: The portion of the single photon that lies outside the momentum uncertainty volume cannot interact with matter. The model of photons says that these waves can pass through matter (rotars) without being absorbed or affected. In the figures 11-1 to 11-4 we carefully avoided the question of the waves encountering other matter by postulating propagation in an empty vacuum. However, the waves external to the momentum uncertainty angle should merely pass through matter without any interaction. Recall that matter is made of rotars that are just empty spacetime that is very slightly strained. (roughly 1 part in 10^{20} for an up quark). If a disturbance in vacuum energy is incapable of transferring angular momentum

¹⁴ http://en.wikipedia.org/wiki/Popper%27s_experiment

¹⁵ Popper, K.R. *Quantum theory and the schism in physics*, Routledge, 1992, p.27

¹⁶ Y.-H. Kim and Y. Shih (1999). "Experimental realization of Popper's experiment: violation of the uncertainty principle?". *Found. Phys.* **29** (12): 1849–1861.

¹⁷ P. Sancho (2002). "Popper's Experiment Revisited". *Found. Phys.* **32** (5): 789–805

because it is outside of the momentum uncertainty volume, then this portion of a photon should be more inert than a neutrino and should easily pass through matter (rotars).

Unity Connection: The circumferential collapse shown in figure 11-4 is the proposed property of unity at work. This proposed property permits faster than the speed of light communication and collapse within a single quantized wave in spacetime. In chapter 14 a speculative mechanism will be proposed for faster than the speed of light communication within a single quantized wave. However, superluminal communication is an experimentally established property of entanglement and it is quite reasonable that a single photon would also possess this same capability even if the complete explanation is not currently available. The superluminal collapse of a photon shown in figure 11-4 is symmetrically balanced and does not involve the transfer of any information or external momentum. The momentum that is transferred is entirely within the single photon. While the collapse is faster than the speed of light, it is not instantaneous. It probably requires a time of at least $2\pi/\omega$ which is a minimum of one cycle of the photon.

It is also clear that there is no mystery how the photon model can carry angular momentum. The shell of waves must be pictured as a 3 dimension spherical shell. The waves that make up a circularly polarized photon would have a phase progression that circulates the spherical shell at a frequency equal to the photon's frequency. Figure 10-9 in chapter 10 showed waves in the equatorial plane of the external volume of a rotar. It is obvious that waves forming an Archimedes spiral carry angular momentum. It is proposed that a circularly polarized photon has a similar Archimedes spiral wave distribution in the equatorial plane. The spatial distribution of this shell of waves makes it easy to see how it is possible for this photon model to carry angular momentum and transfer the angular momentum when the wave structure collapses onto an absorbing body. It is not clear how the conventional model of a photon carries or transfers angular momentum.

Photon Emission from a Single Atom: In the thought experiment involving the annihilation of an electron/positron pair there was no remaining matter to remove momentum and complicate the analysis. We will next address the emission of a photon by a single atom. If a proton and an electron combined to form a hydrogen atom, the energy of the photon emitted would be about 13.6 eV. The emission of this energy would cause the hydrogen atom to recoil with a velocity of about 4 m/s. Hypothetically, it is possible to determine the direction of the photon's momentum by monitoring the motion of the electron and proton prior to forming the hydrogen atom and by monitoring the recoil of the hydrogen atom after the emission of the photon. There is uncertainty in making these measurements, but the accuracy in determining the direction of the photon's momentum increases with the amount of time between emission and detection of the recoiling atom. The photon has the opposite momentum of the recoiling hydrogen atom. The further the recoiling hydrogen atom travels before its position is detected, the more accurate that the momentum vector of the recoiling hydrogen atom can be determined.

The photon is carrying the opposite momentum vector as the recoiling hydrogen atom to within the limits of the uncertainty principle. I claim that not only does our ability to measure the momentum vector of the recoiling hydrogen atom improve with time, but there is continued interaction between the external volume of the recoiling hydrogen atom and the photon even after the photon has been emitted from the atomic volume of the hydrogen atom. The hydrogen atom is surrounded by waves that are part of the external volumes of the rotars that form the atom. As the photon spherical shell expands, it interacts with these external waves and this interaction fine tunes the momentum uncertainty vector of the expanding photon. This interaction reduces the momentum uncertainty angle of the expanding photon over time to coincide with the improved ability to measure the recoil momentum vector of the hydrogen atom.

Compton Scattering Revisited: A hydrogen atom made of 4 rotars (1 electron and 3 quarks) is too complicated to analyze the interaction between the expanding photon and the external volume of the rotars that form the hydrogen atom. Therefore we will switch back to Compton scattering between a single electron and a single photon. This interaction was previously examined using the series of figures from 10-12 to 10-15. Figure 10-15 is the superposition of 4 waves. The waves at the top of this figure represent the photon's waves before and after the scattering. The waves at the bottom of the figure represent the electron's waves before and after the scattering. The middle portion of the figure shows both pairs of waves interacting.

Because of the standing waves in the electron's external volume this interaction continues to occur long after we think that the scattering event has happened. Picture the electron (rotar) as having diminishing standing waves in its external volume that extend a long way from the location of the scattering. The "news" that the rotar has undergone acceleration propagates into these surrounding standing waves at the speed of light. There is a spherical shell that is expanding at the speed of light where the overlap of the before interaction and after interaction waves overlap. Within this expanding shell of overlapping waves, the fringe pattern shown at the top of figure 10-15 still exists, but at greatly reduced amplitude. This is superimposed on the photon's waves which are also spreading away from the scattering site at the speed of light. The interaction between these overlapping waves continues to make successively finer adjustments to the photon's momentum. This explains how the uncertainty of the photon's momentum can improve over time, just like we reasoned by looking at the recoil of a hydrogen atom.

In all of this, the electron does not undergo a gradual acceleration as might be expected for a classical particle that is changing its momentum. Instead, the wave model of the scattered rotar changes from the wave pattern of the rotar before the scattering to the wave pattern of the rotar after the scattering without undergoing the intermediate velocities. Similarly, a hydrogen atom would not gradually accelerate to 4 m/s as it emits a 13.6 eV photon. The "before" wave pattern fades as the "after" wave pattern comes into existence.

From the uncertainty principle we know that a decrease in the momentum uncertainty (Δp) must be accompanied by an increase in the position uncertainty Δx . When we think of a point particle photon, then the physical interpretation of Δx is different than when we think of a single photon as a shell of waves with a large radius. To accommodate this improvement in our knowledge of the photon's momentum (decreased Δp), it is necessary for the radius of the photon to increase with time (increased Δx). This requirement fits perfectly with the proposed photon model because the radius of the photon's shell of waves increases with time.

Recoil from Coherent Emission: In the above examples, it was repeatedly emphasized that they described the properties of a single photon. The characteristics of photons change dramatically when they congregate into coherent beams. We are going to ease into a discussion of a beam of light made of many photons with the following preliminary thought experiment.

Suppose that we have a rotating electrically charged dipole. This imagined electrically charged dipole is made of a positive charge and a negative charge physically separated by a short rod. For example, imagine an electron and a positron separated by a rod 1 mm long and rotating about a perpendicular axis at the center of the rod at a frequency of 10^{10} Hz. Even though it would be virtually impossible to have this electrical dipole mechanically rotate at this frequency, in the thought experiment there is no such limitation. We would expect to see the emission of microwave electromagnetic radiation (10^{10} Hz) in a classical rotating dipole emission pattern from this rotating dipole. This pattern has emission in all directions, but the intensity of emission is twice as strong along the rotation axis as the intensity in the equatorial plane. However, near the equatorial plane there are more steradians for emission so all emission directions are important. The classical rotation dipole radiation pattern is symmetrical around the axis of a mechanically rotating dipole. This pattern is really the result of the emission of many incoherent photons. This symmetrical emission pattern does not produce recoil in any particular direction.

Now suppose that we have a trillion such rotating dipoles distributed over a spherical volume with radius about 1000 times larger than the microwave emission wavelength. The dipoles are therefore distributed in a way that individual dipoles are separated from their nearest neighbor by much less than one wavelength but the group is much larger than a wavelength. If the rotating dipoles are all rotating incoherently, they emit incoherent radiation in all directions. Since the emission is symmetrically balanced, there is no net recoil direction felt by individual rotating dipoles.

However, if all dipoles are rotating coherently (same frequency, parallel rotation axis and controllable phase) the radiation from the group of rotating dipoles can be controlled. For example, the microwave radiation can be made into a diffraction limited beam that can be steered in any direction. This directional control depends entirely on the ability to adjust the phase of individual dipoles in the group so that the multiple emissions add constructively in the desired emission direction.

Now let's think about the recoil felt by each mechanically rotating dipole from the emission of radiation. If only one dipole is mechanically rotating, the emission of multiple photons (photons) is symmetrical and no specific recoil direction is felt by the single rotating dipole. However, when the multiple rotating dipoles are properly phased to constructively interfere in a particular direction, then each rotating dipole must feel a force in the opposite direction as the emitted beam. We would say that this force is the momentum recoil required for conservation of momentum. However, each rotating dipole is just interacting with the local EM field generated by the coherent addition of spherical waves generated by other rotating dipoles. The collimation and directionality of the emitted beam is achieved by the group interaction. The point is that the emission direction and the recoil direction are the result of the coherent addition of properly phased rotating dipoles.

Huygens-Fresnel-Kirchhoff Principle: At this point the analysis converts to a classic example of the Huygens-Fresnel-Kirchhoff principle. With this principle, each point on a wavefront becomes the source of a new wavelet that emits into the amplitude distribution formulated by Kirchhoff: $\cos^2(\theta/2)$. This is exactly the same emission pattern as a photon with its momentum vector aligned with the beam vector. Therefore each cycle of the coherent photon emission is identical to the wavelet that would be formed at the location of the emitting rotating dipole. The Huygens-Fresnel-Kirchhoff principle describes amplitude addition and how intensity is proportional to the square of amplitude. Therefore, the individual photon joins the beam as if it was merely a series of new wavelets. The only difference is that in the Huygens-Fresnel-Kirchhoff principle the total energy of the beam remains constant while the emission of a coherent photon increases the total amplitude and energy of the beam.

It is a short step from mechanically rotating dipoles to many atoms in an excited state in a laser gain medium. The propagation of a laser beam is well described by the Huygens-Fresnel-Kirchhoff principle. Each point on the laser beam becomes a new wavelet and the beam evolves by coherent addition of successive generations of wavelets. When a laser beam passes through a laser gain medium, it interacts with atoms in an excited state. The interaction not only stimulates the emission of photons with the proper frequency and phase, but the interaction also imparts the correct recoil to the atoms so that the photons are emitted with the correct momentum vector. The addition of new photons to the laser beam then corresponds to the wavelet addition of the Huygens-Fresnel-Kirchhoff principle.

Beam of Light: How can the model of a single photon (spherical shell of waves with a Kirchhoff amplitude distribution) be reconciled with the concept of a well behaved beam of light that can be easily reflected off mirrors and brought to a focus? A beam of laser light does not seem to have any of the properties of a spherical shell of waves just described. However, the photon model for a single photon is different than the photon model for many interacting photons. Many interacting photons are better described by the Huygens-Fresnel-Kirchhoff principle which

incorporates wavelet addition from the other photons. Each photon does have a momentum uncertainty angle set by the recoil felt by the emitting atom. The group behavior is limited to photons which have a momentum uncertainty angle which permits propagation in the direction of the rest of the beam. Therefore, there is a limit to the amount of steering that can occur by the rest of the photons. If a photon was emitted with an uncertainty angle at too steep of an angle relative to the direction of the rest of the beam, then that photon will merely exit the beam.

For example, a 1 mw HeNe laser beam contains about 3×10^{15} photons per second. Multiple photons, such as a laser beam, together achieve the familiar beam of light. Even though each individual photon would propagate into a spherical shell of waves previously described, the interaction with the other photons in the beam causes a group behavior described by the Huygens-Fresnel-Kirchhoff principle. For example, the intensity scales as amplitude squared and the only amplitude that counts is the amplitude within the momentum uncertainty angle for each photon. These conditions achieve the familiar properties of a beam of light. Still, the generation of wavelets implies that the photons are exploring every possible path between two points as required by the path integral. Furthermore, there is a presence outside the volume that appears to be the diameter of the beam. Even though the portions of waves that exist outside the beam volume lack the ability to strongly interact with matter, is there any proof that these “external” waves must exist?

The answer to this question is yes. Light is a form of energy and therefore a beam of light must cause a gravitational field (curved spacetime) in the surrounding volume. It is not sufficient to cite “curved spacetime” and claim to have proved that light causes gravity. When we adopt the assumption that the universe is only spacetime, the implication is that everything is knowable including the mechanics of light causing curved spacetime. The gravity and electric field of fundamental particles was explained as being caused by standing waves in the external volume of the particle. Wave frequency, amplitude and nonlinear effects were derived. Similarly, a beam of light causes gravity in the surrounding volume. How is this accomplished? If we think of a beam of light as a stream of particle-like photons (a bundle of quantized energy that lacks rest mass), then there is no mechanism to create gravity in the surrounding volume. Also there is no mechanism for the light to explore all possible paths between two points as required by the “path integral”. However, if we think of light as a wave disturbance in spacetime with each wave becoming the source of new wavelets, then there is a mechanism to explain both the gravitational field and the physics behind the path integral. As previously explained, these waves extend beyond the momentum uncertainty volume which defines the limit where photons can interact with matter.

Normally I would do a plausibility calculation here to show that the proposed photon model resulted in the correct gravitational field. For example, if we imagined many photons (n_γ photons) in maximum confinement, then this “confined energy” propagating at the speed of light would exhibit rest mass as described in chapter 1. An analysis of photons in maximum

confinement could also be made to look something like a rotar. It was already demonstrated how a rotar with internal energy E produces the correct gravitational field for this energy. However, neither of these are exactly applicable because the maximum confinement volume of many photons has a different radius than a single rotar of equal energy. An analysis of this subtlety is incomplete and off the main point. It will merely be stated that the proposed photon model does extend into the surrounding volume. Furthermore, it appears to have the correct properties to create both the required gravitational field and the ability to explore all possible paths. The mathematical proof of this will have to be left to others.

Why Is there No Amplitude Dependence In a Photon's Energy? One of the mysteries of quantum mechanics is contained in the photon's energy equation $E = \hbar\omega$. Why does this equation only contain the frequency term ω with no amplitude term? If two different waves have the same frequency but different amplitudes, they should have different energy. Can the spacetime based model of photons answer this century old mystery of physics?

The maximum displacement of the spacetime field allowed for a dipole wave in spacetime is subject to the previously discussed Planck length/time limitation. While a photon is not technically a dipole wave in the spacetime field, it is produced and absorbed by dipole waves in spacetime. A single photon inherits a connection to Planck length and Planck time. As previously shown, multiple photons can produce a distortion of the spacetime field that appears to exceed the Planck length/time limitation. However, the round trip change in distance does not actually exceed this limitation. The strain amplitude of a single photon in maximum confinement is $A_s = L_p/\lambda$. We will calculate the energy of a photon in maximum confinement using $E = A^2\omega^2ZV/c$.

$$E = A^2\omega^2ZV/c \quad \text{set: } A = A_s = L_p/\lambda, \quad \omega = c/\lambda, \quad Z = Z_s = c^3/G \text{ and } V = \lambda^3$$

$$E = \left(\frac{\hbar G}{c^3\lambda^2}\right) \omega^2 \left(\frac{c^3}{G}\right) \left(\frac{\lambda^3}{c}\right) = \hbar\omega$$

Therefore, the amplitude term disappears and we are left with $E = \hbar\omega$. It is easy to see how this happens. As previously explained, there are two types of amplitude: displacement amplitude and strain amplitude. The displacement amplitude for photons in maximum confinement is always equal to dynamic Planck length L_p . The strain amplitude ($A_s = L_p/\lambda$) is used in the energy equation, but the strain amplitude incorporates the displacement amplitude. The fact that all photons produce the same displacement of the spacetime field makes it possible for cancelations to eliminate amplitude from the energy equation. However, in another sense, the presence of \hbar is a remnant of amplitude term because: $A_s^2 = L_p^2/\lambda^2 = \hbar G/c^3\lambda^2$. Everything cancels from the amplitude squared term except for \hbar . In one sense \hbar is the amplitude term because it is the amplitude of the quantized angular momentum.

Requirements of a Photon Model: A carbon monoxide molecule (CO) is a good source of photons if we are attempting to understand photons. CO has a carbon atom and oxygen atom separated by about 1.1×10^{-10} m. It is a polar molecule since it has a nonzero permanent electric dipole moment. Experiments have shown that the carbon atom is negatively charged and the oxygen atom is positively charged. This charge distribution is the opposite of what might be expected from chemical valences. The CO molecule can rotate around its center of mass axis perpendicular to its bond length. The CO molecule can only possess integer multiples of \hbar angular momentum. ($J = 0, 1, 2, 3$ etc.) The fundamental rotational frequency is about 115 GHz and higher rotational frequencies are approximately integer multiples of this frequency. The higher frequencies are not exact multiples of 115 GHz because the physical rotation of the molecule slightly stretches the bond length because of centrifugal force. The CO molecule also has vibrational energy levels. This is all mentioned because the rotating polarized molecule will be useful in visualizing the model of a photon. The emission or absorption of a photon is always accompanied by an \hbar change in angular momentum of the rotating molecule. All photons, even linearly polarized photons, must possess \hbar of angular momentum. Furthermore, this angular momentum that is transferred between the CO molecule and a photon is not a random rotational direction. For example, the emission of a photon, even a linearly polarized photon, must always remove \hbar of angular momentum and slow down the rotation of the CO molecule by \hbar (one “J” unit).

Conventional models of photons do not explain how linearly polarized photons can possess angular momentum. For example, if we take a rotating polarized molecule as the source of photons, then the emission pattern for rotating dipoles has linearly polarized photons emitted in the equatorial plane and circularly polarized photons emitted from both poles. Elliptically polarized waves are emitted in all other directions. All the emitted photons, regardless of polarization, are each removing \hbar of angular momentum. This is a requirement to preserve the conservation of energy and momentum. Also, photons transfer \hbar of angular momentum when they are absorbed. For circularly polarized photons, the rotational axis is parallel to the propagation direction and it is easy to do experiments that demonstrate that circularly polarized photons carry angular momentum.

For linearly polarized photons the angular momentum should have a rotational axis that is perpendicular to both the propagation direction and the plane of the electric field. In other words, the rotational direction should have its axis in the photon’s magnetic plane. It should be possible to do an experiment that demonstrates this. I have some ideas on this point, but a description of possible experiments would be long and beyond the scope of this book. The point of this is that any model of a photon must be able to explain how individual linearly polarized photons must be able to transfer angular momentum with the axis parallel to the magnetic field.

Angular Momentum of a Circularly Polarized Photon: It is possible to experimentally demonstrate that circularly polarized light possesses angular momentum. For example, the mineral mica is optically birefringent. A thin sheet of mica of a particular thickness can have the ability to reverse the direction of rotation of circularly polarized light. Another way of saying this is that mica can form a half wave plate. If a very small piece of mica is suspended with low friction, (for example in a liquid) then shining a circularly polarized laser beam at the mica chip will cause the mica to rotate in the liquid. The photon's angular momentum is being reversed by the mica. This transfers angular momentum from the photons to the mica and causes the mica to rotate. No photons are being absorbed, but the frequency of the transmitted photons is being lowered slightly by the interaction with the rotating mica. This reduction in frequency is equal to twice the rotational rate of the mica. This loss of photon energy provides the energy required to rotate the mica.

The absorption of a circularly polarized photon by an absorbing object imparts both a translational momentum component $p = E/c = m\mathbf{v}$ and an angular momentum component. The angular momentum component can be expressed as $\mathbf{L} = \mathbf{r} \times m\mathbf{v}$ which is the cross product of the translational momentum component $m\mathbf{v}$ and the radius r relative to the axis of rotation. Imagine that we have a polarized diatomic molecule with two atoms, each with mass of $m/2$. The bond between the atoms approximates a rigid rod that maintains a constant separation distance of $2r$ between the atoms. All molecules can only possess integer multiples of \hbar angular momentum. This translates into the molecule only being able to rotate around its center of mass (distance r from each atom) at a fundamental angular frequency ω_f and integer multiples of this frequency. We are going to make a calculation of the translational momentum (p_t) imparted to the molecule as it recoils from absorbing a photon of frequency ω_f (with wavelength $\lambda_f = c/\omega_f$) and compare this to the rotational momentum (p_r) imparted to the molecule by the photon causing the two atoms to revolve around the center of mass.

$$p_t = \frac{E}{c} = \frac{\hbar\omega_f}{c} = \frac{\hbar c}{\lambda_f c} = \frac{\hbar}{\lambda_f} \quad p_t = \text{translational momentum}$$

$$p_r = \frac{\hbar}{r} \quad p_r = \text{rotational momentum}$$

$$\frac{p_r}{p_t} = \frac{\lambda_f}{r}$$

This is a very interesting result. For all molecules, $\lambda_f \gg r$. Therefore, the momentum transferred to cause rotation p_r is much larger than the momentum transferred that causes translation p_t . We will use a carbon monoxide molecule (CO) to examine this point. This molecule is electrically polarized (C and O atoms oppositely charged) so when it rotates it is a rotating dipole. The molecule can possess rotational angular momentum in integer multiples of \hbar . For example, one \hbar unit is designated $J = 1$ and two units of \hbar is $J = 2$, etc. At the fundamental rotational frequency ($J = 1$) the molecular rotation frequency is 115 GHz and the photon associated with the transition of $J = 0$ to $J = 1$ is a photon with frequency of 115 GHz. The CO molecule is a rotating dipole and

the emission frequency corresponds the frequency difference between rotational states. The photon emitted going from $J = 2$ to $J = 1$ is 230 GHz, twice the frequency emitted going from $J = 1$ to $J = 0$.

To illustrate a point, we will be using the fundamental transition at 115 GHz which corresponds to the fundamental angular frequency of $\omega_f \approx 7.2 \times 10^{11} \text{ s}^{-1}$ and a reduced wavelength of $\lambda_f \approx 4 \times 10^{-4} \text{ m}$. If the molecule is carbon 12 and oxygen 16, this is not quite equal weight atoms as assumed in the calculation, but it is close enough that an approximate calculation will still illustrate the point. Even though the electron clouds partially overlap, this molecule has the carbon atom nucleus and oxygen atom nucleus separated by about $r = 1.1 \times 10^{-10} \text{ m}$. Therefore the radius to the center of rotation (compensating for slightly different masses) is $r \approx 5 \times 10^{-11} \text{ m}$. Therefore the ratio of $\lambda_f/r \approx 8 \times 10^6$. This says that the momentum required to cause the increase in rotation velocity is about 8,000,000 times greater than the momentum transferred which causes the increase in translation velocity (recoil velocity). Transferring \hbar of angular momentum requires a much larger force (momentum times interaction time) than transferring the translational momentum.

We will check this surprising result to see if it is reasonable. We know that the molecule is spinning at 115 GHz when it has absorbed \hbar of angular momentum ($J = 1$ state). If the radial distance is $r \approx 5 \times 10^{-11} \text{ m}$, then 115 GHz rotation frequency produces a circumferential velocity of about 36 m/s. The CO molecule has mass of $m = 4.65 \times 10^{-26} \text{ kg}$. Absorbing a 115 GHz photon ($E = 7.6 \times 10^{-23} \text{ J}$) produces a recoil velocity ($v = E/mc$) of about $5 \times 10^{-6} \text{ m/s}$. Therefore, the ratio of the recoil velocity to the rotational velocity (36 m/s vs. $5 \times 10^{-6} \text{ m/s}$) is indeed about 8,000,000.

This exercise raises an important question. If the full momentum carried by the photon is only able to achieve a velocity of $5 \times 10^{-6} \text{ m/s}$, this is totally inadequate to achieve the transfer of \hbar of angular momentum and accelerate the two atoms (C and O) to a rotational frequency of 115 GHz requiring a rotational speed of about 36 m/s. This insight is revealing something important about how a photon interacts with a molecule or atom. To achieve the rotational velocity of about 36 m/s it is necessary to understand what force the photon uses to apply about 8,000,000 times more momentum than the photon is carrying.

As previously discussed, these transitions are not instantaneous. They last for a time period that is equal to the inverse bandwidth of the emission or absorption. Therefore, somehow a force is being generated that is about 8,000,000 times greater than the force obtained by dividing the momentum by the application time. There is one possibility that will be examined. The CO molecule is polarized meaning that there is charge separation. When a rotating dipole such as a CO molecule generates a photon, the accelerated charge generates a rotating electric field which changes from the near field pattern to the far field pattern which eventually results in propagating transverse electromagnetic waves. The point is that rotating electric fields are responsible for the generation of the photon. The emission of a circularly polarized photon must generate an

electric field which retards the rotation because the CO molecule must lose energy and drop one \hbar quantum of angular momentum (for example $J = 1$ to $J = 0$). It is quite reasonable that the mechanical process of absorbing the same frequency photon is the reverse of the emission process. In other words, the absorption of a circularly polarized photon generates a rotating electric field. It is the electromagnetic coupling of the rotating electric field and the oppositely charged atoms which permits a force about 8,000,000 times larger than the momentum force ($F = p/t$). This coupling transfers \hbar of angular momentum to a CO molecule and changes the rotational energy level from, for example, $J = 0$ to $J = 1$.

The suggestion being made is that the absorption of a photon is interacting with the CO molecule in two different ways. The relatively large force that is increasing the rotational velocity of the CO molecule is the result of the collapsing photon's electric field causing the rotation of the charged atoms to increase. To accomplish this the collapsing photon must generate a rotating electric field with the proper characteristics of phase, orientation, etc. A calculation has been made (not shown here) which shows that an electric field comparable to the electric field present in a CO molecule could easily achieve the transfer of \hbar of angular momentum even if the absorption time is assumed to be the shortest possible time – about 9×10^{-12} second, which is 1 cycle of a 115 GHz photon. Normally the transfer would take place over a much longer time (many cycles).

However, this exercise does show one additional defect in the conventional model of a photon transferring energy from one molecule to another. If spacetime is an empty void and if a photon is a compact packet of energy with probability waves, then how does such a photon generate 8,000,000 times more momentum in the rotational direction than the linear momentum being carried by the photon? This is not a violation of the conservation of angular momentum if you merely look at the photon carrying \hbar of angular momentum and the molecule gains \hbar of angular momentum upon absorbing the photon. However, the problem appears when you try to explain the origin of the force applied over the time required to transfer the angular momentum to the molecule. A favorite trick is for a physics teacher to explain to a student that the photon possesses “intrinsic angular momentum” – end of discussion. The implication is that the student and all other humans are not intelligent enough to understand the physical processes which produce quantum mechanical effects.

When an isolated atom or molecule emits a photon, the wavelength of the photon is typically 1,000 to 100,000 times larger than the radius of the atom or molecule. For example, a rubidium atom has a radius of about 2.3×10^{-10} m and the D2 resonance wavelength is 780 nm. Therefore, the emitted wavelength is about 3400 times larger than the atomic radius. We are not particularly surprised that this small an atom can emit a much larger wavelength photon. The previously cited article titled “How a Photon is Created or Absorbed” shows that the wave properties of the two orbitals beat at the emission frequency of the photon for a time period equal to the emission time. For the Rb emission example, the emission takes about 26 ns. The absorption process is the reverse of the emission process. There is not an instantaneous collapse. The orbitals beat for about 26 ns and the photon's waves collapse into the atom.

Similarly, an isolated CO molecule has a beat between the wave properties of the two different rotational rates with angular frequency $\omega = 115 \times 10^9 \text{ s}^{-1}$. The relatively long wavelength of $\lambda \approx 0.4 \text{ mm}$ reverses the emission process collapses into a much smaller CO molecule with radius of about 1.4 Angstroms. The point is that the energy density of spacetime permits the process to generate the necessary torque to transfer the necessary angular momentum. Recall in chapter 4 we calculated the bulk modulus and interactive energy density of spacetime. The properties of the spacetime field have no problem generating torque beyond the force implied by the photon's momentum.

Chapter 12

Bonds, Quarks, Gluons and Neutrinos

Introduction: This chapter lumps together several difficult subjects not previously covered. These include bonds, the ψ function, quarks, gluons, the weak force and neutrinos. Most of these are not clearly understood in mainstream physics. This vagueness prevents plausibility calculations to test the spacetime model involving these subjects. For example, quarks do not exist in isolation, so their properties are always partly hidden. Even their mass/energy is a mystery. Perhaps the most shocking conclusion is that the spacetime based model in its current state of development does not need gluons. As previously explained, there is only one truly fundamental force (the relativistic force) and this force is always repulsive. This single force appears to be capable of generating a force with the strength and bonding characteristics of the strong force. With this bonding accomplished by an interaction with the spacetime field, are gluons required? Color charge is another property currently assigned to gluons, but the properties requiring color charge can probably be explained as an interaction between quarks (rotars) and the spacetime field. The elimination of gluons is a preliminary conclusion that needs to be refined and perhaps modified upon further analysis. This is the last chapter that deals with particles and forces before switching to cosmology. The subjects with the greatest unknowns are lumped into this chapter.

Virtual Photons Examined: The standard model considers the electromagnetic force to be transferred between point particles by the exchange of virtual photons. This raises interesting questions. Where does the loss of energy occur when an electron is bound to a proton? It is not sufficient to say that there is a reduction in the electric field. The virtual photons ARE the electric field. Do the virtual photons that supposedly bond oppositely charged particles possess negative energy? (no such thing – only the absence of positive energy) Does a proton bound in a hydrogen atom have more or less virtual photons surrounding it compared to the same proton in isolation? What is the wavelength of a virtual photon? These questions are introduced to raise some doubts about virtual photons and the generally accepted explanations.

The spacetime model of the universe proposes that there are no virtual photon messenger particles. These are replaced by fluctuations of the spacetime field which exert pressure. All rotars possess an “external volume” of standing waves and non-oscillating strain in spacetime previously discussed. The external volumes of interacting rotars overlap. Two oppositely charged rotars interact in a way that decreases the Compton rotational frequency of each rotar (ω_c is reduced). The location of the lost energy is easy to identify. Also the overlapping external volumes affect the pressure exerted on opposite sides of a rotar by vacuum energy. This pressure

difference distributed over the rotar's area causes a net force. If a rotar is free to move, there is a net migration of the rotational path of each rotar towards the oppositely charged rotar with each rotation. We consider this force and migration to be electromagnetic attraction.

Electrons Bound in Atoms: In the Bohr model of a hydrogen atom, the electron's 1s orbital (the lowest energy level) is described as having a radius of $a_o = \hbar c / E_e \alpha \approx 5.3 \times 10^{-11}$ m. Also the orbital angular momentum of the electron's 1s orbital is \hbar according to the Bohr model. The combination of this radius size and this angular momentum corresponds to the electron having velocity of $v = \alpha c$ (about 137 times slower than the speed of light). The de Broglie wavelength for an electron at this velocity is $\lambda_d = 2\pi a_o$. This means that the de Broglie wavelength equals the circumference of this Bohr orbit. This is an appealing picture, but according to quantum mechanics, the Bohr atom model is an oversimplification.

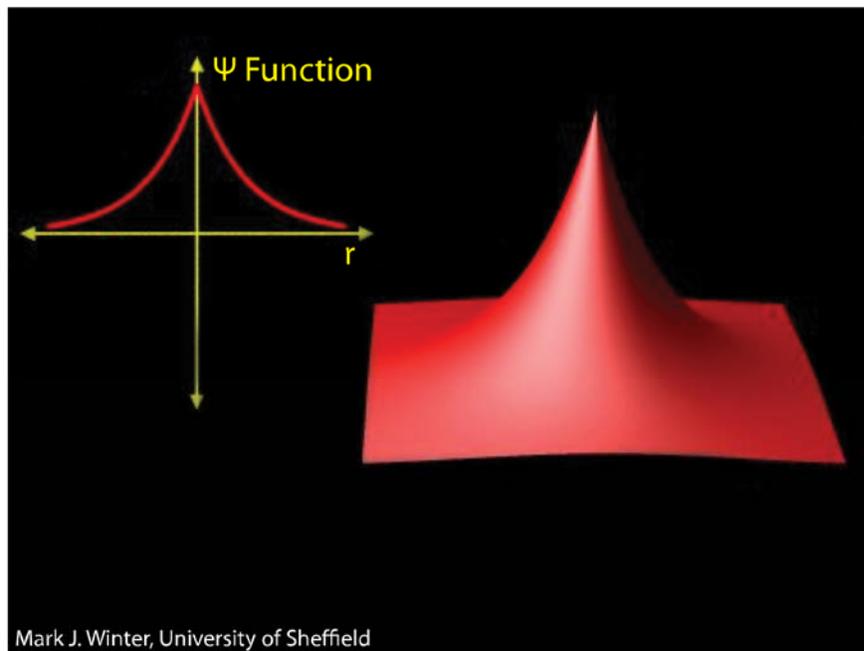


FIGURE 12-1 Plot of the 1s wave function of an Atomic Orbital

Figure 12-1¹ shows the graph and the 3 dimensional plot representing the ψ function of the 1s orbital of an electron in a hydrogen atom. Squaring this ψ function gives the probability of finding the electron. For the 1s atomic orbital, the peak corresponds to the location of the proton in the hydrogen atom. The closer we probe to the proton, the higher the probability of locating the electron. This plot, obtained from the Schrodinger equation, looks nothing like what might be expected from the Bohr model. There is no exclusive orbit with radius a_o . There is no net orbital

¹ Mark J. Winter <http://winter.group.shef.ac.uk/orbitron/>

angular momentum. The only angular momentum of this orbital is the $\frac{1}{2}\hbar$ angular momentum of the electron.

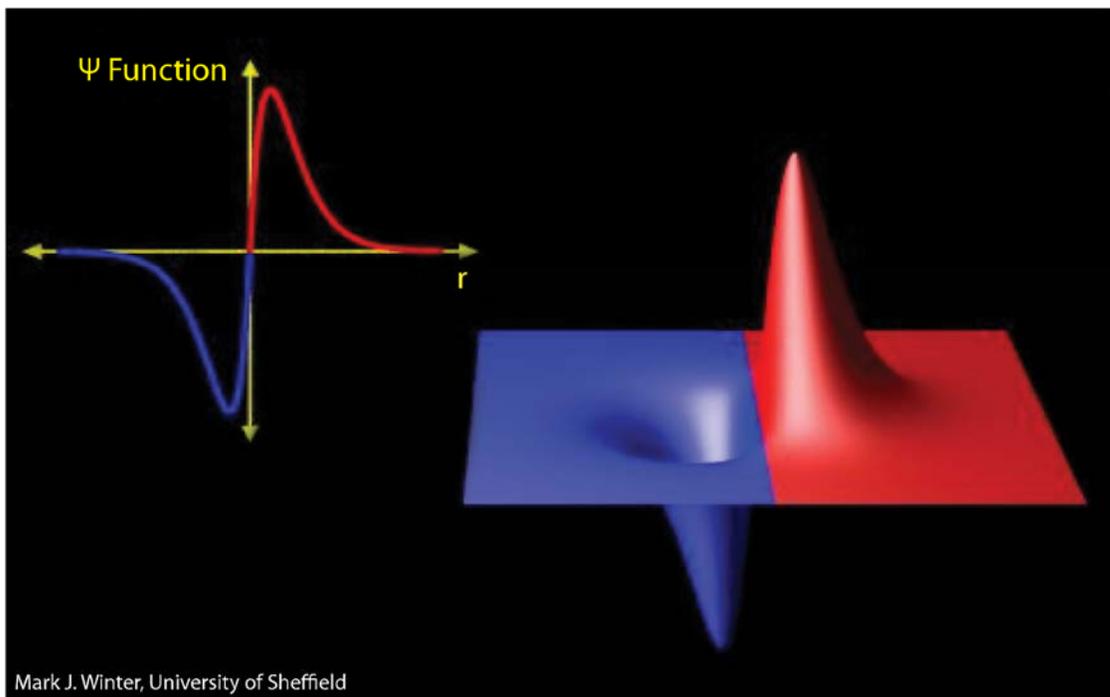


FIGURE 12-2 Plot of the $2p_x$ wave function of an Atomic Orbital

Figure 12-2 is similar to figure 12-1 except figure 12-2 shows the Ψ function and probability of finding an electron that is in the $2p$ orbital of a hydrogen atom. To understand these figures in terms of the spacetime wave model of rotars, it is necessary to examine the Ψ function.

Ψ Function: It is an axiom of quantum mechanics that the ψ function has no physical significance; only the square of the ψ function can be physically interpreted as representing the probability of finding a particle. It is proposed here that the spacetime wave model of rotars does give a physical meaning to the Ψ function. This physical meaning is easiest to explain by returning to the hypothetical example of a “particle in a box”. In this exercise, students calculate what would happen if a particle was placed in a small cavity surrounded by impenetrable walls (an infinite energy well). There are no such cavities, but if there were the particle’s quantum mechanical properties would be exhibited. The particle can only possess a few specific positive energies corresponding to a few specific kinetic energies which produce wave nulls at the walls. Furthermore, the particle can never be stationary within the cavity (never have zero kinetic energy).

If the “particle” is a rotar with the external volume wave structure proposed in this book, then it is conceptually understandable why the “particle” must have a wave structure that produces nulls at the walls. In this example, a single particle moving relative to the box produces a single standing wave pattern with nulls at the walls. This standing wave pattern consists of two wave frequencies propagating in opposite directions. These two counter propagating waves always possess more energy than an isolated particle that is not confined.

The “particle in a box” thought experiment is an idealized thought experiment since in nature there are no cavities surrounded by impenetrable walls creating an infinite energy well. If such a cavity existed, the quantum mechanical properties of a particle (rotar) trapped inside would be revealed. In order for the rotar to meet these boundary conditions imposed by the walls, it is necessary for the rotar to possess slightly more energy than an isolated rotar. Recall that attraction bonding involves a loss of energy and hypothetical repulsive bonding, such as a particle in a box, requires a gain in energy. In order for the rotar to achieve zero amplitude at the two 100% reflectors of the box, it is necessary for two spacetime wave frequencies to be present rather than the single Compton frequency of an isolated rotar.

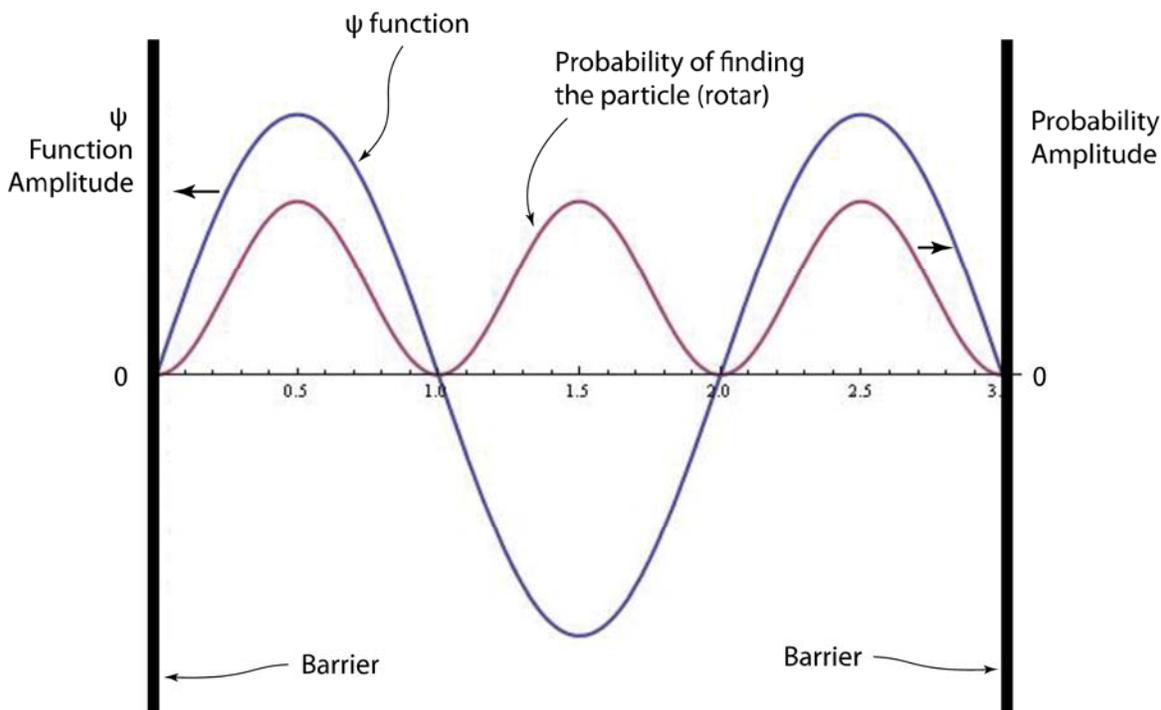


FIGURE 12-3 ψ function of a particle in a box (conventional model)

Figure 12-3 shows the conventional depiction of one possible Ψ function of a particle trapped in a small box with impenetrable walls. Different resonant modes are possible, so a three lobe resonance is chosen for ease of illustration. Note that the Ψ function represented in figure 12-3 has both positive and negative values (above and below the zero line). Quantum mechanics does not give a physical meaning to the Ψ function. Only the square of the Ψ function can be physically interpreted as the probability of finding a particle. The rotar model goes against this convention and gives a physical meaning to the Ψ function.

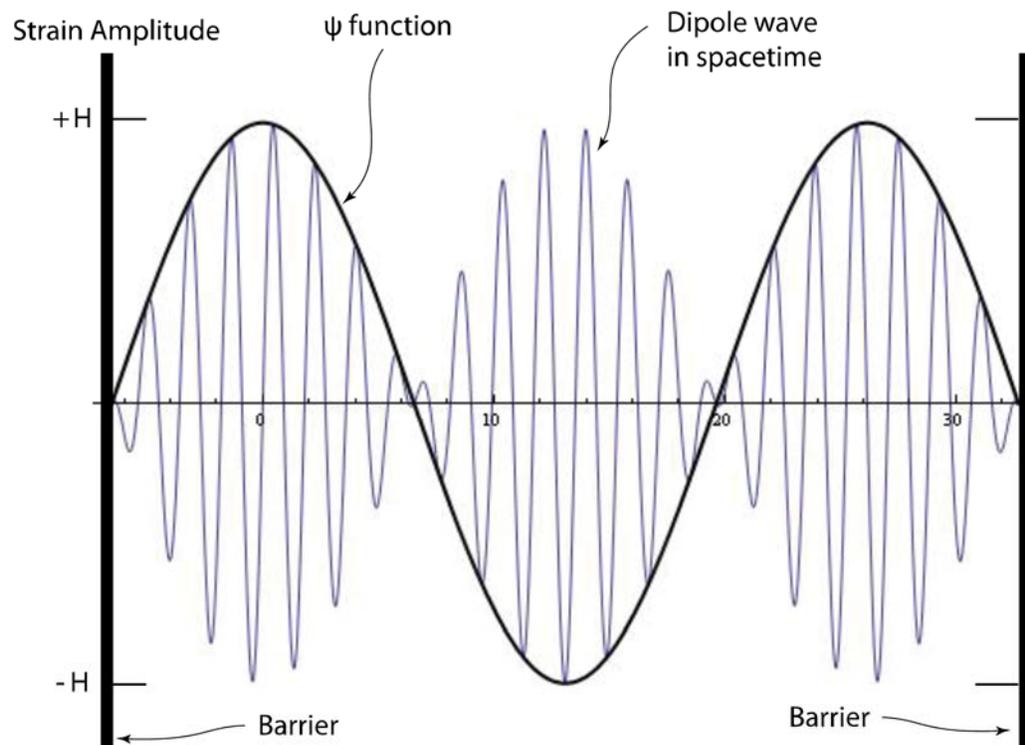


FIGURE 12-4 Spacetime wave model of the ψ function of a particle (rotar) in a box

The ψ function of a bound rotar is the wave envelope of the waves in spacetime that form the rotar.

Figure 12-4 shows the spacetime wave interpretation of the Ψ function of a particle in a box. We will reinterpret the particle in a box to a rotar trapped between two hypothetical barriers that are 100% reflectors for waves in spacetime. The box is essentially a repulsive type of confinement. Placing a rotar in a repulsive confinement requires that energy be added to the rotar in excess of the energy that a rotar would have if it was isolated. This added energy shows up in the rotar having two frequencies (one higher and one lower than the Compton frequency). Together they average more than the Compton frequency of an isolated rotar.

Placing a rotar in such a cavity changes the rotar's boundary conditions compared to an isolated rotar. In order for the rotar to meet the condition of zero amplitude at each of the two 100% reflectors, the rotar must possess two frequencies that are both propagating to the left and right in figure 12-4. These two frequencies traveling both directions produce the "stationary" standing wave pattern shown in this figure. This pattern looks similar to the de Broglie waves previously shown. However, de Broglie waves have the wave envelope moving faster than the speed of light while the wave envelope shown in figure 12-4 is stationary in the sense that its nodes and antinodes do not move.

Next, we will return back to the hydrogen atom that has its electron in the 1s orbital depicted in figure 12-1. The electron and proton are bound together by attraction. The combination lost 13.6 eV energy when they went from being an isolated electron and proton to being an electron bound in the 1s orbital of a hydrogen atom. New frequencies were introduced to the electron and the proton's quarks in this bonding process so that the average frequency of this combination is less than the sum of the Compton frequency of an isolated electron and isolated proton. All the orbitals of an electron in a hydrogen atom have a wave structure that involves two or more frequencies. The total of the energy is equal to the combination's energy in isolation minus the energy lost to form the hydrogen atom in the designated orbital. Orbital angular momentum also has a wave explanation that involves waves of slightly different frequencies propagating in opposite rotational directions around the proton. This is analogous to the waves having a rotating frame of reference.

While the Bohr atom model has been replaced by the quantum mechanical model, the point is that the superposition of counter propagating waves in the spacetime field traveling at the speed of light can achieve the desired orbital angular momentum. It is proposed that it is going to be possible to combine the spacetime wave model with the quantum mechanical atomic model to give a conceptually understandable model of an atom. The mechanism that eliminates energy loss (radiation loss) from an atom is unknown, but presumably it is similar to the mechanism proposed for stabilizing isolated rotars.

This explanation leaves a lot of questions unanswered. Perhaps the most obvious: Is there still a rotating dipole rotar volume buried somewhere within the bound electron's lobes? The electron retains its $\frac{1}{2} \hbar$ angular momentum in addition to orbital angular momentum present in most atomic orbitals. Further insights clearly will involve the marriage of quantum mechanics and improved versions of the spacetime wave theory of rotars. The difference in the spectrum of hydrogen and deuterium is due to the difference in the amount of nutation the two different mass nuclei experience. This seems to indicate that the electron retains a substantial amount of concentrated inertia within the electron cloud that is causing the nucleus to nutate.

The reason for bringing up the particle in a box exercise now is to make a point about bound particles. This lesson creates the erroneous impression that bound particles in nature can also possess a **positive** binding energy (the bound state is more energetic than the unbound state). The particle in a box exercise describes what would happen if a particle is surrounded by walls that are always repelling the particle. I am proposing that in nature, particles are always bound by attraction; not confined by repelling walls. Electrons in an atom are bound by attraction to the nucleus. Gravitational attraction binds a planet to a star. These are all examples of “negative binding energy”. This means that bound state has lower total energy than the unbound component parts. Another way of saying this is that the bound state is an energy well. It is necessary to add energy to break the bond. From this, the following statement can be made:

Rotars bound by attraction always possess less energy than the same rotar when it is isolated. Attraction binding energy can be thought of as negative energy. Energy is emitted when rotars combine.

This seems very reasonable and not controversial. However, this goes against the commonly accepted model of a gluon which is depicted as a positive energy binding mechanism. The subject of gluons and quarks will follow, but first I want to support the contention that all other forms of binding in nature is by attraction forming an energy well (less energy than the unbound state).

In chapter #3 we determined that a particle has more internal energy in zero gravity than when the particle is in gravity. ($E_o = \Gamma E_g$). Gravitational potential energy is a negative value that is referenced to zero at infinite distance. Suppose an observer using a zero gravity clock monitors the Compton frequency of the rotar as the rotar is restrained and slowly lowered towards a large mass. Gravitational energy is removed by the restraining mechanism as the rotar is slowly lowered into stronger gravity. The Compton frequency ω_c of the lowered rotar, measured by a zero gravity clock, decreases as gravity increases and more energy is removed. This decrease in frequency is not noticeable locally because of the gravitational dilation of time. Locally, a slow clock is used to monitor a slow Compton frequency. The point is that gravitational bonding energy is negative energy. The Compton frequency of a gravitationally bound rotar is lower than the same rotar not gravitationally bound when both frequencies are measured using a clock running at zero gravity rate of time.

For another example of a bond reducing energy, an electron and a proton release a 13.6 eV photon when they become electromagnetically bound together to form a hydrogen atom with the electron in the lowest energy level. This released energy represents the negative binding energy of the hydrogen atom. It is possible to go one step deeper in understanding this negative binding energy. An isolated electron has a Compton frequency of about 1.24×10^{20} Hz and the Compton frequency of a proton (sum of all components) is about 2.27×10^{23} Hz. When an electron and a proton are bound together to form a hydrogen atom, the sum of all the Compton frequencies is about 3.3×10^{15} Hz less than the when the electron and proton were isolated. This

difference of 3.3×10^{15} Hz is the frequency of the 13.6 eV photon released when the hydrogen atom formed. Therefore it is possible to see the difference in energy when an electron and proton are bound to form a hydrogen atom. (To be perfect, this example needs to also account for the small amount of kinetic energy carried away by the hydrogen atom as it recoils from emitting the photon.)

A more extreme example is the bonding of an electron to a uranium nucleus which has been stripped of all electrons. This bonding is so strong that the bonding energy is equivalent to about $\frac{1}{4}$ the mass/energy of an electron. The energy lost when this bonding first takes place is removed by the emission of one or more gamma ray photons. Isolated particles are more energetic than bound particles. This concept will later be applied to bound quarks with some surprising implications.

Binding Energy in Chemical Bonds: Next, an example from chemistry. There are a few molecules such as ozone (O_3) and acetylene (C_2H_2) which are commonly described as being “endothermic”. This means that starting with a standardized set of conditions from chemistry, it takes an input of energy (heat) to form the molecule. This would seem to imply that all endothermic molecules form positive energy bonds. The implication is that this is an example where the bound state is more energetic than the unbound state. For example, ozone requires an input of energy when it is formed from molecular oxygen O_2 under standardized conditions. However, we are probing a fundamental question about the nature of bonds. We must compare the bound state to the unbound state which in this case would be individual atoms. It takes $1\frac{1}{2}$ molecules of O_2 to form 1 molecule of O_3 (written as: $3 O_2 \rightarrow 2 O_3$). To separate one of the O_2 molecules into two oxygen atoms takes about 2.6 eV/molecule or 249 kJ/mole. This gives the erroneous impression of the bound state can be more energetic than the unbound state. However, if we formed ozone starting with 3 atomic oxygen atoms, then this reaction releases energy when a molecule of O_3 is formed. Similarly, the formation of acetylene is an endothermic reaction if the standardized starting components of graphite and molecular hydrogen (H_2) are used. However, the formation of acetylene is an exothermic chemical reaction if the starting components are atomic carbon and atomic hydrogen. In fact, there are no endothermic chemical reactions if the starting material is individual atoms. Therefore, even chemistry supports the contention that bonds in nature reduce the energy of the component parts. In this case molecules always possess less energy than the component atoms when the atoms are isolated.

Binding Energy of Nucleons: While it is very difficult to make energy and force measurements inside a proton or neutron, we can obtain a hint of what is going on inside protons and neutrons by looking at the binding that occurs between nucleons. When protons and neutrons are bound together to form atomic nuclei, is there a gain or loss of energy? The answer is obvious. A helium atom (4He) has less mass/energy than 2 deuterium atoms. The binding energy of nucleons is a negative form of energy (energy reduction compared to the sum of the unbound components). There is a decrease in mass (loss of energy) when hydrogen nuclei fuse to form nuclei of heavier

atoms. At first it might appear that ^{235}U and other heavy atoms are an exception to this rule, but this is incorrect. The strongest bound atomic nucleolus is ^{56}Fe with a binding energy of 8.79 MeV per nucleon. ^{235}U has a binding energy of 7.79 MeV per nucleon and this is comparable to the binding energy per nucleon of carbon or nitrogen. Breaking ^{235}U apart releases energy because the two lighter nuclei formed have a greater binding energy per nucleon than ^{235}U . A greater binding energy means that excess energy must be released upon formation. The point is that even ^{235}U has less mass/energy than the energy of the protons and neutrons that form the uranium nucleus.

It is proposed that quarks are bound together to form hadrons by negative energy. The hadrons would have less energy than the total energy of the component quarks if the quarks were stable in isolation so that their energy in isolation could be experimentally measured.

Gluons, Quarks and Hadrons

Background: The previous discussion asserted that in nature the bound state was always a lower energy condition than the individual components in the unbound state (bound state is always an energy well). This concept is going to be important in the following discussion about quarks and gluons. The problem is that if we faithfully develop a model of the universe starting with the assumption that the universe is only spacetime, we obtain the strong force from the pressure exerted by the spacetime field. There is no need to postulate gluons! Since gluons are very much a part of modern particle physics, this seems to present a problem for the spacetime model of the universe. However, it will be argued here that all the functions currently attributed to gluons (color charge, etc.) can be converted to functions attributed to the rotar model of quarks existing in the pressure exerted by the spacetime field.

Previously we rejected virtual photons as the “messenger particles” that carried the electromagnetic force and rejected gravitons as the “messenger particles” that carried the gravitational force. The next remaining virtual messenger particle is the gluon and this is going to be questioned. There is no experimental observations that can be interpreted as being proof that virtual photons or gravitons exist but there is some experiments that seem to imply that gluons exist although they have never been directly observed. Also there is a vast amount of theoretical calculations that are modeling effects that are attributed to gluons. Therefore the discussion about gluons is going to be more nuanced. The analysis of quarks and gluons will begin with a discussion about the mass/energy of quarks.

Mass/Energy of Quarks: Since quarks do not exist in the unbound state, it is not possible to simply compare the energy of an unbound quark to a bound quark. The following is a quote from an article on quark masses written by A.V. Manohar and C.T. Sachrajda²

“Quark masses therefore cannot be measured directly, but must be determined indirectly through their influence on hadronic properties. Although one often speaks loosely of quark masses as one would of the mass of the electron or muon, any quantitative statement about the value of a quark mass must make careful reference to the particular theoretical framework that is used to define it. It is important to keep this scheme dependence in mind when using the quark mass values tabulated in the data listings. Historically, the first determinations of quark masses were performed using quark models. The resulting masses only make sense in the limited context of a particular quark model, and cannot be related to the quark mass parameters of the Standard Model.”

I will expand on this thought somewhat. Suppose that there is an experiment which collides protons and anti-protons together at high energy. The collision produces a complicated shower of particles that is hard to interpret. If protons are assumed to consist of point particle quarks plus gluons and virtual particle pairs forming and annihilating, then the interpretation of the results will be different than if the protons are assumed to be the rotar-model quarks possessing quantized angular momentum colliding in sea of dipole waves designated as the spacetime field. With this being said, we will first look at the widely accepted interpretations of these complicated experimental results.

The description of a proton differs greatly depending on the experiment. For example, in low energy collisions, a proton seems to be made of 3 quarks with each quark possessing approximately $1/3$ of the proton's energy. In high energy collisions a proton seems to have many quarks (over 10) with each quark possessing energy of only a few MeV. We will examine each model.

At the low energy limit a proton appears to have a total of 3 quarks - two up quarks and one down quark. In the low energy condition these 3 quarks are referred to as “constituent quarks”. The two constituent “up” quarks of a proton appear to have energy of 336 MeV each³. The single down constituent quark appears to have energy of 340 MeV. Here is another description of the constituent quarks.

Nonrelativistic quark models use constituent quark masses, which are of order 350 MeV for the u and d quarks. Constituent quark masses model the effects of dynamical chiral symmetry breaking... Constituent masses are only defined in the context of a particular hadronic model.”⁴

² Quark Masses Updated Jan 2012 by A.V. Manohar (University of California, San Diego) and C.T. Sachrajda (University of Southampton) <http://pdg.lbl.gov/2013/reviews/rpp2012-rev-quark-masses.pdf>

³ Griffiths, D., (2008) *Introduction to Elementary Particles* p. 135, Wiley-Vch

⁴ “Note on Quark Masses”:<http://pdg.lbl.gov/2010/reviews/rpp2010-rev-quark-masses.pdf>

This name “constituent quarks” is used when describing the model that emerges from low energy experiments. The name “current quarks” is used to represent the quark model which is obtained in high energy collision experiments. In high energy collision experiments there appears to be many more than 3 quarks and each of these appears to have energy of only a few MeV. To reconcile this difference the difference between the low energy and high energy collision experiments, the 3 constituent quarks observed in low energy collisions are often visualized as being composed of a core current quark with energy of a few MeV which is surrounded by either a cluster of virtual particle-antiparticle pairs or surrounded by gluons. In either case, the total energy of what is interpreted to be a cluster is approximately $1/3$ of the proton energy.

According to the proposed spacetime model, the problem comes in interpreting high energy collisions. In the rotar model of a high energy collision, one or more of the 3 quarks momentarily absorbs far more energy than the rest energy of the quark. Recall the previous discussion of the difficulty determining the size of an electron from energetic collisions of the rotar model of an electron. The kinetic energy of the collision is momentarily converted into the internal energy of the electron (rotar model). This causes the electron’s radius to momentarily decrease so that it was always below the detectable limit of the experiment.

The collision of protons is more complicated, but one thing is clear. The energetic conditions which prevail at the moment of collision are not the same as an isolated proton. If the model of a quark is a point particle, then there is no internal structure and it is valid to assume that the quark retains its properties even in a violent collision. However, if each quark is assumed to have a rotar model, then this is three “fluffy” rotating dipole waves existing in the spacetime field. They each are a rotating dipole wave in spacetime possessing a quantized unit of angular momentum. This rotating wave is distributed over a volume of space. Adding the kinetic energy of the collision momentarily decreases the size of a quark. This changes the bonding conditions but retains a constant angular momentum. The rotar model of protons is in an early stage of development and cannot predict the results which would be expected in an energetic collision. However, it is possible to imply that the complicated results of energetic collisions can be misinterpreted if point particle quarks and gluon messenger particles are erroneously assumed.

The quarks observed in high energy collisions appear to be very different from the constituent quarks at the low energy limit. The three “current quarks” that form a proton appear to have energy less than 10 MeV. In this picture obtained from high energy collisions, only about 1% of the rest mass of a proton appears to be in the form the quarks. In this case about 99% of the mass/energy of a proton is therefore assigned primarily to the energy of gluons with some contribution from the kinetic energy of quarks. In other words, the gluons must possess positive energy in this model. More will be said about gluons later.

Alternative Explanation: The proposed alternative explanation of the mass of a quark is that up and down quarks would be intrinsically high energy rotating dipole waves if they were stable in isolation. They are strongly bound together by an interaction with the spacetime field when they form hadrons. There are no isolated first or second generation quarks because they simply do not attain stability as isolated rotars. (The top quark will be discussed later). When this model of a quark is bound into a hadron it is in a low energy state, an deep energy well. Attempting to remove quarks from a hadron against the strong force increases the quark's energy (Compton frequency) towards the higher energy state which would exist if a quark (rotar model) could exist in isolation. The energy exerted in attempting to remove a quark from a hadron requires so much energy that a new meson (pion) is formed before an isolated quark is obtained. When new mesons are formed, the binding force between former components of the split hadron decreases to near zero. Single first or second generation quarks are never produced.

However, to illustrate the concepts, we will imagine what it would be like if isolated quarks were allowed. It is proposed here (justified later) that if isolated up and down quarks existed, they would be rotating dipoles with energy substantially greater than 400 MeV. If up and down quarks existed as isolated rotars, then they would shed energy when they bond to form a proton or neutron. Hadrons come into existence already formed since this is the lowest energy state and the only form that has stability. However, it is informative to imagine the steps that would occur if a hadron was formed from isolated quarks.

Energy of Bound Quarks: The working proposal is that all the energy of a proton is contained in its three bound quark rotars (rotating dipole waves in spacetime). However, the model of the interaction of quantized waves should not be equated to the expected interaction if the quarks were hard shelled particles. Furthermore, it is proposed that the binding energy is so great that the bound quarks have much less energy than they would have as hypothetical isolated rotars. We will first survey the hadrons that are made of only up and down quarks to compare the energy of the up and down quarks under various bound conditions. The nucleons (protons and neutrons) have almost the same energy ~ 938 MeV. If we assume that all this energy can be traced to the energy of 3 rotating spacetime dipoles (3 quarks) then the implication is that up and down quarks have about the same energy. There are different proportions of up and down quarks, yet approximately the same total energy. We will assume that bound up and down quarks in a nucleon has energy of about 313 MeV ($\sim 1/3$ of the total).

There are two other families of hadrons that consist of only up and down quarks. These are the pi mesons (pions) and the delta baryons. The delta baryons have spin of $J = 3/2$ rather than the spin of $1/2$ for the nucleons. There are 4 delta baryons. These are:

Δ^{++} (uuu); Δ^+ (uud); Δ^0 (udd) and Δ^- (ddd).

These all have about the same energy (1,232 MeV) therefore the up and down quarks bound in this hadron have energy of about $\frac{1}{3}$ of this value: ~ 411 MeV.

The pions consist of a quark and an anti-quark such as an up quark and an anti-down quark. The net spin of the pions is zero (counter rotating dipoles). The energy of the pions is 139.5 MeV for the two charged pions (π^+ and π^-) and about 135 MeV for the neutral pion (π^0). This means that the up and down quarks in a pion have average energy of about 70 MeV for the charged pions (π^+ and π^-) and about 68 MeV for a neutral pion π^0 .

Therefore we have examples where up and down quarks have energy ranging from 411 MeV to 68 MeV. The standard model deals with this difference by assuming that an isolated up or down quark has energy of only a few MeV. The extra energy required to reach 68 MeV, 313 MeV or 411 MeV is assumed to be predominately in the energy of the gluons.

Energy of a Hypothetical Isolated Quark: The proposed spacetime wave model of quarks offers a different answer. It says that an isolated rotar up or down quark would have energy substantially greater than 411 MeV. When quarks are bound into a hadron, the bonds are so strong that a large percentage of the hypothetical isolated energy is lost. It would be radiated away if it was possible to do this experiment. The difference between the 68 MeV, 313 MeV or 411 MeV reflects different amounts of binding energy.

The binding energy per nucleon in ^{56}Fe represents approximately 1% of a proton's energy. An electron bound to a uranium atom's nucleolus stripped of all other electrons has a binding energy that is about 25% of an isolated electron's energy. In order for an electron to attach to a stripped uranium atom nucleolus, it has to emit one or more gamma ray photons to shed a total of about 25% of the electron's energy. Actually part of the lost energy comes from the protons in the nucleus, but that is off the subject.

It is proposed that the binding energy of quarks in a hadron is much greater than these examples. To illustrate this concept, we will choose an energy substantially larger than 411 MeV for the energy of a hypothetical unbound up or down quark. For illustration, we will use the number of about 600 MeV for the energy of isolated up and down quarks. With this assumption, an isolated up or down quark would lose about $\frac{1}{3}$ of its energy when it forms a delta baryon (411 MeV). It would lose about $\frac{1}{2}$ of its energy when it forms a nucleon (313 MeV) and it would lose about 89% of its energy when it forms a neutral pi meson (68 MeV).

Electron vs. Proton Size: Before proceeding too far, it is desirable to do a calculation to see if the ideas proposed here are plausible. We will attempt to calculate the size of a proton. However, first it is necessary to recognize why a proton has a measurable size and an electron does not. A proton has a measurable size because a proton is made up of 3 fundamental rotars. The three quarks of a proton do not respond to a high energy collision as a single quantized unit. The

property of unity only exists within a single quantized wave (rotar). A collision with a proton involves speed of light communication of forces between the three quarks of a proton. This means that the proton exhibits a physical size in a collision even though this size does not exhibit a hard boundary.

When an electron collides with one of the three quarks in a proton, it appears as if there is a collision between two point particles. The reason is the same as previously explained for a collision between two electrons. Both the electron and the quark are quantized rotating dipoles in the spacetime field. In a direct hit, they both convert the kinetic energy of the colliding electron to internal energy of the rotating dipole. This happens faster than the speed of light because preserving the quantized angular momentum results in the previously explained property of unity. The conversion of kinetic energy momentarily increases the Compton frequency of each rotar. In order for angular momentum to be conserved, the rotar radius λ_c of each rotar momentarily decreases. The amount of decrease in size makes each rotar experimentally indistinguishable from a point particle because (as previously explained) the momentary radius is less than the resolution limit set by the uncertainty principle. The other two quarks that were part of the proton only learn about the collision through speed of light communication.

Calculation of Proton Radius: The presence of only three quantized waves means that a proton still exhibits substantial quantum mechanical properties such as no definite shape and the lack of a hard edge. Also the shape of a proton depends on the alignment of the spins of the quarks. An analysis⁵ of all measurements of the proton radius concludes a most probable charge radius for a proton is: 0.877×10^{-15} meter $\pm 0.15 \times 10^{-15}$ meter

We will do a plausibility calculation to see if the proposed rotar model of a proton gives roughly the correct size. This calculation will assume that the proton is made of 3 rotars, each with energy of 313 MeV (5×10^{-11} J). We must decide how these three rotating dipoles fit together. Are there voids or excessive overlaps? It is known that protons are not necessarily spherical depending on the alignment of the spins of the up and down quarks. Still, the simplest assumption is a spherical proton with quarks that are so intimately bound that the proton has three times the volume of an individual rotar quark with radius λ_c . The plausibility calculation will assume this simplified model.

We will first calculate the rotar radius λ_c of a rotar with energy of 5×10^{-11} Joule (313 MeV). Then we will increase this radius by a factor of $3^{1/3}$ to obtain the radius of a sphere with 3 times the volume of an individual rotar quark.

$$\begin{aligned} \lambda_c &= \hbar c / E_i && \text{substitute: } E_i = 313 \text{ MeV} = 5 \times 10^{-11} \text{ J} \\ \lambda_c &\approx 6.3 \times 10^{-16} \text{ meter} && \text{radius of one quark with energy of 313 MeV} \\ \lambda_c \times 3^{1/3} &\approx 9 \times 10^{-16} \text{ meter} && \text{calculated proton radius (3 quarks)} \end{aligned}$$

⁵ <http://arxiv.org/abs/hep-ph/0008137v1>

The experimentally determined radius of a proton is: $8.77 \times 10^{-16} \pm 1.5 \times 10^{-16}$ meter, therefore the calculated radius of 9×10^{-16} meter agrees within the experimental error. This degree of accuracy is probably more than we deserve considering the crudeness of the calculation. In fact, the rotar model could be correct for charged leptons and too simplified to be applied to quarks which are tightly bound with very restrictive boundary conditions. Still, the calculation does give a reasonable answer and cannot be ignored. This calculation could easily have been off by many orders of magnitude if the rotar model was completely wrong.

It is also interesting to note that the density of the quarks in the above calculation is roughly 5.9×10^{17} kg/m³. The density of the nucleus of an atom with many bound nucleons is subject to some interpretation, but is roughly 2.3×10^{17} kg/m³. Therefore, the density of an atomic nucleus is roughly half the density of individual quarks. This is far different from the standard model that depicts quarks as point particles and therefore infinitely more dense than an atomic nucleolus.

To summarize, the rotar model of quarks implies that if quarks could exist in isolation, they would have substantially more energy than they have when bound together to form hadrons. In this case, the quarks would lose energy (emit photons) when they are bound together to form hadrons. This results in an energy well, just like all other bonds in nature. The rotar model depends on the existence of the spacetime field to stabilize the rotars. As previously stated, the spacetime-based model of the universe has only one truly fundamental force (the relativistic force) and that force is always repulsive. The bonding of the quarks is ultimately traceable to pressure exerted by the spacetime field.

Gluon Background: Next, we will examine gluons. According to the standard model, gluons are exchange particles that carry the strong force (the strong interaction) between quarks. Gluons carry the color charge and also participate in the strong interaction in addition to being a mediating exchange particle. The 8 types of gluons have color charge. While there are 3 color charges (red, green and blue), gluons carry complex combinations of these color charges. For example, a description of one of the 8 possible gluons is: (red-anti blue + blue-anti red). Gluons are also described as massless vector bosons with spin of 1 which have two polarization states. The standard model description of gluons is very complex and quantum electrodynamics calculations involving gluons are also complex.

According to theory, bonds between quarks become weaker as the distance increases. Therefore quarks bound in hadrons are in a state of “asymptotic freedom”. When quarks are in their unperturbed state, they can migrate within the hadron as if they are not tightly bound. However, the asymptotic freedom state only occurs when quarks maintain the prescribed distance relative to each other. If the distance is increased, the strong force increases. As the separation distance is increased, energy is being added to the hadron and the restoring force

increases. The added energy supposedly goes into the energy of the gluons. The quarks supposedly maintain a constant energy of less than 10 MeV. When the separation distance between quarks reaches roughly 10^{-15} m, enough energy has been added to the gluons to form a new meson (quark – antiquark pair) and the restoring force drops to nearly zero. There are three problems with this.

- 1) This gluon bond model does not follow the example of the particles possessing less energy in the bound state than they have in isolation. It is true that we cannot obtain an isolated quark for comparison, but the point is that the model is that each quark retains a constant energy as the quarks are being separated. The work being done does not go into increasing the energy of the quarks. This is not a typical energy well.
- 2) The gluons possess positive energy and are traveling at the speed of light. Since the proton has energy density of about 3×10^{35} J/m³, if almost all the energy is attributed to gluons this implies that the gluons should exert pressure of at least 10^{35} N/m². The pressure of this high gluon energy density should destroy protons, not bind them together. How do the gluons achieve attraction?
- 3) Why does the force start at zero and increase with distance? This is “explained” by physicists postulating that as the quarks are separated, the gluons form “flux tubes” and this concentration actually increases the force of attraction even though the distance is increasing. What is the physics behind this concept? What supplies the force to constrain the size of the flux tubes? Depending on the volume of the flux tubes, the confined gluons should exert even more pressure than 10^{35} N/m². All of this is so far removed from anything else in nature that it speaks to the problems created the concept of gluons.

The experimental evidence for the existence of gluons is that very energetic collisions of electrons and positrons sometimes produce “three jet events” (a jet is a narrow shower of particles). The explanation for these three jet events is that at least one of the three jets resulted from a gluon “hadronize” into normal particles (colorless hadrons) which results in the narrow shower of particles known as a jet.

The Relativistic Force: As previously stated, the spacetime model has only one truly fundamental force: the relativistic force. This force is generated when energy, traveling at the speed of light, is deflected in some way. For example, the absorption, emission or reflection of a photon results in the transfer of linear momentum. The relativistic force F_r is the name given when multiple linear momentum transfers can be considered to be a continuous force. The equation is $F_r = P_r/c$ where P_r is relativistic power propagating at the speed of light. The relativistic force is always repulsive. As previously explained the relativistic force can appear to be an attracting force when the spacetime field exerts the relativistic force in a way that brings particles together. For example, the electrostatic or gravitational attraction is actually the result of the spacetime field applying unequal pressure on rotars producing a net force of attraction. This is an introduction of how the relativistic force also produces what we perceive to be the strong force without gluons.

All rotars possess energy density which implies that they have internal pressure. The rotar pressure is: $\mathcal{P}_r = (\omega c^4 \hbar / c^3) = E_i / \mathcal{A}_c^3$. To stabilize this internal pressure the spacetime field must exert an opposing pressure. If this pressure is balanced on all sides, then there is no net force. However, other rotars in the vicinity result in a distortion of the spacetime field and this in turn results in an unbalanced pressure (a net force) exerted on the rotar. When this net force is in the direction of the other rotar, then we say that there is a force of attraction between the two rotars.

The maximum force (F_m) that a rotar can exert was previously shown to be $F_m = \mathcal{P}_r \mathcal{A}_c^2 = E_i^2 / \mathcal{A}_c$. Care must be used in applying this equation because E_i is the instantaneous internal energy and \mathcal{A}_c is the instantaneous rotar radius. For example, in a collision, the kinetic energy gets temporarily added to the rotar's internal energy E_i . Therefore at the instant of the collision the value of E_i increases and the value of \mathcal{A}_c decreases. The result is that the value of F_m is greater in a collision than the theoretical value for a rotar not undergoing a collision.

It is possible to do a rough calculation of the value of the maximum force that the 3 quarks that make up a proton can exert. We will start by assuming that the proton's energy of 938 MeV is evenly distributed among its 3 quarks (rotars). If each quark has energy of about 313 MeV or 5×10^{-11} J, then the value of the maximum force available to the three quarks in the unperturbed state of asymptotic freedom is about $F_m \approx 80,000$ N. This maximum force calculation does not attempt to identify whether the rotar can actually exert this maximum force, it is merely the upper limit.

In chapter 7 the section titled "Asymptotic Freedom" gave the explanation of how the strong force can be zero at the asymptotic freedom separation distance. Recall that at this separation distance opposing forces between the spacetime field and the repulsion of adjacent particles offset each other so the net force on a quark at the asymptotic freedom separation distance is zero. However, displacing a quark in either direction (closer or further from the other quarks) produces a net force which attempts to restore the separation to the asymptotic freedom separation. The energy required to change the separation distance is stored in the quark increasing its rotational frequency. Recall the hypothetical assumption that an up or down quark in a proton has about 313 MeV but it would have energy of about 600 MeV if it could exist as a stable isolated particle. This is the energy well previously discussed. In this example, removing a quark from a proton would require about 300 MeV but a pion forms at 135 MeV, so this happens first and the restoring force falls to nearly zero.

We can do a rough calculation to see if this model is reasonable. We know that the radius of a proton is about 8.8×10^{-16} m and pions are formed when a quark is displaced by roughly this distance. It is possible to do a rough calculation to see how far a quark would have to move against against a constant 80,000 N force before enough energy would be stored to make a pion

with energy of 135 MeV ($E_i \approx 2.2 \times 10^{-11}$ J)? The answer is about 2.7×10^{-16} m. This calculation represents an unrealistic lower limit because the force would not go from zero at the asymptotic freedom separation distance to the full maximum force of 80,000 N abruptly. Instead, there would be a gradual increase starting at zero and ending at some force probably less than 80,000 N. Another simplified calculation of the separation distance required to make a pion would start at zero force at the asymptotic freedom separation and linearly increase the force to 80,000 N at the total energy required to make a pion. In this case the separation distance where a pion is formed would be roughly 5.5×10^{-16} m. Even this over simplified assumption clearly gives an answer in the range of proton radius. Again, this calculation could have been off by many orders of magnitude.

Gluons Not Needed for Bonding: The point of this discussion is to support the contention that the spacetime-based model of the universe can explain the strong force using only the single universal force: the relativistic force. The spacetime-based model of the universe is not developed sufficiently to make predictions about the properties of specific fundamental particles. In particular, it is not possible to say whether a gluon-like particle with spin of 1 exists. The main reason for postulating the existence of a gluon (a messenger particle that conveys the strong force) has been removed. However, something causes 3 jet events in energetic collisions of electrons and positrons. Quantum chromodynamics assigns additional functions to gluons besides being a messenger particle and these additional functions are still required. The rules of the color force which currently require 8 gluons may still require 8 bosons but with redefined wave-based characteristics. Therefore gluons are not needed for bonding, but some of the other functions currently assigned to gluons will need to be reinterpreted.

Stability of Hadrons: Suppose that we imagine starting with the superfluid spacetime field that lacks angular momentum, then we introduce one unit of $\frac{1}{2}\hbar$ quantized angular momentum. Merely stating the amount of angular momentum does not specify the energy, frequency, amplitude, rotational size, etc. that this angular momentum might take. The spacetime field has characteristics that determine what combination achieves long term stability such as an electron and what is semi-stable such as a muon or tauon. There is an infinite number of other possible combinations of frequency, amplitude, rotational size that do not possess any stabilizing characteristics from the surrounding spacetime field. These totally unstable combinations last for only a unit of time equal to $1/\omega_c$ where ω_c is the hypothetical Compton angular frequency. For frequencies in the general range of the known particles, the survival time would be roughly in the range of 10^{-25} to 10^{-20} seconds. The few combinations of angular momentum, frequency, amplitude, etc. that achieve stability are the rare exception.

This is mentioned as an introduction to a discussion of the stability of hadrons. While the leptons are stable or semi-stable as individual rotars, the quarks are not. Somehow two or three quarks acting together can find stability where individual quarks do not. Do the hadrons that find stability achieve this stability by exhibiting the standing wave properties of a single unit? It is

possible to answer this question by looking at the diffraction pattern of neutrons passing through a crystal. The diffraction pattern produced by a neutron (3 quarks) implies a de Broglie wavelength that is characteristic of the neutron's total mass ($\lambda_d = h/mv$) rather than the mass of the three individual quarks with approximately one third this total mass.

Apparently the stability condition required for vacuum energy to stabilize a neutron results in frequency summation in the external volume. In other words, the 3 quarks present in the neutron lose their individuality at the boundary of the neutron. Externally, the vacuum energy stabilizes a neutron by treating it as a single unit. The standing waves generated in the vacuum energy apparently are equivalent to a Compton frequency characteristic of the entire energy of the neutron. The de Broglie waves generated by a neutron imply a single wavelength of the bidirectional standing waves in the neutron's external volume. Besides neutrons, larger composite particles such as alpha particles and even entire molecules exhibit diffraction patterns characteristic of the total energy. An improved rotar model should address the issue of frequency summation further.

Formation of the First Hadrons: The formation of rotars in the Big Bang was previously described as a trial and error process where a few combinations of angular momentum, frequency, and amplitude condensed out of the chaotic energetic waves in spacetime present in the early stages of the Big Bang. It is now proposed that besides single rotating spacetime dipoles, nature also found a few combinations of rotating dipoles that could achieve stability. These also condensed out of the energetic waves in the spacetime field as already formed hadrons. The source of the angular momentum required to form quarks, leptons and photons will be addressed in chapters 13 and 14. It will be shown that even the starting condition of the universe (Planck spacetime) must have possessed quantized angular momentum.

Presumably the first hadrons that condensed out of the energetic waves in spacetime created by the Big Bang were highly energetic hadrons made from generation III and II quarks. The probable sequence that eventually arrives at the dominance of protons and neutrons in the universe today will have to be developed by others.

W and Z Bosons: So far this analysis has not mentioned W^+ , W^- and Z bosons. There is clearly a large body of experimental observations that support these particles in the standard model. However, like gluons, it is proposed that these bosons have a wave explanation. W and Z particles have \hbar spin characteristic which is normally associated with a boson. However W and Z particles also have rest mass which is normally associated with a fermion (spin $\frac{1}{2} \hbar$). Clearly this is more complicated than previously encountered with other fermions or bosons.

Is there any other case discussed in this book where a boson (spin \hbar) possesses rest mass? The answer is: yes. In the first chapter we discussed the case of photons confined in a reflecting box. Photons have \hbar spin yet when they are confined in some way they are forced to have a specific

frame of reference and they acquire rest mass. In fact, it was pointed out that any time a photon has energy of $E \neq pc$, the photon will have rest mass. When a photon is confined between two reflectors it can be thought of as propagating in both directions simultaneously. Since momentum is a vector, the two vectors cancel and $p = 0$. This condition gives the photon rest mass even though the photon is a boson. Therefore even a photon propagating through glass is propagating at less than the speed of light in a vacuum and $E \neq pc$.

The point of this example is that bosons, with spin \hbar , can have rest mass if they interact with fermions (rotars) in a way that results in $E \neq pc$. Apparently spacetime and the hadron structure must have a type of resonance that occurs at $1.22 \times 10^{26} \text{ s}^{-1}$ (W boson 80,38 GeV) and $1.39 \times 10^{26} \text{ s}^{-1}$ (Z boson 91.19 GeV).

Imagine two quarks acting something like mirrors momentarily confining a W or Z boson. With Compton wavelengths of $1.54 \times 10^{-17} \text{ m}$ and $1.36 \times 10^{-17} \text{ m}$ (W and Z respectively) these are the size range that plausibly could interact with the rotar structure of hadrons. The W and Z bosons would have a standing wave structure which would look like standing waves interacting with the wave structure of the two quarks. This would give these W or Z bosons rest mass and the short range properties normally associated with the weak force. This is not a complete explanation, but it does show how the spacetime model of forces and particles can accommodate W and Z bosons. Hopefully others will analyze this further.

The concept of the Higgs field and Higgs boson was originally developed to “explain” how W and Z bosons acquired rest mass (inertia). While I favor the previous explanation of how W and Z bosons acquire inertia, the rest of the scientific community currently believes that the Higgs field interacts with W and Z bosons and that interaction gives them rest mass. In the spacetime model of the universe, the spacetime field is the only one truly fundamental field. Multiple resonances within the spacetime field are responsible for all the various particles. These multiple resonances can be thought of as separate fields. In that sense, it is possible to say that there is a Higgs field the same way that all other particles can be considered to have their own fields (resonances). Since the spacetime model of the universe has not been developed sufficiently to make predictions about W and Z particles, it is not possible to conclusively say how W and Z bosons obtain their inertia. Therefore it is hypothetically possible that the mechanism might include an interaction with the Higgs resonance (Higgs field). However, as previously explained, fermions exhibit rest mass through the same mechanism that confined photons exhibit rest mass. Fermions do not require a Higgs field to obtain inertia.

Neutrinos

Neutrino Introduction: Neutrinos are the least understood of the “fundamental particles”. There are three types or “flavors” of neutrinos (electron neutrinos, muon neutrinos and tau neutrinos). These three flavors are sometimes designated m_1 , m_2 and m_3 respectively. Previously the standard model considered neutrinos to be massless particles but experiments prove that neutrinos can change from one type of neutrino to another type of neutrino as a neutrino propagates through space. This “neutrino flavor oscillation” is interpreted as indicating that neutrinos must have some rest mass. The reasoning is that anything traveling at the speed of light cannot experience time and therefore neutrino flavor oscillation implies that neutrinos must be traveling at less than the speed of light. The flavor oscillation data could not give absolute values for neutrino mass, but the data could give an indication of the difference between the square of the masses⁶. For example, this difference can be expressed as: $\Delta m_{12}^2 \approx 7.6 \times 10^{-5} \text{ eV}^2$ and $\Delta m_{23}^2 \approx 2.4 \times 10^{-3} \text{ eV}^2$. Now there has been the first experimental results which purport to give an absolute value of the sum of the rest mass of the three flavors of neutrinos⁷ as $0.32 \pm 0.08 \text{ eV}$. I will interpret this as the average rest mass since the flavor oscillation is sequential. This was not a direct measurement of mass. Instead it combined cosmological measurements and a theory of the effect neutrino mass should have on these cosmological measurements. Therefore, this measurement could be wrong if the theory is wrong. Still, this mass/energy is reasonable and will be used in further discussion of neutrinos both here and in chapter 13. For example, using a value of 0.32 eV for the mass of the muon neutrino and using the previously mentioned values of the difference in the square of the masses we obtain the following: An electron neutrino should be about $1.2 \times 10^{-4} \text{ eV}$ less than a muon neutrino and a tau neutrino should be about $3.7 \times 10^{-3} \text{ eV}$ larger than a muon neutrino. Therefore this estimate implies that the tau neutrino is about 1% more energetic than the electron and muon neutrinos.

The spacetime wave model of the universe can accommodate neutrinos that have a small rest mass. The starting assumption (the universe is only spacetime) is so restrictive that it greatly narrows the possibilities for physical models. All particles that exhibit rest mass are proposed to generally have the rotar model. Besides the difference in mass, there is obviously a big difference in properties between an electron and an electron neutrino. This implies that there should be a tangible difference in the models of these two spacetime particles. This difference is unknown at the present time. However, since the mechanism for giving a neutrino rest mass, energy and angular momentum is the same as an electron, we will start by using the same general rotar model for an isolated, stationary neutrino as for an isolated, stationary electron.

⁶ K. Nakamura *et al.* (2010). "Review of Particle Physics". *Journal of Physics G* **37**: 1.

⁷ Battye, R. A., Moss, A., Evidence for Massive Neutrinos from Cosmic Microwave Background and Lensing Observations, *Phys. Rev. Lett.* **112**, 051303 (2014)

Modeling a Neutrino: If we assume that the three neutrinos have energy in the range of 0.32 eV, this implies that an isolated neutrino in its rest frame has a Compton angular frequency of $\omega_c \approx 5 \times 10^{14} \text{ s}^{-1}$ and a rotar radius of about $6 \times 10^{-7} \text{ m}$. This large size and low frequency for rotars would seem to present a problem for the rotar model that can be illustrated with an example. A muon decays into an electron, an electron antineutrino and a muon neutrino. The muon has a rotar radius of about $1.9 \times 10^{-15} \text{ m}$ and a Compton angular frequency of about $1.6 \times 10^{23} \text{ s}^{-1}$. If neutrinos have rest mass, how is it possible for the decay of a muon to produce neutrinos that are about 10^8 times larger radius than the muon? ($\sim 10^{-7} \text{ m}$ compared to $\sim 10^{-15} \text{ m}$)

This apparent incompatibility occurs because we are erroneously comparing the size and frequency of isolated rotars in a rest frame when we should be looking at these characteristics when rotars are in the very close proximity to other rotars at the moment of decay. Recall that when an electron collides with a proton or another electron, there is a moment when all the kinetic energy of the electron is converted to internal energy of the electron. This momentarily increases the electron's Compton frequency and momentarily contracts its rotar radius. A 50 GeV electron collision causes the electron to momentarily decrease its rotar radius by a factor of about 100,000 and increase its frequency by the same factor.

It is proposed that a neutrino created in a particle decay (a muon decay for example) is initially created in the high energy, compressed condition characteristic of a collision. This extra energy is converted to the ultra-relativistic velocities of the three decay products produced by the muon decay. This can be seen from the following example: Suppose that we imagine reversing the decay process. The decay products consisting of an electron, an electron antineutrino and a muon neutrino would reverse directions and produce a collision that forms a muon. This collision would be highly relativistic and momentarily return the three decay products to their energetic, compressed state present when the muon initially decayed. In fact, the sum of the frequencies of the three decay products in the compressed state (before separation) would equal the muon's Compton frequency. In this explanation, the neutrinos would not develop the large size and lower frequency until they separate from the other rotars and each is viewed in its rest frame.

Almost all the quantized angular momentum in the universe is contained in neutrinos and photons. All the other leptons and quarks together contain less than one part in 10^8 compared to quantized angular momentum of photons and neutrinos. This makes neutrinos an important consideration when examining the evolution of the universe. Therefore, neutrinos will be discussed again in chapters 13 and 14 on cosmology.

Chapter 13

Cosmology I – The Spacetime Transformation Model

The Big Bang theory is one of only a few theories in science that enjoys virtually universal acceptance. Before about 1929 the “Steady State theory” was favored but since then there have been numerous experimental observations that support the Big Bang theory and disprove the Steady State theory. I am going to propose an alternative to the standard Big Bang model. This might be considered by some as the equivalent of scientific heresy. However, we will faithfully follow our starting assumption (the universe is only spacetime) to its logical conclusion.

As an introduction to the cosmological implications of our starting assumption, we will use a line out of the children’s story of Alice in Wonderland. In this story Alice asks the question: “Is the room getting bigger or am I getting smaller?” Scientists do not ask the equivalent question about the universe. They always assume that the universe is getting bigger while their meter sticks and clocks stay the same. However, this assumption leads to numerous mysteries. How is it possible that distant galaxies are receding at faster than the speed of light? Is new spacetime continuously being created? Is mysterious dark energy required to explain the accelerating expansion of the universe? All of cosmology looks different when we assume that the universe is only spacetime and the properties of spacetime are changing.

Before Copernicus, it was assumed that the earth was the center of the universe. Now we know that we do not live in a special place in the universe, but we at least assume that both our size and our rate of time are constant. I am proposing that the final indignity to mankind is that spacetime is going through a transformation that contracts all physical objects, including the earth and our bodies. Furthermore, the rate of time is also slowing down. It is proposed that the spacetime field is undergoing a transformation which is responsible for what we perceive to be the expansion of the volume of the universe.

Suppose that we imagine going backwards in time from today. The distance between galaxies would decrease and the cosmic microwave background (CMB) photons would increase their energy. Today only a small percentage of the observable energy in the universe is in the form of electromagnetic (EM) radiation. However, going backwards in time we would reach a time when the dominant form of observable energy in the universe was EM radiation. What has happened to this energy that once dominated the universe? Individual photons are not disappearing. Even as photons lose energy they retain all their angular momentum. Electrons and protons appear to be immune from this energy loss, but we have to question whether our standard of energy remains constant over time.

When we assume that the universe is only spacetime both today and throughout its history, we get an entirely different perspective on cosmology. There still is something that can be designated the “Big Bang” but there is no singularity with infinite energy density. In fact, the energy density of the universe never exceeds Planck energy density $\sim 10^{113}$ J/m³. All of this will be explained, but we will start by reviewing the current cosmological principles.

The Cosmic Microwave Background (CMB): The precise measurement of the CMB has had a profound impact on cosmology. The Planck Spacecraft has mapped the full sky distribution of the CMB to a resolution better than 0.1°. The age of the universe has been determined to be 13.8 billion years \pm 0.4%. Also the universe has been determined to not have any large scale curvature. It is “flat” to a measurement accuracy of about 0.1%.^{1,2} The CMB was also mapped by the Wilkinson Microwave Anisotropy Probe (WMAP) which had lower resolution, but some of the data is more accessible and still quite accurate. Therefore, numbers quoted here will be a mixture of these two sources.

Analysis of the data from WMAP has also determined that about 380,000 years after the Big Bang, the energy in the universe was 10% neutrinos, 15% photons, 12% ordinary matter (baryonic matter), and 63% dark matter. For comparison the percentages quoted for today are: 4.9 % ordinary matter, 26.8% dark matter and 68.3% dark energy.

The 15% energy that was photon energy at 380,000 years has today been redshifted by a factor of about 1080. This has reduced the current energy content of these CMB photons to an almost insignificant percentage (\sim 0.014%) of the total energy in the universe. Similarly, neutrinos and other relativistic particles have also lost momentum (kinetic energy) due to the redshift. Therefore, over 20% of the total observable energy present in the universe at an age of 380,000 has disappeared. If we extrapolate back further, the universe was radiation dominated and almost all the observable energy present in the early universe has disappeared (observable energy excludes vacuum energy). The question about what has happened to this observable energy will be discussed later

It can be shown that the energy that was present in ordinary matter and dark matter at 380,000 years is still approximately present in the universe today. The percentages look different because of the addition of dark energy and the subtraction of the energy in photons and neutrinos. Dark energy has never been observed, but it is required by the currently accepted cosmological model. The need for dark energy will also be discussed later.

The measurement of the CMB has also shown that the universe does have a preferred frame of reference. From any given location, the cosmic microwave background only appears isotropic

¹ http://lambda.gsfc.nasa.gov/product/map/dr4/pub_papers/sevenyear/cosmology/wmap_7yr_cosmology.pdf

² Astrophysical Journal Supplement 180: 225-245 February 2009

from a particular frame of reference called the “CMB rest frame”. For example, the sun appears to be moving at about 369 km/s in the direction of the Virgo constellation relative to the CMB as seen from the sun’s location. This relative motion produces a Doppler shift in the CMB that shows up as a redshift in the CMB in one direction and a blue shift in the CMB in the opposite direction (dipole anisotropy). This anisotropy is subtracted from CMB pictures to produce the speckled but uniform CMB pictures commonly exhibited showing only small temperature variations. Each location in the universe has a unique frame of reference that is stationary relative to the CMB.

Hubble Parameter: The expansion rate of the universe will be referred to as the “Hubble parameter \mathcal{H} ”. It is not a true constant since it changes over time. The expansion of the universe quoted by astrophysicists usually is given in units of kilometers/second/mega-parsec (km/s/Mpc). This might be convenient units for astrophysicists, but since we are standardizing on SI units, we will convert this into units of m/s/m. The conversion is: $\text{km/s/Mpc} \approx 3.24 \times 10^{-20} \text{ m/s/m}$. The Hubble parameter measured by the Planck spacecraft has been combined with other measurements to yield composite measurements ranging from about 67 to 68 km/s/Mpc. This book will use $\mathcal{H} = 67.8 \text{ km/s/Mpc} = 2.2 \times 10^{-18} \text{ m/s/m}$. To put this in perspective, two points at rest relative to the local CMB rest frame and separated by $4.5 \times 10^{17} \text{ m}$ (~ 49 light years) would be moving away from each other at 1 m/s. The Milky Way galaxy and even galaxy clusters are gravitationally bound and do not expand with the expansion of spacetime. Galaxies separated by more than about 300 million light years exhibit this expansion.

The Hubble parameter has units of inverse seconds. If the universe expanded linearly from the Big Bang to today, then $1/\mathcal{H}$ would equal the age of the universe in seconds. Using the measured value, $1/\mathcal{H} = 4.5 \times 10^{17} \text{ seconds} = 14.4 \text{ billion years}$ compared to the 13.8 billion years age of the universe measured other ways by the Planck spacecraft.

Comoving Coordinates: The perspective of a unique CMB rest frame at each location has led to the concept that the universe can be modeled as having a “comoving coordinate system”. This is a coordinate grid that expands with the Hubble expansion of the universe. Each point on this grid is in the CMB rest frame for that location. This is also called the “comoving frame”. A comoving observer is the only observer that will see the universe (including the CMB) as isotropic. Galaxies are nearly in the comoving frame, so any velocity they have relative to the comoving frame is their “peculiar velocity”.

At any given instant, all points in the CMB rest frame are experiencing the same rate of time if local gravitational disturbances are ignored. Another way of saying this is that on the scale where the universe is homogeneous (about 300 million light years), all points in the comoving frame are experiencing the comoving coordinate’s cosmological time.

Comoving distance χ is the proper distance between two points (both in the comoving frame) at the present instant of comoving time. While comoving distance corresponds to proper distance at the present instant, comoving distance is imagined to remain at a fixed value of χ over time. In the past or future the proper distance between these two points changes with the Hubble flow but the comoving distance is a fixed designation on an expanding coordinate system. The cosmic “scale factor (a)” is a function of time and usually designated as: $a(t)$. This scale factor quantifies the relative expansion of the universe between two moments in time. The term l_t is proper distance between the two points at a different time (different ages of the universe). The relationship between these terms is:

$$\chi = l_t a(t)$$

The current scale of the comoving coordinate system is designated “ a_o ” and usually set to equal one ($a_o = 1$).

The Λ -CDM Cosmological Model: Λ -CDM is an abbreviation for Lambda-Cold Dark Matter. This is currently considered to be the standard Big Bang model. In 1929 when Edwin Hubble discovered the redshift of galaxies (he called them nebula), the initial interpretation was that these were Doppler shifts due to relative motion of galaxies expanding into a preexisting void. Hubble proposed that there was a linear relationship between velocity and distance. The current interpretation is that the redshift is due to a cosmological expansion of the universe where space itself is being continuously created everywhere. One difference between Hubble’s concept (a preexisting void) and cosmological expansion is that cosmological expansion is currently believed to be able to produce separation velocities that exceed the speed of light. Observations strongly support the general relativistic interpretation of a cosmological expansion over the special relativity interpretation of mass expanding into a preexisting void.

A detailed description of the Λ -CDM model will not be given here. However, there are several physical interpretations and predictions of this model that will be described to establish the current perspective of cosmologists. The favored Λ -CDM model is usually designated as: $\Omega_M = 0.31$ and $\Omega_\Lambda = 0.69$ with the Hubble parameter $\mathcal{H} \approx 67.8 \text{ km/s/Mpc} = 2.2 \times 10^{-18} \text{ m/s/m}$ (in MKS units)

The matter density parameter $\Omega_M = 0.31$ represents that all forms of matter makes up approximately 31% of the critical density of the universe and the cosmological constant density parameter $\Omega_\Lambda = 0.69$ indicates that dark energy makes up about 69% of the critical density of the universe. Dark energy is the hypothetical energy that expands the universe and is associated with Einstein’s cosmological constant Λ .

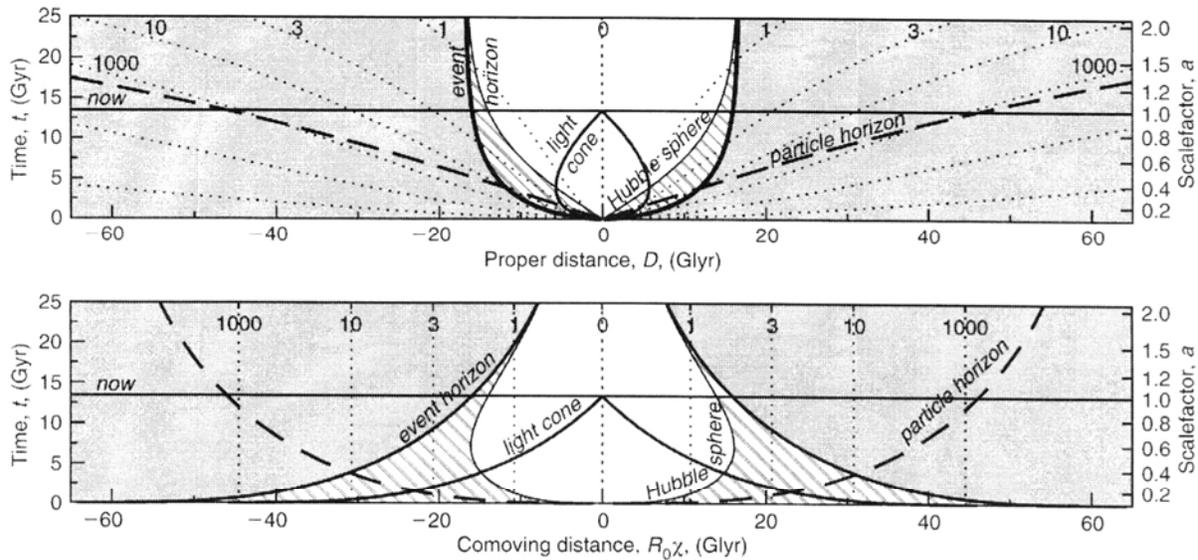


FIGURE 13-1 Spacetime diagrams showing some of the features of the Λ - CDM model of the expanding universe.

(From Davis and Lineweaver, *Astronomical Society of Australia*, 2004, 21, 97-109)

Figure 13-1 is taken from a very good article titled “Expanding Confusion: Common Misconceptions of Cosmological Horizons and Superluminal Expansion of the Universe”³ Figure 13-1 is two spacetime diagrams that plot time versus proper distance D on the top panel and time versus comoving distance on the bottom panel. The panels are drawn from the perspective of an observer located at the intersection of the “now” line (13.8 billion years after the Big Bang) and the distance = 0 line. The lower panel has vertical world lines for objects currently with various redshifts ($z = 0, 1, 3$ etc.) because the comoving distance χ does not change over time. The proper distance changes over time but the comoving distance is a coordinate distance that expands with the comoving coordinate system. The two panels offer different perspectives and the following description applies to both panels.

The dashed line labeled “particle horizon” crosses the 13.8 billion year “now” line at about 46 billion light years. It is to be understood that even though a signal from the most distant source currently reaching us, called the particle horizon, has been traveling at the speed of light for 13.8 billion years, the current distance to that source is larger than 13.8 billion light years. This is because the cosmic expansion of the universe has continued to increase the volume of the universe and the distance between points after the speed of light signal has passed any location.

Next we will look at the line labeled “Hubble sphere”. Currently the boundary of the Hubble sphere is 13.8 billion light years from us. This is the distance where space itself is supposedly

³ T. M. Davis; C. H. Lineweaver; *Publications of the Astronomical Society of Australia* 2004, 21, 97-109.

receding from us at a velocity equal to the speed of light (concept examined later). According to the Λ -CDM model, the space beyond the Hubble sphere is receding from us faster than the speed of light. This gives rise to an “event horizon”.

The line labeled “event horizon” represents the furthest distance that we can receive current information. For example, according to the Λ -CDM model, galaxies that we currently observe as having a redshift of $z = 1.8$ are currently crossing our event horizon. This means that light being emitted by these galaxies today will never reach us because of the accelerating expansion of the universe. All galaxies with redshifts greater than 1.8 have already crossed our event horizon and will disappear from view sometime within the next 14 billion years (larger redshifts disappear sooner).

According to the Λ -CDM model eventually the Hubble sphere and the event horizon will be approximately the same distance. In the distant future the universe will have an event horizon at a constant proper distance of about 17 billion light years. Galaxies will continue to disappear from view as they are carried by cosmological expansion beyond this distance. Eventually only the gravitationally bound galaxies will remain visible. If the concept of accelerating expansion of the universe is carried to its logical conclusion, we would end with the “Big Rip” where expanding spacetime eventually tears apart our galaxy, then our solar system and eventually even atoms.

Problems with the Big Bang Singularity and Inflation: The most widely accepted model for the start of the universe is a “singularity” with no volume and infinite energy density. That starting condition requires that the laws of physics “break down”. It also creates a problem for explaining how today the energy density of the universe is homogeneous on the large scale. Starting with a singularity results in inhomogeneous distribution, even on the large scale. Therefore, physicists postulate a period of “inflation” when the universe expanded much faster than the speed of light. This hypothesis would result in the portion of the universe that we can observe being homogeneous.

However, it is generally agreed that the universe extends far beyond our current particle horizon. Some cosmologists even suggest that the “extended universe” is infinite. We do not need to decide that question in order to do the following thought experiment. Suppose that we could obtain a map of the universe extending far beyond our particle horizon. Would the map reveal that the universe is inhomogeneous on the extended scale? Inflation supposedly did not really eliminate the inhomogeneities caused by starting from a singularity. It merely expanded the volume so much that any single observer does not see obvious large scale inhomogeneities. The implication is that today there are parts of the extended universe that have substantially different density than the density of our observable portion of the universe.

It has been established by WMAP space probe that the portion of the universe that we can observe has flat spacetime to within the 0.4% margin of error. Do we live in a special part of the universe that happens to have achieved this special condition? Surely if there are unobservable parts of the extended universe that have substantially different density, then they would not have flat spacetime. An important cosmological principle is that we do not live in a special part of the universe. This should apply even to the extended universe beyond our particle horizon. The implication is that 13.8 billion years after the Big Bang, all parts of the extended universe should have the same density. Inflation does not explain how the extended universe can be homogeneous.

Spacetime Transformation Model: We are about to start the description of an alternative cosmological model that will be referred to as the “spacetime transformation model”. This model will be more fully explained in the next chapter, but key parts of the model will be presented in this chapter. Initially, these key parts will be explained using the familiar concepts and terminology of the current Big Bang model. When explaining the spacetime transformation model, the initiation of the transformation (the beginning of time) will be referred to as the “Big Bang”. This is a highly descriptive term that is being adapted to express the start of a transformation of one form of spacetime to another. This was accompanied by a tremendous increase in proper volume, so the term “Big Bang” is still applicable.

If the universe is only spacetime, how does the spacetime field create new volume? Today, a lot of attention is being paid to the apparent acceleration of the expansion of the universe. While this is an important question, it is not possible to answer this question until we first understand how any new proper volume is created in the universe. If the expansion of the universe is imagined as mass/energy expanding into a preexisting void, then momentum would continue this expansion and there would be no mystery. However, the Λ -CDM model of cosmology says that the universe is undergoing a cosmological expansion. This expansion is the result of new volume continuously being created everywhere in the universe. This new volume is indistinguishable from previously existing volume. Therefore, the new volume must also contain vacuum energy with energy density of more than 10^{112} J/m³. Suppose that we attempt to put this in perspective. The Hubble parameter is $\mathcal{H} \approx 2.2 \times 10^{-18}$ m/s/m. This means that each second, each cubic meter of spacetime is expanding by $(2.2 \times 10^{-18})^3 \text{ m}^3 \approx 10^{-53} \text{ m}^3$. This small volume seems insignificant until it is realized that the energy density of this new volume is approximately Planck energy density $U_p = 10^{113}$ J/m³. Therefore, 10^{-53} m^3 requires about 10^{60} J of vacuum energy. The mass of the Milky Way is about 10^{42} kg equivalent to an annihilation energy of about 2×10^{59} J. Therefore, each cubic meter in the universe seems to be adding the equivalent the Milky Way’s energy each second.

This seems ridiculous, but it appears that there are only three choices to explain this discrepancy. Either 1) vacuum energy is canceled by some other equally vast offsetting effect; 2) a vast amount of new vacuum energy is being continuously added to the universe to maintain a specific

vacuum energy density or 3) a fixed amount of vacuum energy is being distributed over an increasing volume which vastly decreases the energy density of vacuum energy as the universe expands from the Big Bang today. All of these alternatives seem unappealing. The spacetime transformation model of the universe will propose a fourth explanation which involves the transformation of the properties of spacetime.

The addition of new volume to the universe is not some subtle effect that is taking place in remote parts of the universe between galaxies. It is possible to illustrate the scale of cosmic expansion using our own solar system as an example. Suppose that we consider a spherical volume with the radius of Neptune's orbit (radius $\approx 4.5 \times 10^{12}$ m). This solar system size spherical volume would contain all the major planets and have a volume of about 3.8×10^{38} m³. Calculating from the Hubble parameter ($\mathcal{H} \approx 2.2 \times 10^{-18}$ s⁻¹), this volume would increase by about 10^{21} m³ each second if the spherical volume expanded proportional to the Hubble expansion of the universe. To put this expansion in perspective, this solar system size volume is adding the equivalent of about earth's volume (1.08×10^{21} m³) every second. We do not notice any change in the volume of the solar system or the Milky Way galaxy because these objects are gravitationally bound. The addition of new volume becomes obvious when distance (proper light travel time) is measured between galaxies that are not gravitationally bound together. Only after we have a plausible explanation for the creation of this new volume everywhere in the universe, can we seriously address the question about the nonlinearity in this creation process (accelerating expansion).

The new volume is also spacetime so a rephrasing of the question is: How does spacetime rearrange itself to creating new proper volume? If the universe is only spacetime, and if the universe appears to be expanding, then the properties of spacetime must be changing with time. Something must be changing because today it takes a longer time for light to travel between two galaxies than it did a billion years ago (assuming each galaxy is at rest relative to the CMB).

Proper Volume: What examples do we have of spacetime adjusting itself in a way that changes proper volume? In the example of the Shapiro experiment, the sun's gravity changed the spacetime between the earth and the sun in a way that increased the proper radial distance by about 7.5 km compared to the radial distance that would be expected from Euclidian geometry. This increase in radial distance increased the volume within a sphere that is 1 astronomical unit (1 AU) in radius by $\Delta V \approx 3.46 \times 10^{26}$ m³ (previously calculated). This non-Euclidian increase in proper volume is more than 300,000 times the earth's volume. This volume increase was accompanied with a decrease in the rate of time.

Also, the rotar model has two lobes where the properties of spacetime are slightly distorted. The slow time lobe has a rate of time that loses 1 unit of Planck time in a time period of $1/\omega_c$. That slow time lobe has a volume that is larger than what would be expected from Euclidian geometry. The fast time lobe has less proper volume than would be expected from Euclidian geometry.

Again it appears as if there is an inverse relationship between proper volume and the rate of time.

Near the end of chapter 2 it was shown that the standard solution to the Schwarzschild equation has a 4 dimensional volume that is independent of the gravitational gamma Γ because the change in the time dimension offsets the change in the radial spatial dimension. In all these examples, there is an interconnection between the rate of time, the coordinate speed of light and proper volume. We will explore the following idea:

New proper volume is created when the rate of time decreases.

It is proposed that spacetime is able to exchange the absolute rate of time for proper volume. This concept is implied in the following equation:

$$\frac{dt}{d\tau} = \frac{dL_R}{dR} = \Gamma \quad \text{note inverse relationship between } d\tau \text{ and } dL_R$$

While dL_R/dR applies to the radial direction in the Schwarzschild coordinate system, the above equation also can be interpreted as showing an inverse relationship between the rate of proper time and proper volume even when applied to the entire universe. We see the proper volume of the universe increasing, but proving that this is coupled with a decreasing rate of time is more difficult. An absolute proof that the rate of time is slowing in the universe would require the comparison to a hypothetical coordinate clock outside of the universe. This is an impossible experiment, so instead we will start with several thought experiments.

Cavity Thought Experiments: First we will imagine a spherical shell with mass m and internal radius r . We will place this spherical shell in space where it is in an inertial frame of reference. If the spherical shell has mass, then on the outside surface of this spherical shell we would experience a gravitational acceleration accompanied by the standard time dilation and gravitational effect on volume. Inside this spherical shell, there would be no gravitational acceleration and we could consider this flat spacetime. However, the escape velocity from the shell is greater if we start from inside the shell compared to starting from the outside surface. Even though there is flat spacetime, inside the spherical shell we still have the gravitational effects that are a function of escape velocity and scale with Γ . This point was also made in chapter 2 with examples using a cavity at the center of the earth and the Andromeda galaxy. The gravitational effect on the rate of time, the coordinate velocity of light and on proper volume remains even when there is no gravitational acceleration. However, only the gravitational effect on the rate of time is easy to experimentally see so we will temporally concentrate on the gravitational effect on the rate of time.

Background Gravitational Gamma Γ : Previously we defined the gravitational gamma Γ and a closely related concept, the gravitational magnitude β . These were defined as follows:

$$\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}} = 1/\sqrt{1 - v_e^2/c^2} = \frac{1}{1 - \beta} \quad \Gamma = \text{gravitational gamma; } v_e = \text{escape velocity}$$

$$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2 R}} = 1 - \frac{1}{\Gamma} \quad \beta = \text{gravitational magnitude}$$

$$\Gamma \approx 1 + \beta \quad \text{and} \quad \beta \approx \frac{Gm}{c^2 r} \quad \text{weak gravity approximations}$$

Inside a cavity uniformly surrounded by mass m , there is a gravitational effect, but the gravitational gamma definition $\Gamma = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}}$ needs to be reinterpreted. This equation presumes an isolated mass in an otherwise empty universe. The interior of a spherical shell does not meet this assumption. However, the definition of Γ that incorporates escape velocity v_e is easily definable: $\Gamma = 1/\sqrt{1 - v_e^2/c^2}$. For example, a cavity at the center of the earth would have an escape velocity about 22% greater than the escape velocity starting from the earth's surface (assuming a uniform density approximation and ignoring air friction).

The other alternative definition for the gravitational gamma (stationary frame) also works for a cavity surrounded by mass: $\Gamma = dt/d\tau$. In this case, we define a coordinate clock far from the source of gravity with a rate of time dt and a clock in the cavity with rate of time $d\tau$. Actually, the definition $\Gamma = dt/d\tau$ is preferable because it is also applicable to the entire universe.

The reason for discussing cavities surrounded by mass is that our location in the universe has similarities to a cavity surrounded by mass. In fact, the universe is something like being surrounded by a shell that is increasing in mass every second. What would it be like to be inside a shell that is increasing its mass? (assuming inertial frame of reference) The rate of time would be slowing down and the coordinate speed of light would be slowing down, but we would not be able to directly detect these changes unless we had communication to an outside standard. However, it is proposed that we would notice something strange was happening. A careful experiment would reveal that light was undergoing a slight redshift. The wavelength of light propagating inside the cavity would increase with propagation time. A proof of this contention will be given in the next chapter to explain the redshift observed in the universe.

We often make the assumption that a location in space far from the earth and sun can be considered to be a location with zero gravity. It is true that there might be negligible gravitational acceleration, but we are still surrounded by all the mass/energy within the particle horizon for our location in the universe. We know from observations of the Cosmic Microwave Background (Planck space probe) that the universe is flat spacetime to within a 0.1% margin of error. This suggests that the universe extends infinitely beyond our particle horizon. However, only the mass/energy within our particle horizon can have any influence on us. The mass/energy within our particle horizon exerts a background gravitational effect which must

have greatly slowed down both the rate of time and the coordinate speed of light compared to a hypothetical universe without this influence. We will use a new name to discuss this subject.

Background Gravitational Gamma of the Universe Γ_u : The name “background gravitational gamma of the universe” and the symbol Γ_u will be used to represent the concept that the universe possesses a gravitational effect that produces no acceleration but affects the rate of time, proper volume, the coordinate speed of light and many other physical properties. With background gamma there is distributed mass/energy in all directions so we do not meet the Schwarzschild assumption of a single mass in an otherwise empty universe. However, the definition of Γ based on the effect on the rate of time is the same: $\Gamma_u = dt/d\tau_u$ where $d\tau_u$ is the rate of time in a frame of reference that is stationary relative to the cosmic microwave background (CMB) and far from localized sources of gravity. In this case dt is the coordinate rate of time which is either the rate of time in a hypothetical universe without gravitational influence where $\Gamma_u = 1$ or the rate of time at the instant the Big Bang started (when $\Gamma_u = 1$). This will be explained later.

To illustrate the concept of a background gravitational gamma, an example will be given using the Milky Way galaxy. This galaxy has a visible radius of about 50,000 light years, but dark matter is believed to extend to a radius of at least 150,000 light years. The sun’s orbit is about 26,000 light years in radius around the galactic center. The galactic gravitational acceleration felt by the sun is due entirely to matter that is inside the sun’s orbit. Matter and dark matter in the Milky Way galaxy that lies external to the sun’s orbit does not produce any gravitational acceleration on the Sun. However, this external matter does still produce a gravitational effect in the sense that it affects the rate of time, the coordinate velocity of light, the gravitational potential, the escape velocity from the galaxy, the standard of energy, etc. In other words, this external matter is producing a significant background Γ at the sun’s orbital distance.

It is interesting to estimate the background Γ of the Milky Way galaxy caused by the galaxy’s mass external to the sun’s 26,000 light year orbit. The total mass of the galaxy, including dark matter, is estimated at about 1.2×10^{42} kg. The mass inside the sun’s orbit required to produce the required gravitational acceleration on the sun is only about 15% of this total mass of the galaxy. Therefore the mass of the Milky Way galaxy external to the sun’s orbit is about 10^{42} kg. Almost all of this mass is dark matter that is spherically distributed around the Milky Way galaxy. For this calculation we will estimate that all the mass external to the sun’s orbit can be simulated by a spherical shell 110,000 light years in radius with mass of 10^{42} kg. Substituting into $\beta \approx Gm/c^2r$ we obtain $\beta \approx 7 \times 10^{-7}$ (or $\Gamma \approx 1 + 7 \times 10^{-7}$). The earth’s gravitational magnitude at the earth’s surface is $\beta \approx 7 \times 10^{-10}$ (or $\Gamma \approx 1 + 7 \times 10^{-10}$). While neither the earth nor the Milky Way galaxy have a large effect on the absolute rate of time, the Milky Way’s uniform background Γ slows down the rate of time about 1,000 times more than the earth’s own gravity ($7 \times 10^{-7}/7 \times 10^{-10}$).

Extending the concept to the background gamma to the universe Γ_u , all the mass/energy within the particle horizon is creating a very large value of Γ_u . Individual stars and galaxies represent only a relatively small perturbation of curved spacetime in the flat and very large background Γ_u of the universe. (Black holes will be discussed later.) For example, if the universe had 99 % of the m/R ratio required to form a black hole, the background gravitational gamma of the universe would be: $\Gamma_u \approx 10$. Later we will attempt to calculate the actual current value of Γ_u of the universe. General relativity calculations normally ignores the background gamma of the universe which is the same as assuming that this background is $\Gamma_u = 1$. This is acceptable for all calculations involving discrete mass or even galactic clusters. However, when attempting to explain the expansion of the universe, this cannot be ignored.

Besides Γ_u , there is a related concept that is the background gravitational magnitude of the universe: β_u . The relationship between Γ_u and β_u is the same as the relationship between Γ and β . Some equations are simpler when expressed in terms of gravitational magnitude β rather than gravitational gamma Γ . The exact conversion between Γ and β is: $\beta = 1 - 1/\Gamma = 1 - d\tau/dt$. These relationships also hold for β_u . The gravitational magnitude β has a scale that ranges from 0 to 1 while the gravitational Γ has a scale that ranges from 1 to infinity

Isotropic and Homogeneous Universe: All points on the comoving coordinate system (CMB rest frame) perceive the universe to be isotropic and homogeneous. This includes the rate of time which is the same everywhere in the CMB rest frame. Since points on the comoving coordinates are expanding away from each other, what does it mean for these points to have the same rate of time at a given instant? This can be illustrated with a thought experiment. Suppose we have 3 spaceships located far from sources of gravity in intergalactic space. Each of the three spaceships is exactly stationary relative to the CMB for its location. The three spaceships are widely separated forming a straight line with the middle spaceship exactly halfway between the two outside spaceships. Suppose the two outside spaceships sent out a stable microwave signal at the 9.19 gigahertz corresponding to the frequency of their cesium atomic clocks. When the two signals reach the middle spaceship, the frequency would be slightly lower (redshifted) compared to the atomic clock on the middle spaceship due to cosmic expansion. However, the important point is that both the frequencies from the two outside spaceships would be exactly the same. The middle spaceship observes that both the outside spaceships were experiencing the same rate of time at the instant the signals left the spaceships. With relativity there can be confusion about different definitions of the term “simultaneous”. Therefore, the concept of a “midpoint observer” specifies one way of defining simultaneous. The two outside spaceships are simultaneously experiencing the same rate of time according to the midpoint observer.

This means that all points on the comoving grid are experiencing the same rate of time according to midpoint observers. Therefore, this rate of time is used as coordinate rate of time in the Robertson-Walker metric. Now suppose that all three spaceships are stationary relative to each other. An extrapolation of the thought experiment shows that the even if the three spaceships

are moving relative to the CMB but stationary relative to each other, the midpoint observer will still see that the outside spaceships are experiencing the same rate of time. This concept can be extended to any two points in the universe in the same frame of reference.

On the scale where the universe is homogeneous, any two points in the same frame of reference experience the same rate of time according to a midpoint observer.

No Large Scale Gravitational Acceleration: This thought experiment will be explained using the rotar model of an electron and the explanation for gravity previously developed. Suppose that we place an electron (rotar) in intergalactic space and ignore any locally generated forces. We are only interested in examining gravity on the scale larger than 300 million light years where the universe is homogeneous. We are going to test the large scale gravity of the universe using the rotar model of an electron. Recall that a rotar experiences gravitational acceleration when there is a rate of time gradient across the rotar. This causes the vacuum energy to exert an unbalanced pressure on opposite sides of the rotar. This produces a net force that is the gravitational force. The acceleration of gravity (g) was previously shown to be:

$$g = c^2 \left(\frac{d\beta}{dr} \right) = -c^2 \frac{d\left(\frac{d\tau}{dt}\right)}{dr} \quad g = \text{gravitational acceleration}$$

It was previously shown that the distance designated in the denominator (dr) is proper length, not coordinate length (circumferential radius) from general relativity. If there is no gradient in the rate of time, then $d(d\tau/dt)/dr = 0$ and $g = 0$. There is no gravitational acceleration when there is no gradient in the rate of time. Two points on the opposite sides of the quantum volume of a rotar can be considered to be two points in the same frame of reference. In a homogeneous and isotropic universe, the same rate of time is present on opposite sides of the rotar (according to the midpoint observer). There is no gravitational acceleration on the homogeneous scale of 300 million light years or larger. All this might seem obvious, but it implies that the universe is not struggling to expand against a gravitational force that is attempting to collapse the universe. The gravity of localized objects like stars and galaxies can curve spacetime on a local scale, but there is not a rate of time gradient in the universe on the scale where the universe is homogeneous.

If there is no large scale rate of time gradient in the universe, then there is no tendency for there to be gravitational deceleration or acceleration at this scale.

It might be argued that dark energy is currently providing something like anti-gravity. To defend this position it would have to be argued that gravity is currently producing a rate of time gradient that is attempting to collapse the universe but dark energy is producing an opposite rate of time gradient. The combination offset each other and eliminates any large scale rate of time gradient thereby eliminating large scale gravitational acceleration. However, even this argument has an

obvious flaw. Dark energy only became a significant fraction of the energy in the universe roughly 7 billion years ago. It would have to be argued that prior to this time there was a large scale rate of time gradient in the universe. This is counter to the assumptions contained in the Robertson-Walker metric. It is not possible to have an isotropic universe if there is a large scale rate of time gradient. In fact, if there was a large scale rate of time gradient present when the CMB radiation was emitted, evidence of this rate of time gradient would be preserved as anisotropy in the CMB unless we happen to be located at the exact center of the rate of time gradient.

Rate of Time Gradient in a Dust Cloud: It is an axiom of general relativity that a distributed cloud of dust (no pressure) should experience a uniform gravitational collapse. If the cloud is divided into spherical volumes of successively larger radii, then a particular dust particle (the test particle) in the cloud experiences gravitational acceleration only from the gravity of dust particles within the smaller radii spheres. Mass that lies outside the spherical volume containing the test particle does not contribute to the gravitational acceleration. Enlarging the radius of the imaginary spherical volume increases the enclosed mass. The net effect is that the collapse of the dust particles happens everywhere.

However, gravitational acceleration does not happen in the abstract. To have gravitational acceleration, the cloud of dust particles must have a definable rate of time gradient. It takes a rate of time gradient of about 1.11×10^{-17} seconds/second/meter to produce acceleration of 1 m/s^2 . It would be possible to draw a three dimensional map showing the equivalent of isobar lines within the cloud except depicting regions of constant rate of time. A dust cloud or a galaxy does have rate of time contours that can be mapped. However, the universe has (and always had) the same rate of time everywhere on the large scale addressed by the comoving coordinate system. Is it possible to propose a model of the universe that does not have a rate of time gradient on the scale of the comoving coordinate system? Furthermore, does such a model follow logically from starting the universe as Planck spacetime? These questions will be examined by starting with a thought experiment.

Dust Particle Cloud Thought Experiment: Suppose that the previously mentioned cloud of dust particles is uniformly distributed in space over a volume about the size of the earth. Also, suppose that it is possible to turn off the gravity of all the dust particles in the cloud. This is an unrealistic assumption for a cloud of dust but it will be shown that it is not unrealistic for the beginning of the universe. Therefore attempt to follow this hypothetical thought experiment. After turning off the gravity of each dust particle, the gravitational magnitude within the cloud would quickly drop to $\beta = 0$ which is equivalent to $\Gamma = 1$. The proper rate of time everywhere within the cloud would be equal to the coordinate rate of time, therefore we would start with $d\tau = dt$ or $\Gamma = dt/d\tau = 1$. There obviously would be no rate of time gradient.

Next, the gravity of all the particles is simultaneously turned on. At speed of light propagation, there would be a period of time where the proper rate of time $d\tau$ would be slowing down while the gravitational influence of successively more distant particles is becoming established. For example, it takes about 20 milliseconds for the gravity of a particle at the center of this earth size cloud to affect the rate of time of particles near the outer “surface” of the spherical cloud and vice versa. It would take about 40 ms for the most distant particles on opposite sides of the cloud to make gravitational contact. Therefore, it takes about 40 ms for the mature gravitational acceleration (mature rate of time gradient) within the cloud to become fully established. Since we are defining the gravitational gamma as $\Gamma = dt/d\tau$, we could characterize the establishment of gravity at a particular location in the cloud by referring to the value of Γ as a function of time after the gravity was turned on.

Suppose that we look just at the first few milliseconds after turning on the gravity. Also we will examine several points (test points) within the cloud that are close enough to the center of the cloud that there is not enough time to establish gravitational communication with the boundary condition that occurs at the outer surface of the cloud. In the first few milliseconds the gravitational Γ is increasing exactly the same way at each of these test points. Even though the rate of proper time is slowing (Γ is increasing), there is no gradient in the rate of proper time. This is because all the test points (and all other points far from the surface) have undergone exactly the same amount of gravitational interaction with their surrounding particles. The lack of a rate of time gradient means that there would be no gravitational acceleration attempting to collapse the cloud during the first few milliseconds after gravity is turned on in this thought experiment. There is no tendency towards gravitational collapse only during the nonequilibrium condition of an increasing value of the background Γ . Within the dust cloud there is flat spacetime while Γ is increasing. This flat spacetime does not require a “critical density”. The low density of the dust cloud is vastly less than meeting the conditions of a “critical density”, yet during the nonequilibrium phase of increasing Γ the dust cloud does achieve flat spacetime (no gravitational acceleration). In fact, any homogeneous density can achieve flat spacetime provided that the nonequilibrium condition of an increasing background Γ is somehow achieved.

Immature Gravity: This thought experiment describes a condition that will be called “immature gravity” or the nonequilibrium condition where the gravitational influence of distant mass/energy is in the process of being established. This is to be contrasted to the “mature gravity” condition where there has been sufficient time to establish the gravitational gradients resulting from the existence of distant boundary conditions (distant changes in density). In this example, after about 40 ms there are differences in the rate of time throughout the cloud because of different distances to the cloud boundary. The rate of time gradient produces gravitational acceleration that was previously missing. This is the mature gravity condition we normally assume when we talk about the uniform gravitational collapse that we expect from a cloud of particles. These concepts can be illustrated using the following figures.

Figure 13-2 shows a volume deep within the dust cloud. Suppose that this is a snap-shot about 1 ms after the gravity was “turned on”. The circle labeled “particle horizon for point O” would have a radius of about 300,000 m which represents the speed of light gravitational contact established from point “O” after 1 ms. This horizon is actually an expanding sphere and the figure is a cross sectional representation of a moment in time. There is also another point designated “X” that is relatively close to point O compared to the particle horizon. For example, suppose point “X” is separated by 30,000 m from point “O”. This separation distance is about 10% of the distance to the particle horizon after 1 ms. However, it should be noted that point “X” has a different expanding particle horizon designated by the double line circle. After 1 ms this particle horizon is also a sphere about 300,000 m in radius, but centered on point “X”.

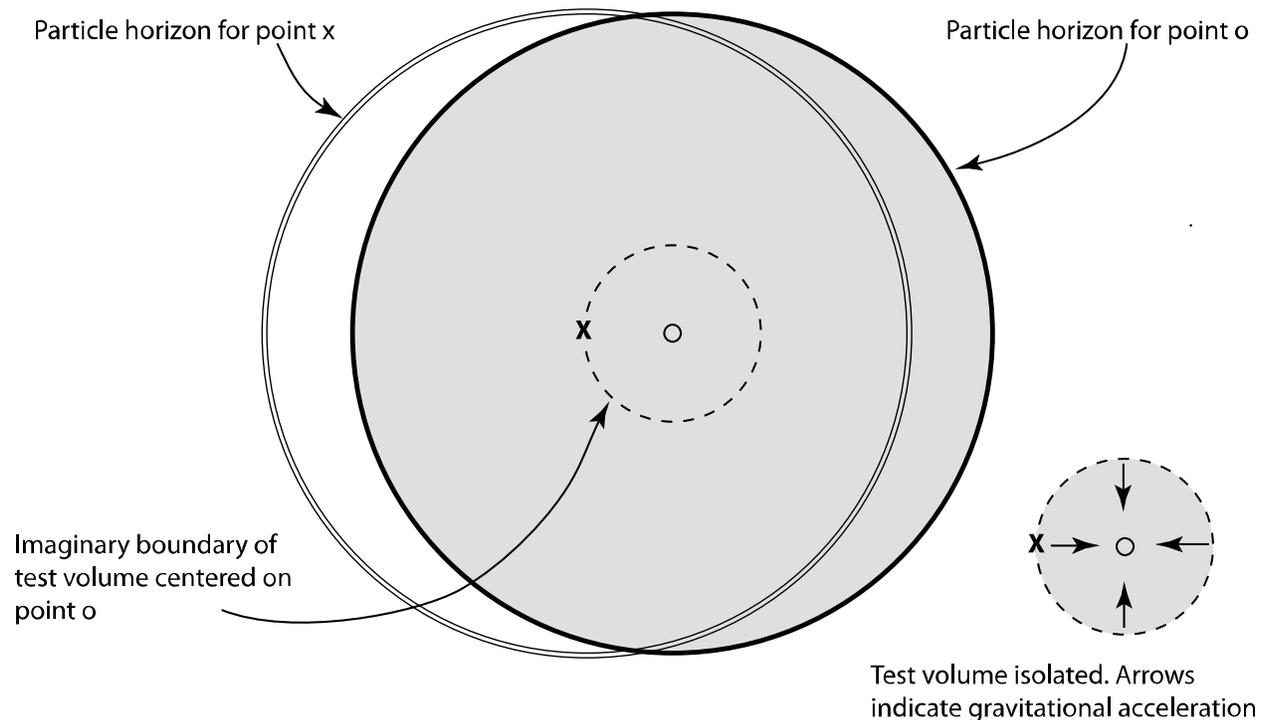


FIGURE 13-2 Observational universe as seen from point o

Figure 13-2 also shows a “test volume”. This is an imaginary sphere that is centered on point “O” and has a radius equal to the distance between point “O” and point “X” (about 30,000 m). Therefore, after 1 ms there has been enough time for the center of this 30,000 m radius spherical volume to establish gravitational contact with all the other dust particles within the test volume (0.2 ms is required for opposite edges to establish gravitational contact). Now we are going to examine the gravitational forces on dust particles within the test volume if the test volume is isolated as shown in the lower right hand corner of figure 13-2. This isolated illustration shows both points “O” and “X”. If this small test volume is isolated as shown, then after 0.2 ms all particles in the test volume have sufficient time to establish gravitational contact with the boundary of the test volume. If the test volume is isolated as shown, the “mature” rate of time

gradient would be established within the test volume after 0.2 ms. In this case, particles within this test volume would start to undergo a gravitational collapse and a dust particle at point “X” experiences a gravitational force towards point “O” as shown by the arrow.

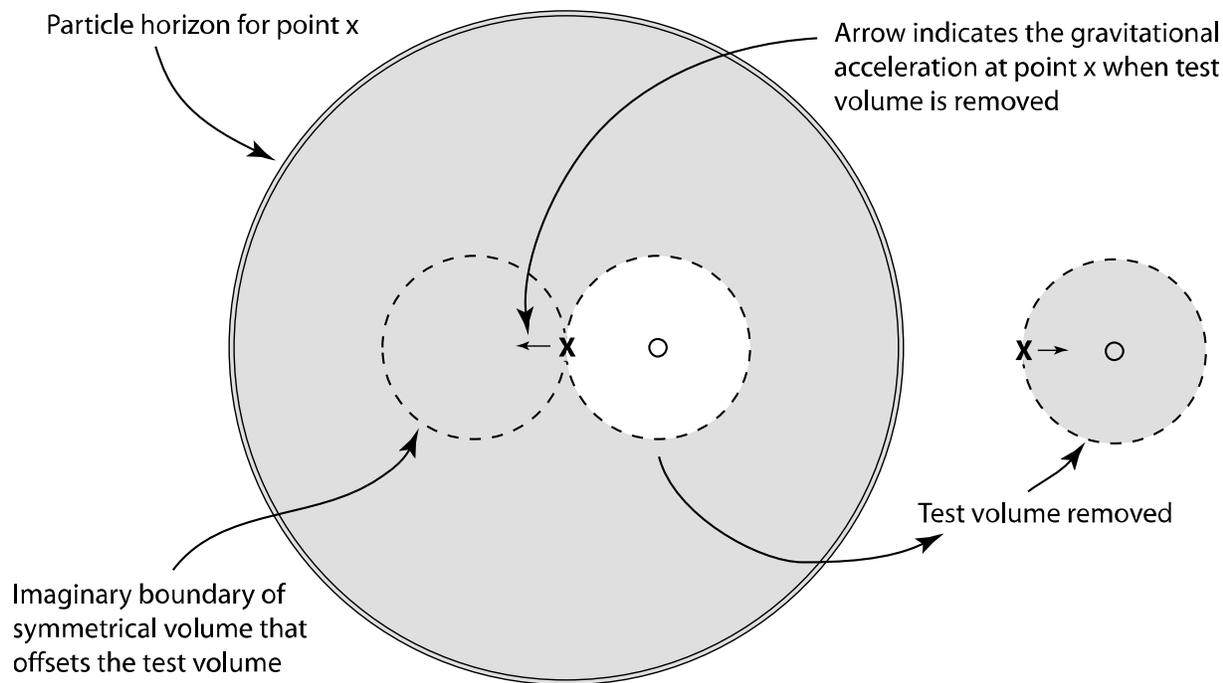


FIGURE 13-3 Observational universe as seen from point x. When test volume is removed, point x experiences a gravitational acceleration in the direction shown. When the test volume is present, there are balanced forces at point x and no net gravitational acceleration.

Figure 13-3 shows a different perspective centered on point “X”. Therefore the particle horizon in figure 13-3 is a sphere centered on point “X”. Now we are going to examine the forces on point “X”. In the previous figure, we concluded that a dust particle at point “X” had a force towards point “O” after 0.2 ms when the test volume was isolated. From this new perspective shown in figure 13-3, suppose that we were to physically remove the test volume as shown to the right. Now 1 ms after gravity has been “turned on” the dust particle at point “X” has unbalanced force from the comparable volume to its left that is designated as “the symmetrical volume that offsets the test volume”. The length and direction of this arrow represents the gravitational force on a dust particle. This force arrow is pointing into the “symmetrical volume” and exactly offsets the length and direction of the force arrow pointing towards point “O” in the test volume. With the test volume removed, point “X” would experience a gravitational force in the direction of the arrow pointing to the center of the “symmetrical volume”. However, if the test volume is present and point “X” is surrounded by a homogeneous distribution of particles, then there is no net force on a dust particle located at point “X”. There is also no rate of time gradient and no net gravitational acceleration.

The point of figures 13-2 and 13-3 is to illustrate that the immature gravity (increasing background Γ) creates a unique condition where there is no rate of time gradient and no tendency for gravitational collapse. Both point "O" and point "X" had their own particle horizons that were partly overlapping, but also each point had a horizon that was uniquely centered on them. This is the condition where all the gravitational forces are balanced and there is no tendency towards a gravitational collapse. Another way of saying this is that the conditions shown create a rate of time that is the same everywhere as defined by a midpoint observer at any given instant. It is ironic that the condition where there is no rate of time gradient (midpoint observer perspective) only happens in immature gravity where the rate of time is continuously decreasing relative to an outside constant rate of time.

Observable Effects of an Increasing Γ : The slowing of the rate of time when Γ is increasing would not be obvious within the cloud while it is happening because it would not be possible to compare the proper rate of time with coordinate rate of time using speed of light communication. However, it will be shown that the condition of a homogeneous increase in the background gravitational gamma would theoretically produce 1) an increase in the proper volume of the dust cloud and 2) would produce a slight redshift in radiation coming from other parts of the dust cloud. The proof for this statement will be given in the next chapter once an easier model for analysis has been introduced.

Implications of an Increasing Γ_u in the Universe: At the start of this chapter, the statement was made that before we can attempt to understand the apparent acceleration in the expansion of the universe, it is first necessary to understand why there is any expansion in the universe. It is proposed that the reason for the apparent expansion of the universe is that the background gravitational gamma Γ_u of the universe is presently increasing. Furthermore, Γ_u was always increasing over the lifetime of the universe but the rate of increase has been different during different epochs.

The purpose of the previous thought experiment is to introduce the concept of immature gravity using a model that is easier to understand than the entire universe. However, a cloud of dust starting with the gravity turned off is not a perfect analogy for the universe. The dust cloud illustrates how it is possible for there to be no rate of time gradient (midpoint observer perspective) as long as the background Γ is increasing, but the example describes a condition where there is only a minute change in Γ . Scale does matter. The change in Γ_u experienced by the universe in its first moments after gravity is "turned on" (the start of the Big Bang) compared to the dust cloud over a similar time period is a difference of more than a factor of 10^{30} . This enormous difference introduces many other differences between the universe and the cloud that will be described.

To my knowledge, no one has mathematically analyzed the implications of living in a universe where the background Γ_u is increasing as a function of the age of the universe. The Schwarzschild

solution to Einstein's field equation assumed a single source of static gravity in an otherwise empty universe. The solution describes the effect on spacetime that surrounded this static source of gravity. The Friedman equation assumes a uniform distribution of matter in the universe. However, even the Friedman solution assumes a mature gravitational distribution. The standard Big Bang model also implies a mature gravitational distribution. It is proposed that this is an erroneous assumption that ultimately leads to the need to invent dark energy.

Note to the Reader: We will divert from the dust cloud example and immature gravity for a short time to introduce additional properties of spacetime. We will then combine all these concepts to develop a model of the expanding universe.

Energy Density of Planck Spacetime: Until now, this book has ignored numerical factors near 1. From observations and calculations, the energy density of the universe as a function of time is well known. In order for a theoretical model to be credible, it is necessary to be able to match observations. Therefore, it is necessary to introduce a missing numerical factor into the definition of Planck energy density to determine the energy density of Planck spacetime. It is necessary to carefully define the energy density of Planck spacetime because this is proposed to be the starting energy density of the universe and this value affects the evolution of the universe.

Planck energy density is defined as $U_p = c^7/\hbar G^2 \approx 4.6 \times 10^{113} \text{ J/m}^3$. This definition describes the energy density that would occur if Planck energy E_p was contained in a cube with dimensions of Planck length on a side ($U_p = E_p/L_p^3$). This definition lacks dimensionless numerical factors. Even though the energy density of Planck spacetime is closely related to Planck energy density, they differ by a dimensionless constant. For cosmology, a more reasonable definition of energy density would be based on the volume of a sphere that is Planck length in radius rather than a cube that is Planck length on a side. The difference between these two volumes is $(4/3)\pi$.

Zero Point Energy: There is one other dimensionless numerical factor that must also be included. It is proposed that vacuum energy is equivalent to zero point energy. Zero point energy is the lowest energy that a quantum mechanical system may have. The energy of the ground state of a quantum harmonic oscillator is:

$$E = \frac{1}{2} \hbar \omega \quad \text{zero point energy}$$

It is proposed that Planck spacetime was the highest zero point energy density possible. The dipole waves in spacetime can be visualized as quantum harmonic oscillators. The highest possible zero point energy density can be visualized as a quantum oscillator that is oscillating at the highest possible frequency in the smallest possible volume. The highest possible frequency is Planck angular frequency: $\omega_p = \sqrt{c^5/\hbar G}$. The zero point energy of this oscillator is:

$$E = \frac{1}{2} \hbar \omega_p = \frac{1}{2} \sqrt{\hbar c^5/G} = \frac{1}{2} E_p \approx 9.78 \times 10^8 \text{ J}.$$

Therefore, the highest energy density of the spacetime field is to have this energy ($\frac{1}{2} E_p$) in the volume of a sphere that is Planck length in radius. This energy density of Planck spacetime will be identified by the symbol U_{ps} .

$$U_{ps} \equiv \frac{1}{2} \frac{E_p}{\left(\frac{4\pi}{3}\right)L_p^3} = \left(\frac{3}{8\pi}\right) \left(\frac{c^7}{\hbar G^2}\right) = k' U_p \quad \text{where: } k' \equiv \frac{3}{8\pi}$$

$$U_{ps} \approx 5.53 \times 10^{112} \text{ J/m}^3 \quad U_{ps} \equiv \text{energy density of Planck spacetime}$$

The correction factor $3/8\pi$ will also be used frequently and will be identified by the symbol $k' = 3/8\pi$. A sphere Planck length in radius which has spherical Planck energy density contains energy of $\frac{1}{2} E_p \approx 9.78 \times 10^8 \text{ J}$. However, we will often round this off to about a billion Joules (10^9 J). The constant $k' = 3/8\pi$ is the conversion factor between Planck spacetime energy density U_{ps} and Planck energy density ($U_p = U_{ps}/k'$). These concepts are expressed using energy density (U) rather than mass density (ρ) because mass is a measurement of inertia. Waves in spacetime are naturally expressed in units of energy density rather than units of mass density which implies inertia.

Difference between Planck Spacetime and Vacuum Energy: Planck spacetime at the start of the Big Bang possessed the same proper energy density as vacuum energy today. Therefore, what is the difference? One of the key differences is hidden in the qualification of “proper energy density”. Planck spacetime had a background gamma of the universe of $\Gamma_u = 1$ while today the value of Γ_u is an extremely large number that will be calculated later. This large value of Γ_u affects everything including the rate of time and our standard of a unit of energy. Even though one Joule today appears to be the same as one Joule a billion years ago or one Joule at the Big Bang, these are comparisons of proper values that do not take into account the effect of a different value of Γ_u . On an absolute scale of energy that compensates for the change in Γ_u , one Joule today is far less energy than one Joule when $\Gamma_u = 1$ at the start of the Big Bang (explained below).

Another difference is that vacuum energy has no quantized angular momentum (no spin) while at the start of the Big Bang 100% of the energy in Planck spacetime possessed quantized angular momentum. The lack of quantized angular momentum in vacuum energy means that this is a perfect superfluid that does not interact with our observable universe except through subtle quantum mechanical interactions. There are no fermions (half integer spin) or bosons (integer spin) in “pure” vacuum energy. We would say that vacuum energy has a temperature of absolute zero. Even though there is energy density, vacuum energy is incapable of giving kinetic energy (temperature) to particles. On the other hand, in Planck spacetime at the start of the Big Bang each of the $\frac{1}{2} E_p$ units of energy (zero point energy) possessed \hbar of angular momentum. This results in the highest possible interaction with other quantized units of energy. The temperature of Planck spacetime had the highest possible temperature for zero point energy which is equal to $\frac{1}{2}$ Planck temperature ($\frac{1}{2} T_p \approx 7 \times 10^{31} \text{ }^\circ\text{K}$).

Proposed Alternative Model of the Beginning of the Universe: The alternative model proposed here starts the universe not as a singularity but as Planck spacetime with volume and finite energy density. Recall that Planck spacetime has a spherical correction factor and a zero point energy correction factor that total $3/8\pi \approx 0.12$ compared to Planck energy density. However, Planck energy density eliminates numerical factors by assuming a cubic volume. Therefore, Planck spacetime is the highest zero point energy density achievable. What is the implied rate of time (or the implied coordinate speed of light) required to achieve the highest possible energy density on an absolute scale? This question can also be stated as follows: What value of the gravitational gamma is required to achieve Planck spacetime? The highest possible energy density on an absolute scale that takes into consideration the value of Γ can only be achieved if $\Gamma = 1$. If $\Gamma > 1$ then the rate of time is slower than coordinate rate of time and the unit of energy is less than the coordinate unit of energy. The theoretical largest energy density on an absolute scale can only be achieved at the theoretical fastest rate of time which is also the fastest coordinate speed of light.

Therefore, Planck spacetime has what might seem like a contradiction. The highest possible energy density starts with a rate of time that we would expect to find in a hypothetical empty universe (no slowing of time caused by gravitational fields). If we are truly at the beginning of time, then there was no prior time for gravity to become established. There is no contradiction for $\Gamma = 1$ if this was the starting condition.

The source of Planck spacetime is an open question. Perhaps spacetime merely came into existence as Planck spacetime or perhaps this is a phase change in a repeating cycle. In either case, we assume that Planck spacetime starts with a rate of time commensurate with $\Gamma_u = 1$. This assumption means that at the start of the Big Bang the rate of proper time equaled the rate of coordinate time ($d\tau_u = dt$ at the beginning).

Extending the Dust Cloud Example: Previously we had the thought experiment involving a cloud of dust distributed in space. In this thought experiment we imagined eliminating all gravitational effects from this cloud of particles (gravity turned off). This means that we started with a background gravitational gamma of $\Gamma = 1$. Then we “turned on” gravity everywhere. The starting condition for the entire universe is proposed to be similar in some respects to this thought experiment. Planck spacetime had an energy density roughly 10^{100} times larger than the energy density of the dust cloud but Planck spacetime was not a singularity. Planck spacetime had an extremely uniform energy density because the energy density was determined by the limitations of spacetime itself. Therefore, it is proposed that the universe started with the finite energy density of Planck spacetime. This quantifiable condition was the starting condition for the evolution of the universe.

There was no preexisting gravity present in this volume, so when time started the waves in spacetime began to distort because of the nonlinearity of spacetime. The background Γ_u of the universe began to rapidly increase from the starting condition of $\Gamma_u = 1$ of Planck spacetime. This is similar to gravity being “turned on” in the thought experiment, except the changes brought about by an increasing Γ_u were vastly larger than occurred in the thought experiment. Rather than an almost imperceptible effect on proper volume in the thought experiment, there was a tremendous increase in the proper volume of the universe as Γ_u rapidly increased. The rate of time in the universe slowed and the coordinate speed of light slowed. All of this produced the immature gravity condition. This immature gravity lacks gravitational acceleration on the large scale of homogeneity as previously described in the dust cloud example.

Comparison to the Big Bang Model: We are now beginning to resolve the difference between two models of the universe. The Big Bang model does not attempt to explain the process which results in cosmic expansion. Matter is not expanding into a preexisting void. Instead, the Big Bang model has a vast expansion in the volume of the universe but no explanation is given as to how new volume is created. The proposed model of the universe that starts with Planck spacetime will be called the “spacetime transformation model”. This model attributes the expansion in proper volume to a change in the properties of spacetime that can be quantified as a continuous increase in Γ_u . Most important, there is a uniform increase in Γ_u everywhere which implies that there is no large scale gravitational gradient attempting to collapse the universe. This contrasts with the Big Bang model of the universe which has gravity attempting to slow down the expansion of the early universe. The following quote by P. J. E. Peebles in the book “Principles of Physical Cosmology” describes the current reasoning.

“Newton’s iron sphere theorem says that the Newtonian gravitational acceleration inside a hollow spherical mass vanishes. The relativistic generalization is that spacetime is flat in a hole centered inside a spherically symmetric distribution of matter.

Now we are in a position to find the relation between the mass density, ρ , and the local rate of expansion or contraction of the material. We are considering a spatially homogeneous and isotropic mass distribution. Suppose the matter within the space within a sphere of radius r is removed and set to one side. Then spacetime is flat within the sphere. Now replace the matter. If r is small enough, we have placed a small amount of material into flat spacetime. Therefore, we can use Newtonian mechanics to describe the gravitational acceleration of the material.”

This goes on to show that the spherical volume with homogeneous density has gravitational acceleration that attempts to contract the distributed mass. When this reasoning is applied to the entire universe it naturally results in gravity opposing the expansion of the universe. Even if the universe is undergoing accelerated expansion because of dark energy, the Big Bang model

has gravity attempting to contract the universe. This sounds reasonable and it has been accepted by generations of physicists. However, it is proposed to be wrong.

If we assume that the universe has immature gravity and an increasing Γ_u , then the fallacy in the above reasoning is that removing a spherical volume of homogeneous density material from the universe would **not** leave a void with flat spacetime. Instead, the remaining void would have negative curvature which has gravitational acceleration away from the center of the void. Figure 13-3 showed that point "X" on the edge of the void has gravitational acceleration away from point "O" at the center of the void. Point "X" in figure 13-3 is not unique. All other points within the void also have gravitational acceleration away from point "O" at the center of the hypothetical void. This negative curvature effect can be understood since each point in the void can be thought of as existing in a spherical particle horizon centered on them. Therefore these other points within the void are similar to point "X" and also have a gravitational acceleration vector pointing away from the central point "O". These vectors exactly offset the gravitational acceleration towards point "O" caused by the test volume. Replacing the test volume would result in offsetting vectors that eliminate any gravitational acceleration. The immature gravity described here has no tendency towards gravitational collapse of the universe on the current scale of homogeneity (~ 300 million light years).

The previous paragraph might be misunderstood if quickly read, so here is another attempt. On the large scale of 300 million light years, there is flat spacetime. However, on the smaller scale of 1 million light years there can be positively curved spacetime near a galaxy or negatively curved spacetime in a volume of space without any matter. Suppose matter was uniformly distributed throughout the universe so that every cubic meter of space possessed uniform energy density of about 10^{-9} J/m³. Also, the universe extends perhaps infinitely, but definitely far beyond our present particle horizon. Then the universe would have flat spacetime even on the small scale. The matter in each spherical volume 1 meter in radius would be producing a gravitational field which would tend to collapse the matter to the center of the sphere if that spherical volume was isolated like the "test volume" in figure 13-3. However, in the actual universe the immature gravity condition is producing an offsetting negative curvature, so the combination results in flat spacetime.

Low Density Regions of the Universe: On the scale smaller than 300 million light years the universe is currently not homogeneous. There are volumes containing galactic clusters which have above average density and volumes of space between the galactic clusters with below average density. These volumes with below average density should exhibit negative curvature analogous to the void previously discussed. A low density region in the universe would have a similarity to the concept of an electronic "hole" in a semiconductor (electrons and holes). A volume of a semiconductor that is missing an electron is the equivalent of a positive electrical charge. Similarly, a low density region in the universe (missing mass compared to the average) exhibits the repulsive properties as if the missing mass had anti-gravity properties (had an

inverse rate of time gradient). This effect only happens if the universe has the immature gravity characteristic.

If low density regions of the universe exhibit something like anti-gravity, this would substantially speed the rate of formation of stars and galaxies in the early universe. Any matter within the low density regions of the early universe would tend to be expelled. Furthermore, the anti-gravity acceleration would extend into the edges of surrounding higher density regions. This would tend to drive these high density regions to even greater density. The average density of the early universe was much greater than today. Therefore the repulsive gravitational acceleration of low density regions of the early universe would be much greater than today. Modeling galaxy formation in the early universe should take this proposed effect into consideration.

Scaling Factor Based on Planck Spacetime a_u : The comoving coordinate system uses “ a_o ” to represent the present scaling factor of the coordinate system and the scaling is usually based on the convention of considering the current scale of the universe as $a_o = 1$. This is convenient since a model of the universe that starts with a singularity does not have any absolute scaling factor from the start of the Big Bang. However, the concept that the universe started as Planck spacetime means that the spacetime transformation model does have a definable initial size and rate of time at the start of the Big Bang. It is natural that we would choose this absolute starting condition as the basis of our scaling factor. Therefore we will use the symbol “ a_u ” to represent the scaling factor relative to the scale of the universe when it was Planck spacetime at the start of the Big Bang.

Therefore the spacetime transformation model sets $a_u \equiv 1$ for Planck spacetime when the universe was 1 unit of Planck time old and $\Gamma_u = 1$. According to this proposal, at the start of the Big Bang Planck spacetime had energy density of about $U_{ps} \approx 5.53 \times 10^{112} \text{ J/m}^3$ and 100% of this energy was “observable”. Another way of saying this is that all the energy in Planck spacetime had quantized angular momentum. Today almost all the energy density in the universe is in the form of vacuum energy which lacks any quantized angular momentum. Therefore only roughly 1 part in 10^{122} today has quantized angular momentum and is “observable” to us and our instruments. We only interact with the vast energy density in vacuum energy through quantum mechanical effects. These numbers then become the basis for gauging the scale of the universe at any other time in the history of the universe.

Cosmic Expansion from Γ_u : What happens to the comoving coordinate system when there is an increase in the background gravitational gamma of the universe Γ_u ? In chapter 2 we did a thought experiment involving two concentric shells. The changes that occur when mass is introduced inside the inner shell are: 1) the rate of proper time $d\tau_u$ slowed compared to coordinate time dt and 2) the proper volume between the two shells increased. We live in a universe which is proposed to have started with a background gravitational gamma $\Gamma_u = 1$ and this value then started to increase at the beginning of time (at the Big Bang). We also know that

the proper volume of the universe rapidly increased initially and the proper volume of the universe continues to increase today (the so-called cosmic expansion).

Assuming that the universe is only spacetime, there appears to be only one way that the universe can rearrange itself to increase its proper volume. I am proposing that the reason for the observed cosmic expansion is that the background gravitational gamma Γ_u of the universe is continuously increasing towards $\Gamma_u = \infty$. This is a transformation in the characteristics of spacetime. When the background gravitational gamma of the universe Γ_u increases, proper volume increases, the rate of time decreases and the coordinate speed of light decreases proportional to $1/\Gamma_u^2$. It will be shown later that the model being developed results in new mass/energy continuously coming into view at our particle horizon. The proposal is that the rate of time continues to get slower, but we are unaware of this change because we cannot directly compare our rate of time to either the rate of time yesterday or the rate of time in a hypothetical static universe that is not undergoing any change. This obviously is a different model than the Λ -CDM model currently considered to be the cosmological standard.

The proposal is that the expansion of the proper volume of the universe is caused by the background gravitational gamma of the universe Γ_u increasing.

We can see if this proposal is compatible with the Robertson-Walker metric (hereafter R-W metric). The highly successful R-W metric has been called the standard model of modern cosmology. It assumes an isotropic and homogeneous universe and a spherical coordinate system that expands with the “Hubble flow” so that the coordinate system remains in the CMB rest frame everywhere. The standard way of writing the R-W metric is:

$$dS^2 = c^2 dt^2 - a^2(t) \left[\frac{dr^2}{1 - kr^2} + r^2 (d\theta^2 + \sin^2 \theta d\phi^2) \right]$$

where $a(t)$ is the scale factor of the universe and r is physical distance. The convention is to use the current scale factor of the universe as $a_o = 1$. Therefore $a(t)$ is usually scaled into the future or past from the current scaling factor and “ r ” is set equal to the current distance between two points which can be considered a unit of length. However, it is also possible to choose some other standard for “ a ” and “ r ” if there is a compelling reason. In our case, we have a very compelling reason to choose a different standard for “ a ” and “ r ” because unlike the Λ -CDM model, we have an exact scale for the universe at the beginning of the beginning of time (at the start of the Big Bang). Therefore this scale factor which changes with time but was $a_u = 1$ when the universe was Planck spacetime will be designated $a_u(t)$. Also the physical length between two points will use as its standard the length when the universe was Planck spacetime ($\Gamma_u = 1$). This length standard (coordinate length) will be designated \mathcal{R} . Therefore, rewriting the R-W metric with these changes we have:

$$dS^2 = c^2 dt^2 - a_u^2(t) \left(\frac{d\mathbb{R}^2}{1 - k\mathbb{R}^2} + \mathbb{R}^2 d\Omega^2 \right) \quad \text{R-W metric where } d\Omega^2 = (d\theta^2 + \sin^2\theta d\phi^2)$$

The spatial curvature term is k and in the general case “ k ” can take values of +1, 0 or - 1. However, analysis of the CMB using experimental data from WMAP has established that spacetime on the large scale is flat to better than 0.4% experimental accuracy. Therefore, we are going to assume a flat universe and set $k = 0$. We can determine the spatial metric for a flat universe by setting $dt = 0$ and follow a radial ray by setting $\Omega = 0$.

$$dS^2 = c^2 dt^2 - a_u^2(t) \left(\frac{d\mathbb{R}^2}{1 - k\mathbb{R}^2} + \mathbb{R}^2 d\Omega^2 \right) \quad \text{set } k = 0, dt = 0, \Omega = 0 \text{ and } dS = cd\tau = dL$$

$$dL^2 = a_u^2(t) d\mathbb{R}^2$$

$$a_u(t) = \frac{dL}{d\mathbb{R}}$$

The proposed physical interpretation of this is that the reason that the scale factor increases is because proper length contracts relative to coordinate length \mathbb{R} when the universe had $\Gamma_u = 1$ or compared to a unit of length in a hypothetical empty universe. If a unit of proper length L is smaller than a unit of coordinate length \mathbb{R} , then progressing in the radial direction the rate of change in proper length dL will be greater than the rate of change in $d\mathbb{R}$. This ratio is equal to the scale factor $a_u(t)$. Since the spacetime field is homogeneous and isotropic on the large scale, this applies to all spatial directions since the choice of a “radial” direction is arbitrary. The relationship to the gravitational background of the universe Γ_u is proposed to be:

$$\text{Seventh Starting Assumption: } \Gamma_u(t) = a_u(t) = \frac{dL}{d\mathbb{R}}$$

It is not possible to conclusively prove this equation. Therefore, this equation is an assumption. However, it is possible to support its validity by showing that it is compatible with observations and gives a compelling model of the universe. The proper volume of the universe is indeed expanding. This equation is a key step in explaining why the universe is undergoing what appears to be a cosmic expansion. The Big Bang model does not go far enough to explain the underlying physics behind the proper volume expansion of the universe.

This equation allows us to estimate the value of Γ_u of the universe today because we know the initial scale of Planck spacetime and we can estimate the expansion that has occurred since the universe had the energy density of Planck spacetime. We will proceed by assuming $\Gamma_u = a_u$ to obtain other insights. If the answers obtained by the use of this equation are reasonable, this can also serve as a check on the equation.

The appeal of the concept that the universe is undergoing an increase in Γ_u is that: 1) it explains the apparent cosmic expansion of the universe 2) it gives the correct redshift to light from distant

galaxies (proven later), 3) it gives a universe with a uniform rate of time on the comoving grid and 4) it eliminates the mystery of expanding space supposedly carrying galaxies away from us at faster than the speed of light 5) it is one of several steps that eliminate the need for dark energy 6) it solves the mystery of how the energy density of vacuum fluctuations (zero point energy) can remain constant when the proper volume of the universe expands.

Coordinate Rate of Time dt : As explained previously, the definition of the coordinate rate of time (designated dt) used by the spacetime transformation model is the rate of time when $\Gamma_u = 1$. This only occurred in our universe during the first Planck unit of time in the age of the universe. Therefore, the coordinate clock can be imagined as a clock that continues to run at the rate of time that was present at the beginning of time. This is also the rate of time that would occur in a hypothetical empty universe where always $\Gamma_u = 1$. After the first unit of Planck time, the background Γ_u of the universe began to increase ($\Gamma_u > 1$) and the rate of proper time in the universe $d\tau_u$ decreased relative to the coordinate rate of time. The gravitational gamma of the universe can also be defined by the following temporal relationship:

$$\Gamma_u = dt/d\tau_u$$

Coordinate and Hybrid Speed of Light: The symbol " dt " in the R-W metric represents the rate of time in the comoving coordinate system. This is actually the proper rate of time in the CMB rest frame of the universe. We need to substitute a different symbol because we want to use " dt " as the coordinate rate of time when $\Gamma_u = 1$. The rate of time used in the R-W metric is actually the proper rate of time in the universe (the rate of time on the cosmic clock). Therefore in the R-W metric we will make the following substitution $dt \rightarrow d\tau_u$. Also making the substitution of a_u and \mathbb{R} previously discussed, we have:

$$dS^2 = c^2 d\tau_u^2 - a_u^2(t) \left(\frac{d\mathbb{R}^2}{1 - k\mathbb{R}^2} \right) + \mathbb{R}^2 d\Omega^2 \quad \text{modified R-W metric}$$

Combining these substitutions with substitutions previously explained we have:

$$\text{Set: } dS = 0, \quad d\Omega = 0, \quad k = 0, \quad a_u(t) = \Gamma_u$$

$$c^2 d\tau_u^2 = a_u^2(t) d\mathbb{R}^2$$

$$c = a_u(t) \left(\frac{d\mathbb{R}}{d\tau_u} \right) \quad \text{set } a_u(t) = \Gamma_u(t) \quad \text{and } \frac{d\mathbb{R}}{d\tau_u} \equiv \mathcal{C}$$

$$\mathcal{C} = \frac{c}{\Gamma_u(t)} = \frac{d\mathbb{R}}{d\tau_u} = \text{hybrid speed of light (coordinate length and proper rate of time)}$$

Next we will determine the coordinate speed of light ($\mathcal{C} = d\mathbb{R}/dt$) which references the coordinate rate of time dt and the rate of change of coordinate length $d\mathbb{R}$ both in a hypothetical empty universe where $\Gamma_u = 1$. The definition of dt used for the remainder of this book is the rate of time in a hypothetical $\Gamma_u = 1$ universe. Therefore: $dt \equiv \Gamma_u(t) d\tau_u$.

$$c = \Gamma_u(t) \left(\frac{d\mathbb{R}}{d\tau_u} \right) \quad \text{set } d\tau_u = \frac{dt}{\Gamma_u(t)}$$

$$c = \Gamma_u^2(t) \left(\frac{d\mathbb{R}}{dt} \right) \quad \text{set } \mathcal{C} = \frac{d\mathbb{R}}{dt}$$

$$\mathcal{C} = \frac{c}{\Gamma_u^2(t)} = \frac{d\mathbb{R}}{dt} = \text{coordinate speed of light}$$

There are times when it is necessary to use the coordinate speed of light \mathcal{C} but usually the hybrid speed of light \mathcal{C} is adequate and simpler. When possible, it is more convenient and intuitive to use the proper (comoving) rate of time. If we are determining the time required for light to travel a distance between two stationary points, we usually want the answer expressed in units of proper time that would be recorded on the cosmic clock. The difference between the hybrid speed of light $\mathcal{C} = d\mathbb{R}/d\tau_u$ and the proper speed of light $c = dL/d\tau_u$ is the difference between a unit of coordinate length \mathbb{R} and a unit of proper length L . The reason that it takes more time for light to travel between two distant galaxies today than it did a billion years ago is that the hybrid speed of light is less today than it was a billion years ago. The distance between these two galaxies is constant when measured in units of coordinate length \mathbb{R} . A slowing hybrid speed of light implies that a unit of proper length, (such as 1 meter today) is contracting relative to a unit of coordinate length (such as 1 meter when $\Gamma_u = 1$).

Reconciliation With Proper Length Being Constant: Clearly the physical interpretation that is emerging is that a unit of proper length contracts when Γ_u increases. In chapter 3 it was proposed that it was an acceptable basis of a coordinate system to consider a unit of proper length, such as a meter, to be the same everywhere in the universe. A meter in a location with a large gravitational Γ was considered to be the same as a meter in a location far from any source of gravity which we were previously calling “zero gravity”. How is it possible to reconcile the view that proper length is contracting as Γ_u increases with the view in chapter 3 that proper length is constant everywhere in the current universe?

The answer is that the “normalized” coordinate system of chapter 3 used the equation $L_o = L_g$. This does not imply that L_o and L_g are constant over time. It merely says that this coordinate system assumes that in a stationary frame of reference, a unit of length in a zero gravity location (L_o) is the same as a unit of length in a location with gravity (L_g) at a given instant in time (midpoint observer perspective). Both of these lengths can be simultaneously contracting as the universe ages and yet maintain $L_o = L_g$. More will be said about this in chapter 14.

Planck Sphere: We will now define terms necessary to quantify and analyze the evolution of the universe. Planck spacetime has energy density equivalent to a sphere that is Planck length in radius containing the maximum zero point energy permitted by the properties of spacetime. This maximum energy is equal to $\frac{1}{2}$ Planck energy ($\frac{1}{2} E_p \approx 9.78 \times 10^8$ J). Most important, Planck

spacetime has $\Gamma_u = 1$ and all the energy possesses quantized angular momentum. The implications of these conditions will be explained later.

We will call the basic quantized unit of Planck spacetime a “Planck sphere”. Besides having a radius of Planck length it also has quantized angular momentum of \hbar (perhaps $\frac{1}{2}\hbar$). The choice between these two will have to be worked out by others, but \hbar is more reasonable and we will use \hbar in the following discussion. The concept of a Planck sphere is introduced primarily because this is a convenient reference to help us visualize the apparent expansion of the universe in units of proper length. We can describe what happens to the radius, energy and angular momentum that are initially in the Planck sphere. In this way the evolution of the Planck sphere becomes an easy reference for what happens to all the spacetime in the universe.

Angular Momentum in Planck Spacetime: Besides having energy density, Planck spacetime also must have a distributed density of quantized angular momentum. Our current universe possesses quantized angular momentum primarily in the form of CMB photons. Currently the CMB has the photon density of a 2.725° K black body cavity which is about 4×10^8 photons/m³. The angular momentum (\hbar) possessed by this vast number of photons exceeds by a factor of about 10^8 the internal angular momentum possessed by baryonic matter in the universe (ignoring dark matter). If we simply imagine reversing time, all the CMB photons would be compressed and blue shifted until each photon was reduced to a sphere that is Planck length in radius. This idea can be checked with a plausibility calculation that will be made later.

Starting the Universe from Planck Spacetime: The remainder of this chapter will look at the evolution of the universe. This combines the concepts of an increasing Γ_u and Planck spacetime with the Big Bang model of expanding spacetime. This combination allows us to introduce new ideas in the familiar context of the Big Bang model. In the next chapter we will drop the Big Bang model and switch completely to the proposed spacetime transformation model that is more compatible with the premise that the universe is (and always was) only spacetime.

We are setting the stage for the start of the Big Bang. In this thought experiment we are going to witness the Big Bang from the vantage point of an infinitely small point that is at the center of a Planck sphere at the start of the Big Bang. From this vantage point we are going to pay particular attention to what happens to the approximately one billion Joules ($\frac{1}{2} E_p$) that is the energy of the Planck sphere that surrounds our infinitely small vantage point. All of this energy is initially within a distance of Planck length of our location.

We will imagine that we can watch the evolution the universe (watch the Big Bang) from our infinitely small vantage point within Planck spacetime. We are also going to equip ourselves with two clocks that will start running the moment that time starts to progress forward at the start of the Big Bang. Both of these clocks are digital clocks that run in quantized increments of Planck time ($\sim 5.4 \times 10^{-44}$ second steps). One of these clocks will be called the “cosmic clock”

that measures the proper age of the universe in the comoving frame of reference. Time on the cosmic clock, expressed in dimensionless Planck units of time, will be designated with the symbol $\underline{\tau}_u$ (bold and underlined designates Planck units) and defined as:

$$\underline{\tau}_u \equiv \tau_u / t_p.$$

The other clock will be called the “ $\Gamma=1$ clock”. This is a hypothetical clock that runs at the rate of time of an empty universe where the background gravitational Γ_u is always equal to 1. Time on the $\Gamma=1$ clock also is in Planck units of time and designated as \underline{t}_u . Since the universe started with $\Gamma_u = 1$, the $\Gamma=1$ clock can also be thought of as a clock that continued running at the rate of time that was present at the beginning of the Big Bang. This clock is keeping coordinate time which is the “ dt ” term in the equation: $\Gamma_u = dt/d\tau_u$.

The Big Bang Starts: Now for the big event: Time starts and the Big Bang has begun. Actually, the observable, proper energy density defining Planck spacetime only exists in this form during the first unit of Planck time. After this brief time the observable energy density (energy with spin) rapidly drops to less than $U_{ps} = 5.53 \times 10^{112}$ J/m³ and Γ_u rapidly increases ($\Gamma_u > 1$). However, the total energy density of the universe remains constant when we add together the vacuum energy density (no spin) plus the observable energy density (with spin) as explained later. It is not possible to talk about what happens “before” time starts to progress (when $\underline{t}_u = 0$) because this implies that the rate of time has stopped and there is no motion of waves in spacetime. We will adopt the position that there was no time “before” $\underline{t}_u = 1$. In order for the spacetime field to be energetic, there must be moving dipole waves in spacetime (there must be dynamic spacetime). There is no energy in static spacetime. If the spin in each Planck sphere is \hbar , then this is the equivalent of one photon per sphere. Initially the energy of this single photon per Planck sphere would be equal to the maximum zero point energy which is $\frac{1}{2} E_p$. Another way of saying this is that all the energy of Planck spacetime had quantized angular momentum and was “observable” energy. Today only about 1 part in 10^{122} of the total energy in the universe has quantized angular momentum and is “observable”.

We are going to assume that time starts simultaneously everywhere within the Planck spacetime. This obviously requires either faster than speed of light communication or some other way of synchronizing the start of time. The only justification for this assumption is that observations today indicate a simultaneous initiation of the Big Bang. Perhaps this can be rationalized by assuming that in this highest possible energy density, the entire universe was like a single particle that exhibited the instantaneous communication of entanglement or unity. We will not dwell on this point. This assumption seems more understandable than starting with a singularity, but ultimately the simultaneous initiation of the Big Bang (simultaneous starting of time) is just a starting assumption.

At the instant that the Big Bang starts, our imagined vantage point is completely isolated. There has been no time for any communication with any of the surrounding energy in Planck spacetime and there has been no nonlinear distortion of the waves in spacetime that constitute Planck spacetime. This means that at the start of the Big Bang there is no preexisting gravitational effects – no preexisting gravitational acceleration and for the first unit of Planck time, $\Gamma_u = 1$ everywhere in the universe. Therefore, for the first unit of Planck time, the cosmic clock and the $\Gamma=1$ clock both run at the same rate of time ($d\tau_u = dt$). This starting condition is similar to the dust cloud thought experiment where we started with gravity “turned off”.

Increasing Value of Γ_u : The first tick of Planck time was easy because it happens with $\Gamma_u = 1$. Our “particle horizon” was equal to Planck length which is the boundary of the Planck sphere. The question is: What happens with subsequent ticks as our particle horizon expands beyond the boundary of our Planck sphere? Speed of light contact is being made with adjacent waves in spacetime just beyond the boundary of our Planck sphere. The nonlinearity of spacetime begins to affect these waves causing an increase in the background gravitational gamma from $\Gamma_u = 1$ to $\Gamma_u > 1$. The rate of time slows and proper volume increases, but there is no time gradient. All points are experiencing the same rate of time so there is no tendency for gravitational attraction or gravitational collapse. This is the start of the immature gravity condition that continues today. A uniformly increasing Γ_u eliminates the time gradient necessary for gravitational attraction.

For the first unit of Planck time the cosmic clock and the $\Gamma = 1$ clock were synchronized. However, all subsequent ticks exhibit the fact that the cosmic clock has a rate of time that is slowing relative to the $\Gamma=1$ clock. Also the proper distance to the boundary of the Planck sphere increases. Both of these effects are the result of Γ_u increasing which in turn is the result of the nonlinear effects of spacetime accumulating. The waves in spacetime responsible for the energy density of Planck spacetime have begun to distort. Unlike the gravity produced by an isolated mass, inside the early universe the stressed spacetime is a homogeneous distribution of energy that extends beyond our particle horizon. This wave distortion would produce an increase in the background gravitational gamma Γ_u similar to the increase in the background Γ in the dust cloud thought experiment. However, because the universe started with the maximum possible quantized energy density, the effects on volume and the rate of time are vastly larger than in the dust cloud thought experiment.

Spacetime Evolves into Different Types of Energy: The distortion free oscillating spacetime (Planck spacetime) that was present during the first tick of the cosmic clock begins to exhibit distortion for all subsequent ticks. The nonlinearity of spacetime causes the waves in spacetime to distort. The distorted waves can be thought of as being split into three component parts. These three components are:

- 1) The distortion free component of the original waves in spacetime that retain the original quantized angular momentum (spin). This is proposed to become the source of everything in the universe that we can sense today (all fermions and bosons).
- 2) The non-oscillating component (the A_β^2 component of chapter 6) that results when the waves in spacetime are distorted by the nonlinearity of spacetime. This is responsible for gravitational effects and also responsible for the background Γ_u of the universe.
- 3) The high frequency oscillating component of gravity (the $A_\beta \cos 2\omega t$ component described in chapter 6) proposed to be responsible for vacuum energy. This component lacks angular momentum and becomes the vacuum fluctuations component of the universe today.

Therefore starting with Planck spacetime means that any nonlinear distortion caused by an interaction of waves in spacetime (gravitational contact with surrounding energy) must increase Γ_u . However, as Γ_u increases this also increases proper distance between stationary points and decreases the rate of time. New energy is always adding its gravitational influence as the particle horizon expands and new energy comes into view. As Γ_u increases, the proper distance to the particle horizon increases even faster than the speed of light because our unit of length is also shrinking relative to coordinate length \mathbb{R} . The value of Γ_u increases towards infinity.

Avoiding Gravitational Collapse: What prevents Planck spacetime from collapsing into a singularity? In fact, when $\underline{\tau}_u = 1$ each Planck sphere appears to contain the exact amount of energy required to become a black hole with a Schwarzschild radius equal to Planck length. Even today the proper energy density of spacetime is approximately the same as the energy density of Planck spacetime. According to general relativity, energy in any form produces gravity. Therefore, general relativity considers the energy density of the spacetime field required by quantum mechanics to be a ridiculously large number ($\sim 10^{120}$ times larger than the critical energy density of the universe). What prevents the energy density of the spacetime field from collapsing into a black hole? A partial answer will be given here and additional details will be given in the next chapter.

Think of the energy density of the spacetime field as being the necessary ingredient to give the spacetime field properties such as a speed of light, impedance, a gravitational constant, elasticity, etc. Therefore it is an oversimplification to say that energy in any form creates gravity. The more correct statement would be that any form of energy that possesses quantized angular momentum creates gravity. In other words, fermions and bosons create gravity. The dipole waves in spacetime that form vacuum energy lack angular momentum and are part of the fabric of spacetime. They have superfluid properties and are as homogeneous as quantum mechanics allows. They are also the necessary ingredient required to support the existence of fermions and bosons.

When rotars with their quantized angular momentum are introduced into an otherwise homogeneous volume of the spacetime field, this is adding an **additional energy density** to the previously homogeneous energy density of the spacetime field. For example, if there was a rotar with Planck energy, then this rotar would have a quantum radius equal to Planck length. The energy density of such a rotar would be equal to the energy density of an equivalent volume of the spacetime field. Therefore, introducing such a rotar into a previously homogeneous volume of the spacetime field would **double** the energy density of that volume of the spacetime field. This doubling reaches the theoretical limit of the properties of the spacetime field and results in the creation of a black hole.

There are no fundamental particles (rotars) with Planck mass/energy. The conditions which create a stellar size black hole or a super massive black hole do not match the total energy density of the spacetime field ($\sim 10^{113}$ J/m³). However, they do match the interactive energy density U_i previously discussed in chapter 4. Recall from chapter 4 the following:

The interactive energy density $U_i = F_p/\mathcal{A}^2$ is a very large energy density. How does this energy density compare to the energy density of a black hole (symbol U_{bh})? We will designate the black hole's energy as E_{bh} and its defined Schwarzschild radius as $R_s \equiv Gm/c^2$. Ignoring numerical factors near 1 we have:

$$U_{bh} = \frac{E_{bh}}{R_s^3} = \left(\frac{R_s c^4}{G} \right) \left(\frac{1}{R_s^3} \right) = \frac{F_p}{R_s^2}$$

Therefore, since $U_i = F_p/\mathcal{A}^2$ and $U_{bh} = F_p/R_s^2$ it can be seen that if $\mathcal{A} = R_s$ then $U_i = U_{bh}$.

Adding additional energy to a specific volume by introducing matter increases the total energy density and produces the gravitational effects described by general relativity. The largest force that the vacuum energy/pressure can exert is Planck force ($F_p = c^4/G$). With the rotar model it was stated that the energy density of a rotar implied a specific pressure. This pressure needed to be contained by an offsetting pressure exerted by vacuum energy/pressure. Likewise, the matter of a larger body such as a star has a collective energy density that must be stabilized by offsetting pressure from vacuum energy/pressure. The pressure on a star can be considered as two opposing forces exerted on opposite hemispheres of the star. The maximum force that the spacetime field can exert is Planck force. Therefore the conditions which form a black hole occur when the spacetime field is asked to exert this maximum force. The energy density of a black hole (ignoring numerical factors near 1) is $U_{bh} = F_p/R_s^2$. The point is that the energy density of spacetime does not form a black hole. Instead, a black hole forms when additional energy density (matter) is introduced to a volume and equals the interactive energy density where $\mathcal{A} = R_s$ in the equation $U_i = F_p/\mathcal{A}^2$.

When the universe started at the beginning of the Big Bang ($\tau_u = 1$), 100% of the energy of Planck spacetime possessed quantized angular momentum. There was no vacuum energy during the first unit of Planck time. Therefore, the total energy density of a Planck sphere did not form a black hole and the particle horizon was equal to Planck length. The possibility of forming black holes only occurred later when some of the energy of Planck spacetime was converted to vacuum energy. Then it became possible to overload a particular volume of the spacetime field with the combination of vacuum energy and energy with quantized angular momentum (multiple rotars and/or photons). In chapter 14 we will see how it is possible for the proper energy density of the spacetime field to remain constant while the proper volume of the universe expands.

Three Epochs in the Evolution of the Universe: The rate of expansion of the universe (rate of change of Γ_u) is currently believed to have gone through 3 different phases. The following calculations use the current estimates for the rates of expansion of the universe and the current estimates of age of the universe when transitions occur. As improved estimates become available, they should be substituted for the following preliminary estimates.

The first phase is the radiation dominated epoch and is currently believed to have started with the Big Bang and ended roughly 70,000 years after the Big Bang. During this epoch, the scaling factor of the universe grew as: $a_u(t) = \tau_u^{1/2}$. Next came the matter dominated epoch from roughly 70,000 years after the Big Bang to about 5 billion years after the Big Bang. The matter dominated epoch is believed to have a scaling factor that grew with a slope characteristic of $\tau_u^{2/3}$. However it is not accurate to say that $a_u(t) = \tau_u^{2/3}$ because during the radiation dominated epoch the slope was different. Therefore, we will say that during the matter dominated phase the change in scaling factor is $\Delta a_u(t) = \Delta \tau_u^{2/3}$. From about 5 billion years until the present we are in what is referred to as the “dark energy” dominated epoch. During this phase a first approximation of the change scaling factor can be described as: $\Delta a_u(t) = \Delta \tau_u$. However, the change in scaling factor appears to be more complex than this because the change in the scale factor is probably accelerating. The Λ -CDM model of cosmology has parameters that can be adjusted to permit it to match observations. Fortunately, the key points of the proposed spacetime transformation model can be stated without requiring a precise equation for the scale factor in the “dark energy” dominated epoch.

Radiation Dominated Epoch: The standard Big Bang theory (without inflation) has the scale factor of the universe increase proportional to the square root of time during the radiation dominated epoch $a_u(t) = \tau_u^{1/2}$. Even the model of the universe that includes inflation starts off with the scale factor increasing proportional to $\tau_u^{1/2}$ between the start of the Big Bang and about 10^{-37} second after the start. The inflation model then has a brief period where a vast exponential expansion takes place. This is then followed by a return to expansion proportional to $\Delta \tau_u^{1/2}$.

The spacetime wave model proposed here does not need the hypothetical inflationary exponential expansion to make the universe homogeneous, isotropic and spatially flat. All of this

automatically follows from starting the universe at the highest possible energy density that spacetime can support - Planck spacetime. This energy density is as homogeneous as quantum mechanics allows. These quantum mechanical fluctuations are traceable to the Planck length/time limitation of wave amplitude in the model of the universe based on waves in spacetime. These quantum fluctuations provide the small amount of inhomogeneity required to seed the eventual gravitational formation of stars and galaxies. The symbols and equations that we will be using to characterize the radiation dominated epoch are:

$$a_u(t) = \Gamma_u = \underline{\tau}_u^{1/2} = \sqrt{\tau_u/t_p} \quad \text{radiation dominated epoch relationships}$$

The Universe at $\underline{\tau}_u = 9$: We will illustrate some important concepts about the early stages of the expansion of the universe with an example. Previously an imaginary vantage point at the center of a Planck sphere was described. Suppose that we return to that infinitely small vantage point and look at the changes that occur 9 units of Planck time ($\underline{\tau}_u = 9$) after the start of the Big Bang. From $\underline{\tau}_u^{1/2} = \Gamma_u$ we obtain that at $\underline{\tau}_u = 9$ the background gravitational gamma of the universe is: $\Gamma_u = 3$. This has a profound effect on spacetime. The scale factor of the universe relative to Planck spacetime (a_u) has tripled. Therefore, the Planck sphere that started with a radius of Planck length l_p now has a proper radius 3 times as large ($r = 3 l_p$). However, the coordinate radius always assumes $\Gamma_u = 1$, therefore the coordinate radius of the Planck sphere (measured in units of \mathbb{R}) remains constant at 1 unit of Planck length ($\mathbb{R} = 1$)

The Hubble sphere with radius r_h around the origin point, has a proper radius of $r_h = c\tau_u$ so when $\underline{\tau}_u = 9$ then $r_h = 9 l_p$. The Hubble sphere defines the distance where objects seem to be receding at the proper speed of light. The proper distance to the particle horizon (designated r_{ph}) at an instant in time is larger than the Hubble sphere at that same instant in time. This is because the instantaneous proper distance to the particle horizon includes distance that has expanded after a speed of light signal has passed any point. During the radiation dominated epoch it can be shown that the proper distance to the particle horizon is always twice the radius of the Hubble sphere. At age of the universe τ_u , the radius of the particle horizon is $r_{ph} = 2c\tau_u = 18 l_p$ when $\underline{\tau}_u = 9$ or $\tau_u = 4.85 \times 10^{-43}$ s. Today the value of Γ_u is much larger than 3 (calculated later). Therefore the proper dimensions quoted when $\underline{\tau}_u = 9$ and $\Gamma_u = 3$ would be different today because Γ_u is much larger. However, the coordinate dimensions (measured in units of \mathbb{R}) always are constant because they do not scale with Γ_u .

Any signal obtained from the particle horizon has infinite redshift but a signal emitted from inside the particle horizon has less of a redshift. The gravity of an apparently receding mass is less than the gravity of a stationary mass at the same distance. Therefore, the redshift at various distances also affects gravity. It is the combination of the gravity of all the energy inside the particle horizon that together is increasing the background gamma at our observation point. Since all other observation points are experiencing a similar gravitational effect, the background

gravitational gamma of the universe is increasing homogeneously because Planck spacetime started off at the maximum homogeneity permitted by quantum mechanics.

We will now return to our example of the universe when it was 9 units of Planck time old ($\underline{\tau}_u = 9$). At this instant we had: $\Gamma_u = \underline{\tau}_u^{1/2} = dt/d\tau_u = 3$. The rate of proper time shown on the cosmic clock has slowed to a third the rate of time shown on the $\Gamma=1$ clock. Also the hybrid speed of light $\mathcal{C} = d\mathbb{R}/d\tau_u$ has slowed to a third the proper speed of light expressed by the universal constant $c = dL/d\tau_u$ because of the difference between $d\mathbb{R}$ and dL . Therefore:

$$\mathcal{C} = \frac{c}{\Gamma_u} = c/\underline{\tau}_u^{1/2} \quad (\text{assumes radiation dominated epoch})$$

The Planck sphere initially contained about 10^9 Joules during the first unit of Planck time when the universe was Planck spacetime. All this energy initially possessed \hbar of quantized angular momentum. Therefore these initial waves were photons in maximum confinement. However, energetic photons can be converted to particles. For example, it has been experimentally proven that two 511,000 eV photons can be converted to an electron/positron pair.

When $\underline{\tau}_u = 9$ and $\Gamma_u = 3$ the photon-like waves have been redshifted by a factor of 3. Therefore, the proper volume of the Planck sphere has increased by a factor of 27 and the “observable energy” (possessing quantized angular momentum) in the Planck sphere has decreased because of redshift by a factor of 3 to about 0.33 billion Joules. Where did the difference in energy go?

Lost Energy Becomes Vacuum Energy: When physics students hear about the cosmic redshift decreasing the energy of photons, they often ask where the energy went. Answers often involve a discussion of stretched wavelengths, and eventually imply that conservation of energy does not apply to the cosmic expansion of the universe. The proposed spacetime transformation model gives a different answer. When the proper volume of the universe expands, a photon loses energy but retains 100% of its proper angular momentum. Therefore the lost energy possesses no angular momentum.

It is proposed that all the observable energy lost by photons is being converted to vacuum energy (zero point energy) that is in a superfluid state that cannot possess angular momentum. In fact, it is not only photons that are losing energy to cosmic expansion. Neutrinos and other relativistic particles (moving relative to the local CMB rest frame) are also losing substantial amounts of observable kinetic energy. This lost energy is also being converted to vacuum energy. In the next chapter we will attempt to calculate the ratio of vacuum energy density to observable energy density in the universe today.

Radiation-Matter Equality Transition: The radiation dominated epoch ended when the energy density in radiation fell to eventually equal the energy density of matter in the universe. The proper energy of matter (such as an electron) does not decrease when Γ_u increases so

eventually radiation energy density falls to equal the average energy density of matter. This transition is called the radiation/matter equality and occurred about 70,000 years after the Big Bang. Before the WMAP probe accurately measured the CMB, this transition was thought to have occurred earlier, perhaps 10,000 years after the Big Bang. However, analysis of the WMAP data has determined that the energy content of the universe at 380,000 years after the Big Bang was 15% radiation, 10% neutrinos, 12% baryonic matter and 63% dark matter. Since both radiation and neutrino energy decrease in energy at virtually the same rate (assuming no new sources), the breakdown at 380,000 years can be generalized as 25% radiation-like energy and 75% energy in matter. These numbers imply the radiation/matter equality occurred about 70,000 years after the Big Bang ($\underline{t}_u \approx 4.09 \times 10^{55}$ Planck units of time). It is possible to calculate the value of the background gravitational gamma at the radiation/matter equality transition. This background gamma is important for later calculations and will be designated as: Γ_{eq} .

$$\begin{aligned} \Gamma_u &= \underline{t}_u^{1/2} && \text{set } \underline{t}_u \approx 4.09 \times 10^{55} \quad (\approx 70,000 \text{ years}) \\ \Gamma_{eq} &\approx 6.4 \times 10^{27} && \Gamma_{eq} = \Gamma_u \text{ at the radiation/matter equality transition} \end{aligned}$$

Therefore, about 70,000 years after the Big Bang the absolute scale factor of the universe was: $a_u = \Gamma_{eq} \approx 6.4 \times 10^{27}$. This means that the Planck sphere increased in radius from Planck length ($\sim 10^{-35}$ m) to about 10^{-7} m (obtained from $l_p \times 6.4 \times 10^{27} \approx 10^{-7}$ m). Furthermore, the redshift that occurred during the radiation dominated epoch decreased the proper energy of radiation by a factor equal to Γ_{eq} . This means that the “observable” energy in the Planck sphere decreased by a factor equal to Γ_{eq} from about a billion Joules to about 1.53×10^{-19} J. All the missing observable energy (i.e. energy possessing angular momentum) was converted to vacuum energy. Therefore the total energy in the Planck sphere (observable energy plus vacuum energy, both measured in units of coordinate energy) remained constant at about 9.78×10^8 Joules at the end of the radiation dominated epoch (discussed later). This can be confusing since there are two different standards for energy the same way that there are two different standards of length (proper and coordinate). The conclusion is that the energy density of the universe has not changed from the Big Bang to today if vacuum energy is included in the energy density. What has changed is that the “observable” energy density of the universe (excludes vacuum energy) has decreased by a factor of about 10^{122} .

After the radiation dominated epoch ended, the next phase was the matter dominated epoch which lasted from about 70,000 years to about 5 billion years after the Big Bang. The scale factor (and Γ_u) during this epoch scales proportional to $\underline{t}_u^{2/3}$. The current epoch is usually referred to as the dark energy dominated epoch and extends from about 5 billion years to the present. The scale factor and Γ_u during this epoch might be linearly increasing proportional to \underline{t}_u or it might be increasing faster than linearly in which case it would be an exponential increase. This is the famous accelerating expansion of the universe and the exact representation of this phase will be left to the astrophysicists.

Γ_{uo} Calculation from Expansion: Our objective here is to determine the current value of the background gravitational gamma for the universe designated Γ_{uo} . We have calculated the value $\Gamma_{eq} \approx 6.4 \times 10^{27}$ for the radiation dominated epoch. The remaining part of the calculation required to determine Γ_{uo} is greatly helped by the fact that the redshift from the radiation/matter equality to the present has been experimentally measured by WMAP. The following quote is from the 5 Year WMAP report⁴; “The equality redshift z_{eq} is one of the fundamental observables that one can extract from the CMB power spectrum⁵”. The term “equality redshift z_{eq} ” is the value of the redshift since the radiation/matter transition (equality) to the present. This redshift has been measured by WMAP and found to be: $z_{eq} = 3253 \pm 88$. Therefore this number includes all of the redshift that occurred during both the matter dominated epoch and the dark energy dominated epoch until now. This single number includes even accelerated expansion.

Therefore since the redshift z_{eq} equals the change in scaling factor since equality, we can simply multiply this times the previously calculated value of Γ_u prior to radiation/matter equality to obtain the total value of the background gravitational Γ_u of the universe today. We make use of the contention that $\Gamma_u = a_u$ therefore the current values are $\Gamma_{uo} = a_{uo}$.

$$\Gamma_{uo} = \Gamma_{eq} z_{eq} = 6.4 \times 10^{27} \times 3253$$

$$\Gamma_{uo} \approx 2.1 \times 10^{31} \qquad \Gamma_{uo} \text{ calculated from cosmological expansion}$$

This calculation of Γ_{uo} and a_{uo} simply extended the starting assumption (the universe is only spacetime). This means that we begin the universe with Planck spacetime at one unit of Planck time old ($\underline{\tau}_u = 1$) rather than starting with a singularity at $\tau_u = 0$. The calculated expansion incorporated the radiation dominated epoch, the matter dominated epoch and the so called “dark matter” epoch when there was accelerated expansion. The calculation did not incorporate an “inflation” phase. Inflation is an *ad hoc* assumption necessitated when the universe is presumed to start from a singularity.

To keep track of the expansion since the universe was $\underline{\tau}_u = 1$, we will be referencing as our standard of comparison the properties of a Planck sphere when $\underline{\tau}_u = 1$. For example, the proper radius of the Planck sphere was Planck length l_p at that time and $\Gamma_u = 1$. The calculated value of $\Gamma_{uo} \approx 2.1 \times 10^{31}$ says that the proper radius of the Planck sphere today has increased by a factor of about 2.1×10^{31} times. Therefore, the proper volume of the Planck sphere has increased by a factor of about 10^{94} times (2.1×10^{31} cubed).

Γ_{uo} Calculation from Planck Temperature: One advantage of the proposed spacetime transformation model of the universe is that it describes the starting condition of the universe in

⁴ Five-Year Wilkinson Microwave Anisotropy Probe * Observations: Cosmological Interpretation, E. Komatsu et.al. The Astrophysical Journal Supplement Series, 180:330–376, 2009 February

a way that we can make both predictions and plausibility calculations that check the model. The current characteristics of the universe have been experimentally measured. It is only the physical interpretation of these measurements that is being called into question. We can do simple calculations extrapolating from the proposed starting conditions to see if the model is reasonable. The first of these plausibility calculations determines the value of Γ_{uo} by comparing the temperature of Planck spacetime to the current temperature of the CMB. The ratio of these two temperatures should be equal to Γ_{uo} . The reasoning is that the temperature of the universe changed inversely with the scaling factor which means that the change in temperature also scaled inversely with the change in Γ_u . To express this relationship we will use the following new symbols

$$\begin{aligned} T_{ps} &= \text{temperature of Planck spacetime: } T_{ps} = \frac{1}{2} E_p/k_B = 7.08 \times 10^{31} \text{ }^\circ\text{K} \\ T_{uo} &= \text{current temperature of the universe (CMB temperature) } T_{uo} = 2.725 \text{ }^\circ\text{K} \\ \Gamma_{uo} &= \text{current value of the background gravitational gamma of the universe} \\ \Gamma_{uo} &= \frac{T_{ps}}{T_{uo}} = 7.08 \times 10^{31} \text{ }^\circ\text{K}/2.725 \text{ }^\circ\text{K} \approx 2.6 \times 10^{31} \quad \Gamma_{uo} \text{ from ratio of temperatures} \end{aligned}$$

This is a fantastic result. From the ratio of temperatures we obtain $\Gamma_{uo} \approx 2.6 \times 10^{31}$ compared to $\Gamma_{uo} \approx 2.1 \times 10^{31}$ from the redshift calculation. This supports the assumption that the starting condition for the Big Bang was Planck spacetime and not a singularity or any other energy density in excess of Planck energy density.

Γ_{uo} Calculation from Total Energy Density: There is another way that we can calculate the value of Γ_{uo} using the energy density of Planck spacetime and comparing this to the total observable energy density of the universe today. The energy density of the universe today is commonly thought to be about $8.46 \times 10^{-10} \text{ J/m}^3$ (equivalent to $9.4 \times 10^{-27} \text{ kg/m}^3$). However, this is a calculated number based on the concept that the universe must maintain a critical density. Only about 27.9% of this energy density or $2.36 \times 10^{-10} \text{ J/m}^3$ is “observable” mass/energy consisting of fermions and bosons (including dark matter). Dark matter is considered “observable” because the gravitational effects of dark matter are clearly observable. Only the observable $2.36 \times 10^{-10} \text{ J/m}^3$ is traceable to Planck spacetime. The remaining approximately 72.1% of the “critical” energy density ($8.46 \times 10^{-10} \text{ J/m}^3$) is currently attributed to dark energy. Almost all this dark energy has supposedly been added to the universe since the universe was about 5 billion years old. It did not originate with Planck spacetime and therefore will be excluded from this calculation. Therefore, the current energy density of the universe that excludes dark energy is about $2.36 \times 10^{-10} \text{ J/m}^3$. This will be called the “currently observable energy density of the universe” and designated with the symbol U_{obs} .

There is another way of calculating the value of Γ_{uo} using only U_{ps} , U_{obs} and z_{eq} . The reasoning is that the universe started with Planck spacetime with energy density of $U_{ps} \approx 5.53 \times 10^{112} \text{ J/m}^3$ and today the observable energy density is $U_{obs} \approx 2.36 \times 10^{-10} \text{ J/m}^3$. There are two reasons for

this change in energy density. First, the volume of each Planck sphere increased by a factor of Γ_{uo}^3 because the radius of the Planck sphere increased by a factor of Γ_{uo} . Secondly, the cosmic redshift reduced the energy in the Planck sphere during the radiation dominated epoch. This epoch started with $\Gamma_u = 1$ and ended roughly at the radiation/matter equality with a background gamma designated as Γ_{eq} . We do not experimentally know the value of Γ_{eq} , but we do experimentally know the redshift that has occurred since the radiation/matter equality. As previously stated, this redshift value has been measured by WMAP and found to be $z_{eq} = 3253 \pm 88$. The value of Γ_{uo} is $\Gamma_{uo} = \Gamma_{eq} z_{eq}$ therefore $\Gamma_{eq} = \Gamma_{uo} / z_{eq}$. The initial energy density of Planck spacetime was reduced both because of expansion (a factor of Γ_{uo}^3) and because of cosmic redshift (a factor of Γ_{eq}). We can now calculate the value of Γ_{uo} using this knowledge.

$$\begin{aligned}
 U_{ps}/U_{obs} &= \Gamma_{uo}^3 \times \Gamma_{eq} & \text{set } \Gamma_{eq} &= \Gamma_{uo}/z_{eq} \\
 U_{ps}/U_{obs} &= \Gamma_{uo}^4 / z_{eq} \\
 \Gamma_{uo} &= (U_{ps} z_{eq} / U_{obs})^{1/4} \\
 \text{set } U_{ps} &= 5.53 \times 10^{112} \text{ J/m}^3 & U_{obs} &= 2.36 \times 10^{-10} \text{ J/m}^3 & z_{eq} &= 3253 \\
 \Gamma_{uo} &= 2.95 \times 10^{31} & & & & \Gamma_{uo} \text{ calculated from } U_{ps}, U_{obs} \text{ and } z_{eq}
 \end{aligned}$$

This is another successful plausibility calculation that supports the model that the universe started as Planck spacetime because this value of Γ_{uo} generally agrees with the previous two values of Γ_{uo} .

Calculation from Energy Density of the CMB: The CMB currently has energy density equal to the energy density of 2.725 °K black body radiation: $U_{CMB} \approx 4.2 \times 10^{-14} \text{ J/m}^3$. Through the entire lifetime of the universe, the energy density in radiation has scaled proportional to $1/a^4$. Therefore if we only track the energy density of radiation we have an extremely simplified model of the universe. This assumption ignores all the fermions and other bosons which have about 5,000 times greater energy density than the energy density of photons in the CMB. Therefore, this greatly simplified assumption represents a rough upper limit estimate of Γ_{uo} . We assume that the universe started as Planck spacetime with energy density of $U_{ps} \approx 5.53 \times 10^{112} \text{ J/m}^3$ and through expansion achieved the current energy density of just the U_{CMB} . The cosmological redshift plus increased volume resulted in a $1/a^4$ scaling of energy density.

$$\Gamma_{uo} \approx (U_{ps}/U_{CMB})^{1/4} \approx (5.53 \times 10^{112} / 4.2 \times 10^{-14})^{1/4} \approx 3.4 \times 10^{31}$$

I find it surprising that this simplified estimate that includes only radiation achieves a relatively close value for Γ_{uo} . The reason is that the greatest expansion factor occurred when the universe was radiation dominated therefore most of the energy loss in fact scaled as $1/a^4$. This Γ_{uo} value would more closely approach the previous three values if we included the relativistic energy of particles in the early universe which are similar to radiation because they also exhibit a relativistic “redshift”.

Calculation from Spin: There is one last calculation that I find amazing. It is based on the assumption that quantized spin should be approximately conserved. The term “quantized spin” is best defined with an example. Two gamma ray photons, each with \hbar spin, can interact to form an electron and a positron. These two fermions each have spin of $\frac{1}{2}\hbar$. The concept of quantized spin ignores spin direction and makes no distinction between \hbar spin and $\frac{1}{2}\hbar$ spin. To determine the total number of quantized spin units we merely add together the number of bosons and fermions (\hbar and $\frac{1}{2}\hbar$ units of spin are treated the same).

We know the density of quantized spin units in Planck spacetime and we know the density of photons and fermions in the universe today (except for dark matter). The spacetime based model of the universe does not require the exchange of virtual particles to transmit forces so no quantized spin is allotted to virtual particles. However, the assumption that there is large scale preservation of quantized spin is questionable. For example, two photons can be absorbed and reemitted as a single photon. However, with black body radiation there is large scale preservation of the total number of photons because the numerous absorptions and reemissions average out. For this calculation to be accurate we will make the questionable assumption that quantized spin has a similar averaging. If the answer is reasonable, then this will support the accuracy of this assumption.

Planck spacetime had \hbar spin in each Planck sphere with initial volume of $(4\pi/3)l_p^3 = 1.77 \times 10^{-104} \text{ m}^3$ or a quantized spin density of $5.65 \times 10^{103} \text{ spin units/m}^3$. Today matter dominates the universe but the quantized spin units contained in observable matter is small compared to the quantized spin in the CMB. Ordinary matter is 4.6% of the “critical density” of the universe. Therefore the density of ordinary matter has a density of about $4.3 \times 10^{-28} \text{ kg/m}^3$. This is equivalent to about $\frac{1}{4}$ hydrogen atom per cubic meter. Since a hydrogen atom has 3 quarks and one electron, $\frac{1}{4}$ hydrogen atom per cubic meter is equivalent to about 1 quantized spin unit per cubic meter.

Recall that the spacetime based model has no virtual photons, gravitons or gluons. If there really are gravitons, etc. then this calculation should be wrong by many orders of magnitude. The quantized spin in the photons of the CMB dominate baryonic matter because the 2.725K blackbody CMB photon density is $4.2 \times 10^8 \text{ photons/m}^3$ compared to about 1 fermion/m^3 for ordinary matter. The photon density of starlight is also considered insignificant because it has been estimated⁶ that the density of starlight photons is less than 1% of the photon density of the CMB. We will also temporarily ignore the spin in neutrinos and dark matter. Therefore, with these exceptions the quantized spin of the CMB dominates the universe.

If each Planck sphere contained one unit of quantized spin in Planck spacetime and if there was preservation of quantized spin, then we would expect that the expanded Planck sphere would still on average contain one unit of quantized spin. The best estimate of the current proper radius

⁶ Paul Davies, 1982 The Accidental Universe, Cambridge University Press ISBN 0-521-24212-6

of this Planck sphere is: $I_p \Gamma_{uo} \approx I_p \times 2.6 \times 10^{31} \approx 4.2 \times 10^{-4} \text{ m}$ or a volume of about $3.1 \times 10^{-10} \text{ m}^3$. This estimate uses the value of Γ_{uo} obtained from the ratio of temperatures ($\Gamma_{uo} \approx 2.6 \times 10^{31}$). This number represents the middle of the range of values and is obtained from the simplest calculation. Therefore, assuming spin preservation we would expect that the current density of quantized spin units would be $3.2 \times 10^9/\text{m}^3$. It appears as if the CMB photon density of 4.2×10^8 photons/ m^3 is low by a factor of about 7.6. However this is actually very good agreement considering that the volume has expanded by a factor of about 10^{94} from: $\Gamma_{uo}^3 = (2.6 \times 10^{31})^3 \approx 10^{94}$. In fact, compared to 10^{94} , this small factor could be explained by not including a numerical factor near 1 such as 2π .

Dark Matter Calculation: Even though we should be satisfied with an agreement that is quite accurate considering that it covers a range of 10^{94} , we still have not accounted for neutrinos and dark matter. Suppose that we assume that statistically there is virtually perfect preservation of quantized spin. This assumption gives us the opportunity to estimate the energy of a dark matter particle (rotar). Using 4.2×10^8 photons/ m^3 and an expanded Planck sphere volume of $3.1 \times 10^{-10} \text{ m}^3/\text{sphere}$ we have:

$$4.2 \times 10^8 \text{ photons}/\text{m}^3 \times 3.1 \times 10^{-10} \text{ m}^3/\text{sphere} = 0.13 \text{ photons/sphere}$$

Assuming spin preservation and $\Gamma_{uo} \approx 2.6 \times 10^{31}$, there should be 1 spin unit per sphere therefore we are missing 0.87 spin units/sphere. The average density of dark matter in the universe is about $2.2 \times 10^{-27} \text{ kg}/\text{m}^3$ or an energy density of $1.9 \times 10^{-10} \text{ J}/\text{m}^3$. The current volume of a Planck sphere is $3.1 \times 10^{-10} \text{ m}^3$, therefore combining these we have:

$$1.9 \times 10^{-10} \text{ J}/\text{m}^3 \times 3.1 \times 10^{-10} \text{ m}^3/\text{spin unit} \times (1/0.87) = 6.8 \times 10^{-20} \text{ J}/\text{spin unit}$$

The implied energy per dark matter fundamental particle is $6.8 \times 10^{-20} \text{ J} \approx 0.4 \text{ eV}$. Perhaps this is a coincidence, but out of the many orders of magnitude involved in this calculation, the answer of about 0.4 eV is in the energy range currently attributed to neutrinos and it is far removed from the $>10^{10} \text{ eV}$ energy range assumed for the hypothetical WIMP dark matter particle model. For example, a photometric redshift survey⁷ has set an upper limit of $0.28 \text{ eV}/c^2$ on the sum of the masses of the three types of neutrinos known to exist. An analysis of the Planck space probe data has set an upper limit ($0.23 \text{ eV}/c^2$) on this mass sum⁸. Allowing for the speculative nature of this result, this surprising result warrants a new examination of dark matter candidates.

Can Neutrinos Be Dark Matter? Neutrinos have been discounted as possible explanations of dark matter because they are considered to be "hot dark matter" propagating at velocity in

⁷ Thomas, S.A.; (2010). "Upper Bound of 0.28 eV on Neutrino Masses from the Largest Photometric Redshift Survey". *Physical Review Letters* **105** (3): 031301.[arXiv:0911.5291](https://arxiv.org/abs/0911.5291)

⁸ Planck Collaboration, "Planck 2013 results. XVI. Cosmological parameters". *Astronomy & Astrophysics* **1303**: 5076.[arXiv:1303.5076](https://arxiv.org/abs/1303.5076)

excess of 0.1c. They have such low rest mass that even at a temperature of about 1° K, they would have a velocity much greater than the escape velocity of a galaxy. For example, the Milky Way galaxy has an escape velocity of roughly 600,000 km/s. Also, in the early universe a high density of ultra-relativistic neutrinos would excessively homogenize the CMB distribution. However, the leading candidate for dark matter (a WIMP) also has problems. For example, the hypothetical fundamental particle of a WIMP ($\sim 10^{10}$ to 10^{12} eV) must not exhibit any electromagnetic or strong interaction. Therefore these hypothetical particles would not experience collisions with baryonic matter except through the unlikely event of a weak interaction. Most important, the WIMPs cannot lose kinetic energy by EM radiation to form a stable gravitationally bound orbit.

Think about the required properties of a WIMP particle. It must have such a high probability of being formed that in the early universe, that over 80% of the energy that was destined to become a fermion would have had to go into the formation of these highly energetic particles. In all other respects, the lowest energy particles are the most stable and have the highest probability of surviving to today. If a WIMP is dark matter, then this trend should be reversed. A high energy island of stability would have to exist and over 80% of the rest mass in the universe would have to currently exist as WIMPs.

Now look at the ease with which neutrinos are produced. They are formed with the birth of almost every new particle. They are the lowest energy fermion known and they are known to have long term stability. Also, the low mass/energy of neutrinos more easily forms a mass distribution around a galaxy that is characteristic of the dark matter spherical “halo” provided that they can somehow be slowed to fit the definition of cold dark matter. However, a plausible method for them to lose kinetic energy and cool to less than about 0.01 °K must be suggested. Neutrinos at 2.7 °K would greatly exceed the escape velocity from galaxies. However, neutrinos at a temperature in the range of 0.01 °K would have the required properties.

Neutrinos have the following advantages: 1) They are known to exist, 2) They are known to be produced in large numbers in the early universe and 3) They are known to only interact with ordinary matter by the weak force. Using the known properties of neutrinos, the density of neutrinos has been estimated⁹ at about $3/11$ of the CMB photon density per species. Therefore the 3 species of neutrinos would have a total density of about 82% of the photon density ($\sim 3.4 \times 10^8/\text{m}^3$ for 3 species). This is not quite the density required to satisfy the missing quantized spin (requires $\sim 2.8 \times 10^9/\text{m}^3$), but it is within an order of magnitude. Even though this is not enough, the known formation mechanisms make them the most abundant fermion in the universe.

A rotar model of a neutrino with internal energy of 5×10^{-20} J (about 0.3 eV) would have a quantum radius of $\lambda_c = \hbar c/E_i \approx 6.3 \times 10^{-7}$ m or a quantum volume of about 10^{-18} m³. The energy

⁹ J Rich; Fundamentals of Cosmology (second edition 2009); Springer, Heidelberg, New York

density of a 0.3 eV rotar would be about 10^{24} times smaller than the energy density of an electron. The enormous difference in energy density of neutrinos compared to any other fundamental particle suggests the possibility that perhaps neutrinos also possess other characteristics not observed with other fundamental particles.

Neutrino flavor oscillation has been well documented experimentally. However, it is difficult to explain how neutrinos can change their rest mass if they are visualized as propagating through an empty vacuum. The usual explanation invokes the neutrinos existing simultaneously in three states that differ slightly in mass/energy. These three states would have three slightly different de Broglie frequencies when they are moving relative to an observer. The three frequencies can then constructively and destructively interfere with each other producing what is a change in neutrino flavor (mass). However, this explanation has problems. It is difficult to devise an explanation which allows for a change in rest mass while maintaining both a conservation of energy and a conservation of momentum.

I would like to propose a new consideration which is best explained by an example. The so called “MSW effect” occurs when neutrinos pass through matter such as a star and achieve a resonance with electrons. This is analogous to introducing a different index of refraction for each of the 3 neutrino flavors and results in an increase in flavor oscillation frequency. The mystery of neutrinos changing their mass ceases if we postulate an interaction with other particles because conservation laws hold if other particles are introduced.

Suppose that we assume that there is some mechanism by which neutrinos can be cooled to a temperature less than 0.01 degrees K. Then neutrinos would exhibit the properties of dark matter. At the earth’s distance from the galactic center, the energy density of dark matter is about 3×10^{14} eV/m³. If we assume neutrinos to have energy of about 0.3 eV, then this works out to about 10^{15} neutrinos/m³ at the earth. With this density, the experiments conducted on earth are not measuring the flavor oscillation rate in a total vacuum. Our best vacuum would still contain about 10^{15} neutrinos/m³. The interesting point is that an interaction between neutrinos would produce acceleration and deceleration of fermions with rest mass. This would generate gravitational waves and cooling of neutrinos.

Perhaps this is an over simplification, but a flavor oscillation which involves an interaction between neutrinos with different energy resulting in a slight mass change would involve acceleration and deceleration of matter. This should produce a small gravitational wave. If this happens, it would represent a loss of kinetic energy relative to the cosmic microwave background (CMB) rest frame of reference. Neutrinos which originated at the Big Bang could possibly be cooled by gravitational wave emission to a temperature far below the temperature of the CMB photons. If this additional cooling occurs to an extent that neutrino temperature is lowered to less than about 0.01 degree K, then neutrinos would qualify as being cold dark matter.

Summary of the Γ_{u0} Calculations: We took a deviation in the discussion of dark matter. However, now we will return to the earlier discussion of the Γ_{u0} calculation. We have now

calculated the value of Γ_{u0} several different ways and they all give about the same answer. The closeness of the results obtained with very different approaches supports the model being used. We will use the value $\Gamma_{u0} \approx 2.6 \times 10^{31}$ as representative of the range of values calculated here for future calculations. Using this value, today each Planck sphere has expanded to a proper radius of $l_p \times \Gamma_{u0} \approx 0.42$ mm. However, measured in coordinate units which presume $\Gamma_u = 1$, the Planck sphere still has a radius of $\mathcal{R} = 1$. It also appears to still have on average 1 unit of quantized spin. The analysis of the spin per Planck sphere will be made in the next chapter.

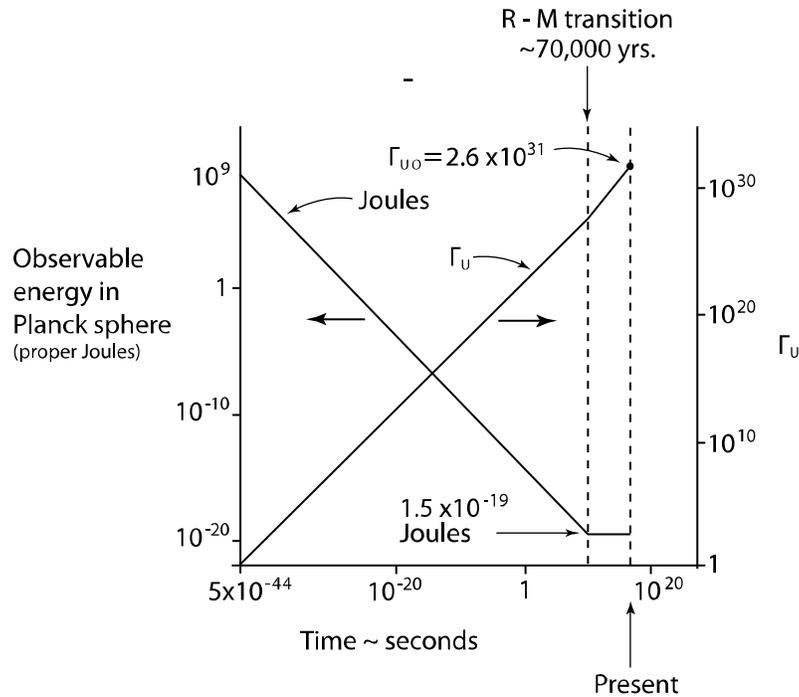


FIGURE 13-4 Left Scale: Plot of the observable energy in the Planck sphere over the age of the universe. Right Scale: Plot of the background gravitational gamma of the universe Γ_u over the age of the universe.

Graph Showing the Evolution of Γ_u and Observable Energy: Figure 13-4 shows two superimposed graphs that use the same time line but different Y axis scales. Note first that the X axis is a log scale of the age of the universe in seconds. The time scale extends from 5×10^{-44} s which is 1 unit of Planck time to 10^{20} seconds which is an age of about 3 trillion years. The present age of the universe is about 4.3×10^{17} seconds ($\sim 13.8 \times 10^9$ years) and is designated with an arrow and a vertical dashed line.

The graph line designated Γ_u is the value of the background gravitational gamma of the universe (Γ_u). This graph uses the right scale which is a log scale extending from $\Gamma_u = 1$ to about $\Gamma_u \approx 10^{32}$. It can be seen from this graph that $\Gamma_u = 1$ at a time of $\tau_u = 5 \times 10^{-44}$ seconds and ends with $\Gamma_u \approx 2.6 \times 10^{31}$ at the present ($\tau_u \approx 4.3 \times 10^{17}$ s). Note that there is a slight change in the slope of

this line as it crosses the vertical line designated R-M transition. This is the transition between a radiation dominated universe and a matter dominated universe that occurred about 70,000 years after the beginning of the universe (the Big Bang). There should also be another slope change at the transition between the matter dominated epoch and the dark energy dominated epoch. However, this slope change is so small that it does not show up on this log-log graph.

The other graph (designated "Joules") uses the left scale and is the observable energy in the Planck sphere (also a log scale). A sphere Planck length (l_p) in radius started with about 1 billion Joules when the universe was Planck spacetime for the first unit of Planck time. Over the age of the universe as Γ_u increased, the proper radius of this sphere increased and equaled $\Gamma_u l_p$. The proper energy of this imaginary Planck sphere decreased during the radiation dominated epoch by a factor of 6.4×10^{27} from about 10^9 J to about 1.5×10^{-19} J and then the proper energy generally has remained constant since the end of the radiation dominated epoch. Therefore, note the flat line from an age of about 70,000 years to the present. However, the energy on an absolute scale where $\Gamma_u = 1$ continues to decrease as Γ_u increases. For example, the decreasing rate of time makes it appear that the Compton frequency of fundamental particles is constant. However, if we timed the Compton frequency of an electron using the $\Gamma=1$ clock, we would find that on this absolute time scale, even the Compton frequency of an electron would be slowing down each second. It is not noticeable because our cosmic clock is slowing down at the same rate.

Chapter 14

Cosmology II – The Big Picture

In chapter 3 we determined the changes in energy, force, voltage, etc. that are required to keep the laws of physics constant in different gravitational potentials where there is a difference in the rate of time. The “normalized” coordinate system of chapter 3 used the equation $L_o = L_g$. This does not imply that L_o and L_g are constant over time. It is now proposed that both of these units of length are simultaneously contracting as the universe ages. This simultaneous contraction maintains $L_o = L_g$ in the CMB rest frame according to a midpoint observer.

Now we are attempting to understand the evolution of the universe. To do this I propose that it is most convenient to use a coordinate system based on the properties of Planck spacetime when $\Gamma_u = 1$. Even though the universe has always had flat spacetime, there has been a continuous increase in Γ_u since the Big Bang. As previously explained, the current value of Γ_u is about $\Gamma_{u0} \approx 2.6 \times 10^{31}$ and this number continues to increase. This affects many things including our rate of time, our length standard and our energy standard. The best reference we have to quantify these changes is to use a coordinate system based on the conditions that existed when $\Gamma_u = 1$. Another way of saying this is that we should reference the conditions that existed at the start of the Big Bang when we had Planck spacetime.

Relative to the spatial and temporal coordinate system that existed at the Big Bang when $\Gamma_u = 1$, there has been a decrease in the rate of time and a decrease in a standardized unit of length such as one meter. As will be explained, this combination keeps the laws of physics unchanged. This has some similarities to the gravitational effects previously discussed in chapter 3. However, with the universe the background gravitational gamma (Γ_u) is continuously increasing. One of the few indications that anything is changing in the universe is that light that was emitted a long time ago from distant sources has undergone obvious changes in wavelength and intensity.

Spacetime Transformation Model: A model of the universe based on a continuously increasing Γ_u represents an alternative to the Big Bang model. What we perceive as an increase in the scale of the universe is actually due to an increase in the background Γ_u of the universe changing the spatial and temporal dimensions of spacetime. This is a change in the properties of spacetime that has an effect on everything in the universe. The radius of an atom or the rotar radius of a rotar would decrease relative to coordinate length \mathcal{R} . An increase of Γ_u results in the following: 1) the hybrid speed of light of the universe decreases; 2) proper length contracts relative to coordinate length; 3) the rate of proper time decreases relative to the rate of coordinate time; 4) the total energy density of the universe remains the same (total energy includes vacuum energy).

Perhaps most surprising of these is that the spacetime transformation model says that the coordinate energy density of the universe has remained constant since the beginning of the universe (since the Big Bang). The coordinate energy density utilizes coordinate length \mathbb{R} and coordinate rate of time dt to quantify coordinate energy density. The observable energy density of the universe (measured in proper units of energy) has decreased by a factor of roughly 10^{120} since the beginning of time (since the Big Bang). However, including the waves in spacetime responsible for vacuum energy, it will be shown that the spacetime transformation model of the universe sees no change in the coordinate energy density of the universe. This also eliminates the famous 10^{120} discrepancy between the “critical” energy density of the universe derived from general relativity and supported by observation compared to the calculated energy density of the universe derived from quantum mechanics and quantum chromodynamics.

This spacetime transformation model might seem like an unnecessary contrarian view that is fundamentally equivalent to depicting the universe as expanding. However, it will be shown that this model is not equivalent to the Big Bang model. This proposed model gives the same redshift and the same increase in proper volume as the Big Bang model, but the spacetime transformation model offers different predictions about the future of the universe. Probably the most controversial difference is that the spacetime transformation model purports to eliminate the need for dark energy and a cosmological constant.

Observable Universe from Planck Spacetime: As previously stated in chapter 13, Planck spacetime had spherical Planck energy density. Most importantly, Planck spacetime had $\Gamma_u = 1$ and all the dipole waves in spacetime had $\frac{1}{2}$ Planck energy (about 10^9 J) and \hbar angular momentum. This means that 100% of the energy in Planck spacetime was “observable” (had quantized spin). The value of $\Gamma_u = 1$ also means that the rate of time was the highest possible and the proper volume of the universe was the smallest possible. $\Gamma_u = 1$ also implies that a unit of energy such as one Joule was the highest possible value when measured on the absolute energy scale which uses coordinate rate of time and coordinate length. In comparison, it will be shown that one Joule today is a vastly lower energy on the absolute energy scale because today $\Gamma_{uo} \approx 2.6 \times 10^{31}$. Also, the transformation of spacetime that has taken place since the Big Bang has resulted in a decrease in the percentage of the energy in the universe that possesses quantized angular momentum. Today, only about 1 part in 10^{122} of the energy in the universe is “observable” (possesses quantized angular momentum)

All the energy required to form our current universe (including vacuum energy) would be contained in a sphere of Planck spacetime about 15×10^{-6} meters (~ 15 microns) in radius. This radius is calculated by reducing the current distance to our particle horizon (~ 46 billion light years or 4×10^{26} m) by a factor of $\Gamma_{uo} = 2.6 \times 10^{31}$. Our current universe has $\Gamma_{uo} \approx 2.6 \times 10^{31}$ which greatly reduces both our current standard of energy and the fraction of the energy in the universe that is “observable energy”

It is presumed that the universe currently extends far beyond our current particle horizon. This means that the original volume of Planck spacetime was far bigger than the 15 micron radius spherical volume required to form everything (including vacuum energy) within our current particle horizon. This original volume of Planck spacetime might not have been infinite, but it is presumed to be effectively infinite because there is no detectable difference as far as a model of the universe is concerned. It is also presumed that there are galaxies, dark matter, etc. beyond our particle horizon that have a similar appearance and density to our observable universe.

The spacetime transformation model of the universe has a fixed (not expanding) coordinate system. For example, two distant galaxies are considered to be separated by a constant distance when measured in units of coordinate length \mathcal{R} . The coordinate grid used by the spacetime transformational model has similarities to the coordinate grid used by the Λ -CDM model. Both grids correspond to the CMB rest frame at all locations in the universe. However the difference is that the Λ -CDM model has a grid that expands with the proper volume of the universe and the spacetime transformation model has a grid that remains stationary. In the spacetime transformation model, the expansion in the proper volume of the universe is accommodated by the change in Γ_u over the age of the universe.

Hubble Parameter and Shrinking Meter Sticks: Today, astronomers do not realize that their meter sticks are contracting due to changes in spacetime. The term “meter stick” represents any means of length measurement. Astrophysicists calculate that the distance to distant galaxies is increasing. However, this distance is measured using contracting meter sticks (contracting units of length). The distant galaxies that are stationary on the static coordinate system appear to be receding at a velocity given by the Hubble parameter.

In astronomical terminology, the Hubble parameter is often expressed as about $\mathcal{H} \approx 70.8 \text{ km/s/Mpc}$ where Mpc is mega parsec, a unit of length used in astronomy equal to about 3.09×10^{22} meters. Converting the Hubble parameter to SI units we have $\mathcal{H} \approx 2.29 \times 10^{-18} \text{ m/s/m}$. The seconds used here are today’s proper seconds. The common interpretation of the Hubble parameter is that this is the current expansion rate of the universe. The spacetime transformation model interprets the Hubble parameter differently:

$$\mathcal{H} = \frac{da_u}{d\tau_u} = \frac{d\Gamma_u}{d\tau_u} \quad \text{or} \quad \mathcal{H} = \frac{\dot{a}_u}{a_{u0}} = \frac{\dot{\Gamma}_u}{\Gamma_{u0}} \quad \text{note the dots representing time derivative}$$

The dots are shorthand for time derivatives. Therefore, the Hubble parameter \mathcal{H} equals the rate of change of Γ_u divided by the current background value Γ_{u0} . Also a_{u0} is the current scaling factor of the universe which is equal to Γ_{u0} .

A meter stick (1 meter long) is contracting at a velocity of about 2.29×10^{-18} meters/second when compared to a hypothetical meter stick that is not contracting (a meter stick with fixed

coordinate length in units of \mathbb{R}). As explained in chapter 13, the Hubble sphere is a 13.7×10^9 light year (1.3×10^{26} m) radius imaginary spherical shell where galaxies and space itself are calculated to be receding away from us at about the speed of light. However, it is proposed that we are using a contracting unit of length, such as a contracting meter stick, as reference for this calculation. The proper distance between us and a galaxy at the edge of the Hubble sphere is indeed increasing by 3×10^8 m/s, but that is because we are measuring the distance using a contracting meter stick. Our meter stick is shrinking at the rate of 2.29×10^{-18} meters/second so we obtain an increase in proper distance of 3×10^8 m/s (obtained from 2.29×10^{-18} m/s/m \times 1.3×10^{26} meters). This is not the same as saying that the galaxy is physically receding from us at the speed of light. The spacetime transformation model says that the calculated speed is erroneous because it is obtained when we measure a fixed distance using shrinking meter sticks.

The reasonable explanation is that spacetime is undergoing a transformation that changes the coordinate speed of light while keeping the laws of physics unchanged (including a constant proper speed of light). This is similar to the covariance of the laws of physics in different gravitational potentials as discussed in chapter 3. However, with the universe Γ_u increases with time but the laws of physics remain unchanged. One observable effect is that it takes longer for light to travel between galaxies as the universe ages. Since we measure no change in the proper speed of light we interpret this as indicating an expansion. However, the alternative explanation proposed here is that the change occurring in the properties of spacetime produces a dimensional contraction. In chapter 3 we saw how the rate of time can change at different elevations of a gravitational field without being detectable locally. Gravity also was shown to affect proper volume which implies a difference in the unit of length. The universe is also producing an omnidirectional gravitational effect that is continuously increasing. One result of this is what we perceive to be the cosmological increase in the volume of the universe.

It was shown in chapter 3 that gravity affects many of the units of physics in a way that keeps the laws of physics unchanged. It is proposed that something similar is happening with the entire universe except that there is an important difference. With the universe at any instant the value of Γ_u is uniformly increasing everywhere. This is the opposite of the gravity assumed in chapter 3 which was static and had a gravitational gradient. The continuous increase in Γ_u causes changes in various units of physics (energy, force, voltage, etc.) which together preserve the laws of physics. Only when we look at distant galaxies do we obtain a hint that change over time is occurring.

No Cosmic Event Horizon: The Λ -CDM model considers the accelerating expansion of the universe to have a cosmic event horizon. This is defined as the largest comoving distance from which light emitted now can *ever* reach the observer in the future¹ According to the Λ -CDM model, galaxies that we observe as having a redshift greater than $Z = 1.8$ are currently beyond

¹ Bergström, L.; Goobar, A.: "Cosmology and Particle Physics", WILEY (1999), p. 65. ISBN 0-471-97041-7

our cosmic event horizon. Light that is currently being emitted by these galaxies will supposedly never reach us because cosmic expansion of space is adding volume at such a fast rate that the distance increase exceeds the speed of light. Even the expansion of our Hubble sphere cannot overcome the accelerating expansion of the universe. Photons being emitted now by galaxies with $Z > 1.8$ will be swept away from us by the accelerating expansion of the universe. The only reason that we can see those galaxies today is that we are seeing the light emitted from a long time ago before they crossed our event horizon. Once again, that is the Λ -CDM model interpretation.

The spacetime transformation model of the universe makes a prediction that is different than the Λ -CDM model. The proper distance between us and the $Z > 1.8$ galaxies is indeed increasing faster than the speed of light. However, this is because of the current rate of increase in Γ_u is causing our meter sticks to shrink. The galaxies are actually stationary on the proposed coordinate grid. The prediction is that light currently being emitted from those galaxies will eventually reach us but at a slower hybrid speed of light than today. Even though the universe appears to have accelerating expansion, the spacetime transformation model says that there is no event horizon at a distance corresponding to $Z = 1.8$ or at any other distance in the foreseeable future.

We can obtain a better insight into the properties of the hybrid speed of light with a numerical example. Since $\mathcal{C} \equiv d\mathbb{R}/d\tau_u = c/\Gamma_u$, therefore the current value of the hybrid speed of light is:

$$\mathcal{C} = c/\Gamma_{u0} = c/2.6 \times 10^{31} \approx 10^{-23} \text{ m/s}$$

This is the current hybrid speed of light where the units m/s are coordinate meters (\mathbb{R}) divided by proper comoving seconds (note use of italic in coordinate units). The hybrid speed of light is decelerating every second at a current rate of:

$$\mathcal{CH} \approx 10^{-23} \text{ m/s} \times 2.3 \times 10^{-18} \text{ s}^{-1} \approx 2.3 \times 10^{-41} \text{ m/s}^2 \quad \text{deceleration of } \mathcal{C}$$

Finally, the current rate of time ($d\tau_{u0}$) is about 2.6×10^{31} times slower than the coordinate rate of time ($d\hat{t}$) which assumes $\Gamma_u = 1$.

Constant Coordinate Energy Density: The energy density of this $15 \times 10^{-6} \text{ m}$ spherical volume is equal to spherical Planck energy density: $U_{ps} \approx 5.5 \times 10^{112} \text{ J/m}^3$. At the beginning of time (the Big Bang) this energy was in the form of dipole waves in spacetime with the unique properties of Planck spacetime previously enumerated. Today the characteristics of the dipole waves in spacetime that form both vacuum energy and the observable mass/energy in our universe have changed their characteristics compared to Planck spacetime. Almost all the energy in the universe today is in the form of vacuum energy – dipole waves in spacetime that do not possess angular momentum. Only an extremely small part is in the form of observable energy that

possesses angular momentum. However, it will be shown that not only the proper energy density (including vacuum energy) but also the coordinate energy density of the universe today is still the same as Planck spacetime. There have been changes relating to the distribution of quantized angular momentum, the rate of time, proper length, etc. but the total energy density has not changed even when measured using coordinate energy density that assumes $\Gamma_u = 1$. Therefore, it is possible to adopt a coordinate system based on these coordinate values that does not expand over time. This is the stationary coordinate system of the spacetime transformation model.

It might seem that the Big Bang model is ultimately equivalent to the spacetime transformation model with its stationary coordinate system. However, this is not a case of simple coordinate transformation. For example, the two models make different predictions about the existence of an event horizon as previously noted. Also, the Big Bang model cannot accommodate the fact that new volume being added to the universe must also possess the vacuum energy with energy density exceeding 10^{112} J/m³. Where did this additional energy come from? The spacetime transformation model can accommodate this requirement as will be explained later in this chapter.

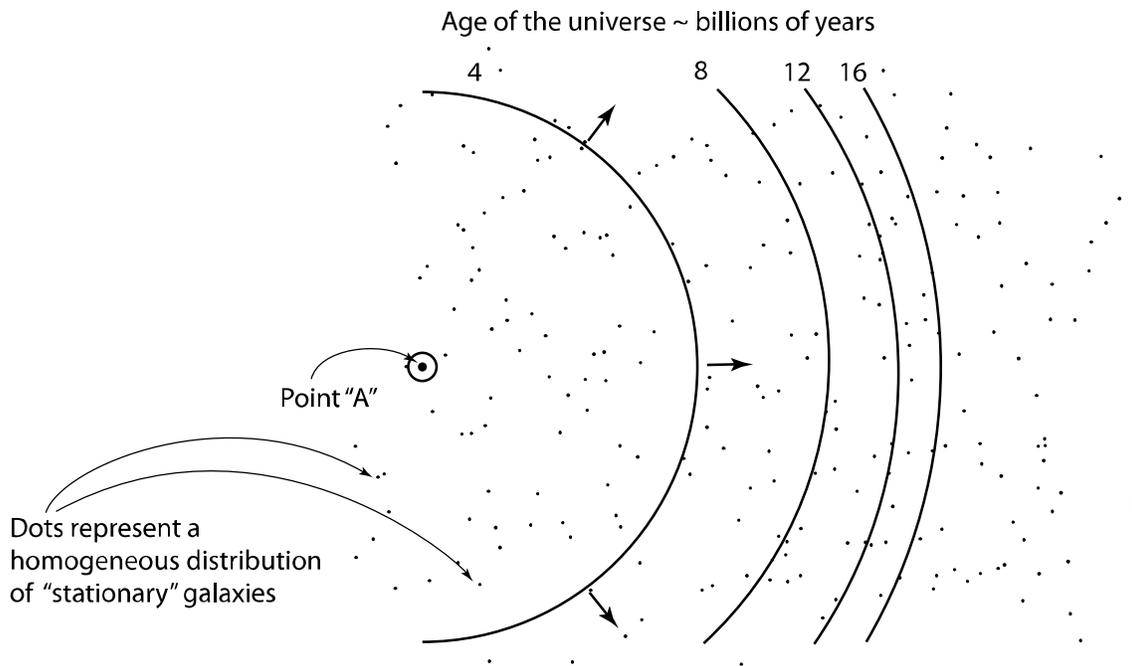


FIGURE 14-1 This Figure is drawn assuming the dimensional contraction model which uses coordinate length and assumes a homogeneous distribution of stationary mass (galaxies). The gravitational influence of energy at a point spreads at the coordinate speed of light which is decreasing with time as Γ_u increases.

Illustration of Slowing Hybrid Speed of Light: Figure 14-1 illustrates the concept of a stationary coordinate system with a slowing hybrid speed of light. This figure uses coordinate length, therefore the distance in coordinate length units between Point A and the furthest curved surface (16 billion years) is roughly 10^{-5} m. Point "A" can be imagined as initially a Planck sphere

within Planck spacetime at the beginning of time. This sphere contained about a billion Joules, so when time began to progress the gravitational influence of this energy began to propagate away from point A at the proper speed of light c . However, the rate of propagation as measured using the hybrid speed of light decreases as Γ_u increases. After 4 billion years the gravitational influence had reached the propagating particle horizon designated 4 billion years. (The term “propagating particle horizon” is used here to designate the expanding sphere of influence of a point of mass/energy) Similarly, the propagating particle horizons for 8, 12 and 16 billion years are shown.

The purpose of this figure is to illustrate the slowing rate of propagation as indicated by the decreasing distance separating the curved surfaces as time progresses and Γ_u increases. There is no tendency for this progression to be swept backwards by cosmic expansion. The rate of progress will continue to decrease, but there is no event horizon where the progress is stopped. It is speculation whether Γ_u ever reaches such a large value that a quantum mechanical transition occurs. The spacetime transformation model of the universe predicts that for the foreseeable future, we will continue to see new, more distant galaxies appear in the sky. The galaxies that we currently see will get dimmer (less photons per second per m^2) but also paradoxically be less redshifted than today.

Redshift: The spacetime transformation model is also the best model to see why an increasing background Γ_u produces a redshift on the light that we see from a distant galaxy. The presence of a redshift in cosmology is counter intuitive when it is realized that the spacetime transformation model claims that the rate of time was faster when the light was emitted ($d\tau_{em}$) than when the light is observed ($\Gamma_{em} < \Gamma_{obs}$ and $d\tau_{obs} < d\tau_{em}$). For example, Schwarzschild assumed a single stationary mass in an empty universe. This assumption presumed a “mature gravity” condition (no time dependence). Under these conditions, light propagating from a location far from the mass (small gravitational Γ) to a location near the mass (large gravitational Γ), undergoes a “gravitational blue shift”. This was previously discussed and shown that a distant observer using a single rate of time perceives no change in the energy of the photon. The locally observed apparent increase in energy is due to the slow rate of time in gravity (large Γ).

When the background Γ_u of the universe increases uniformly everywhere, this is completely different than a photon propagating from a location with a small value of Γ to a location with a larger value of Γ . It will be shown below that an increase in the background Γ_u of the universe produces a redshift which includes an increase in proper wavelength and a decrease in proper frequency and a decrease in proper energy.

Coordinate Wavelength Constant: When the background Γ_u of the universe is increasing homogeneously throughout the universe, this means that the hybrid speed of light is decreasing homogeneously as: $C = c/\Gamma_u$. Light in flight just slows down homogeneously everywhere. This homogeneous slowing maintains the same coordinate wavelength for a light wave. The entire

wave just slows down without changing its size when measured using coordinate length. If the light in flight is constant wavelength when measured in units of coordinate length, what result will we obtain when we measure the wavelength in units of proper length using a contracting meter stick? We will obtain the result that the light is increasing its wavelength relative to the contracting meter stick. In other words, we would see a redshift (an increase in wavelength).

Redshift – Wavelength Analysis: To analyze this we will assume that light is emitted in location #1 at an age of the universe t_1 and a background gravitational gamma Γ_1 . The emission is at coordinate wavelength λ which can be converted to proper wavelength λ_1 at the time of emission. At a later time (age of the universe t_2 and background gamma Γ_2) the coordinate wavelength is still the same λ but the proper wavelength is λ_2 relative to the contracted meter stick. All we have to do is compare λ_1 to λ_2 which means that we need to convert λ which is always in units of coordinate length \mathcal{R} into wavelength λ expressed in proper length at two different times. The coordinate wavelength λ does not change; it only slows down due to a change in the hybrid speed of light \mathcal{C} when Γ_u increases ($\mathcal{C} = c/\Gamma_u$). Therefore we must convert between coordinate length and proper length at two different values of background gamma: Γ_1 and Γ_2 . From chapter 13 we know that the conversion of units of coordinate length \mathcal{R} to units of proper length is $L = \Gamma_u \mathcal{R}$. When we express this conversion in terms of wavelength symbols we have $\lambda = \Gamma_u \lambda$. This says that a given wave appears to have a bigger wavelength (more units of proper length) when it is measured with the contracted meter stick used for proper length than when it is measured with the coordinate scale meter stick that is not contracted. Since λ is independent of the background Γ_u we have:

λ = wavelength of light when measured in units of coordinate length.

λ_1 and λ_2 = wavelength of light (proper wavelength) at time t_1 and t_2 where $t_2 > t_1$

Γ_1 and Γ_2 = background Γ_u of the universe at time t_1 and t_2 where $t_2 > t_1$

a_{em} = cosmological scale factor at emission (a_{em}) at time = t_1

a_{obs} = cosmological scale factor at observation (a_{obs}) at time = t_2

$$\lambda = \frac{\lambda_1}{\Gamma_1} \quad \text{and} \quad \lambda = \frac{\lambda_2}{\Gamma_2} \quad \text{conversion of } \lambda \text{ to } \lambda_1 \text{ and } \lambda_2$$

$$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_2}{\Gamma_1} \quad \text{since } \Gamma_2 > \Gamma_1 \text{ therefore } \lambda_2 > \lambda_1 \text{ (wavelengths in units of proper length)}$$

Since Γ_u is increasing with time, therefore $\Gamma_2 > \Gamma_1$ and $\lambda_2 > \lambda_1$. This all says that λ_2 is redshifted (longer wavelength) compared to λ_1 . The amount of the redshift is: $\lambda_2/\lambda_1 = \Gamma_2/\Gamma_1$ which can also be expressed in terms of the ratio cosmological scaling factors at emission ($a_{em} = a_1$) and observation ($a_{obs} = a_2$) or in terms of redshift $1 + Z$.

$$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_2}{\Gamma_1} = \frac{a_2}{a_1} = \frac{a_{obs}}{a_{em}} = 1 + Z$$

Since λ_1 is the proper wavelength at emission (time t_1) and λ_2 is the proper wavelength at observation (time t_2), therefore the relationship can be written as:

$$\frac{\lambda_{obs}}{\lambda_{em}} = \frac{a_{obs}}{a_{em}} = 1 + Z$$

This answer, obtained from the spacetime transformation model agrees with the answer obtained from the Big Bang model that assumes cosmic expansion of the universe.

Redshift – Frequency Analysis: Therefore, it has been shown that looking just at wavelength there is the correct redshift when we presume that the redshift is caused by a change in the background Γ_u rather than an expansion of the universe. It is possible to work this same problem looking at the frequency of the radiation rather than at the wavelength. In this case we would expect a lower frequency at a later time when we express frequency relative to proper time.

We will start off by working this problem using coordinate values. As before, there is no change in wavelength expressed in terms of coordinate length between the emission and observation. The new symbols are:

C_1 and C_2 = hybrid velocity of light at times t_1 and t_2 respectively

λ = wavelength expressed in units of coordinate length – this does not change at t_1 and t_2

ν_1 and ν_2 = proper frequency of light at times t_1 and t_2 respectively

proper frequency has a redshift since $\nu_1 > \nu_2$ and $\Gamma_{u2} > \Gamma_{u1}$

Since ν_1 can be considered the frequency when the light was emitted ($\nu_1 = \nu_{em}$) and ν_2 can be considered the frequency when the light was observed ($\nu_2 = \nu_{obs}$), therefore the following is another way of stating these results:

$$\frac{\nu_{obs}}{\nu_{em}} = \frac{a_{em}}{a_{obs}} = \frac{1}{Z + 1}$$

Therefore the spacetime transformation model gives the same redshift (proper wavelength and proper frequency) as the Big Bang model. However, this analysis leaves one question unanswered. If the rate of time was faster in the past than it is today, why don't we observe a blue shift on light from distant galaxies? The answer to this question is not obvious in the previous analysis because that analysis used the "hybrid speed of light $C = dR/d\tau_u$ ". This definition incorporates the proper rate of time in the universe ($d\tau_u$) which hides the question about the blue shift. This question can only be answered if we compare proper values to coordinate values. This comparison requires that we rework the problem using coordinate rate of time (dt), coordinate speed of light (C) and coordinate frequency (ν_c).

To begin, we will return to the example previously stated and examine light emitted at location #1 at an age of the universe t_{u1} which had a background gravitational gamma Γ_{u1} . This light is later observed at location 2 with the age of the universe t_{u2} and background gamma Γ_{u2} . Again, the wavelength of the light measured in units of coordinate length is λ . This coordinate wavelength does not change; the light merely slows as the coordinate speed of light decreases. The coordinate speed of light at ages of the universe t_{u1} and t_{u2} will be designated as \mathcal{C}_1 and \mathcal{C}_2 respectively.

$$\mathcal{C}_1 = \frac{c}{\Gamma_{u1}^2} \quad \text{and} \quad \mathcal{C}_2 = \frac{c}{\Gamma_{u2}^2}$$

We will now state the frequency of this light using the rate of coordinate time dt as our standard. Recall that $dt = \Gamma_u d\tau_u$. Frequency obtained using the coordinate time standard will be designated ν_c . The particular coordinate frequency produced by wavelength λ will be designated ν_{1c} when the background gamma is Γ_{u1} and ν_{2c} when the background gamma is Γ_{u2} . Therefore:

$$\lambda = \frac{\mathcal{C}_1}{\nu_{1c}} = \frac{\mathcal{C}_2}{\nu_{2c}} \quad \text{set } \mathcal{C}_1 = \frac{c}{\Gamma_{u1}^2} \text{ and } \mathcal{C}_2 = \frac{c}{\Gamma_{u2}^2}$$

$$\frac{c}{\nu_{1c}\Gamma_{u1}^2} = \frac{c}{\nu_{2c}\Gamma_{u2}^2}$$

$$\frac{\nu_{2c}}{\nu_{1c}} = \left(\frac{\Gamma_{u1}}{\Gamma_{u2}}\right)^2 \quad \text{ratio of coordinate frequencies}$$

This says that using coordinate frequency results in a redshift proportional to the square of the ratio of gammas. This means that the correction due to the slowing rate of time does not produce an observable blue shift, but instead this blue shift is used to reduce a coordinate redshift that is proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ to a proper redshift proportional to just $(\Gamma_{u1}/\Gamma_{u2})$. This is shown by making the substitution $\nu_{1c} = \frac{\nu_1}{\Gamma_{u1}}$ and $\nu_{2c} = \frac{\nu_2}{\Gamma_{u2}}$ to obtain the ratio of frequencies expressed in proper frequencies ν_1 and ν_2 .

$$\frac{\nu_2}{\nu_1} = \frac{\Gamma_{u1}}{\Gamma_{u2}} \quad \text{ratio of proper frequencies}$$

Rotar's Frequency: Since photons lose proper frequency as Γ_u increases, why does the proper Compton frequency of rotars remain constant? To put this question in perspective, we should first acknowledge that on the coordinate time scale that assumes $\Gamma_u = 1$ the Compton frequency of a rotar does decrease. Therefore, all fundamental rotars are continuously slowing down on an absolute time scale. We do not notice this slowing because our cosmic clock is also slowing.

Therefore we are using a continuously slowing clock to time the frequency of a continuously slowing rotar such as an electron. This is a moving standard, but each second an electron is losing about 282 Hz if we measured the Compton frequency using the rate of time that existed in the previous second ($\omega_{\mathcal{H}}/2\pi \approx 282 \text{ Hz/s}$).

Therefore, on an absolute time scale, why does a photon's frequency decrease proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ while a rotar's frequency scales with just $(\Gamma_{u1}/\Gamma_{u2})$? The answer is that the propagation rate of the rotar's dipole wave decreases proportional to $(\Gamma_{u1}/\Gamma_{u2})^2$ but this is partly offset by a decrease in the rotar's circumference (measured on the absolute scale of \mathbb{R}). The reduced circumference distance and reduced rotar radius (both measured on the absolute scale of \mathbb{R}) means that a dipole wave with quantized angular momentum propagates around the shortened circumference (measured in units of \mathbb{R}). The decrease in a rotar's circumference results in a rotar's frequency scaling with $(\Gamma_{u1}/\Gamma_{u2})$ which matches the rate of time decrease on an absolute scale. Therefore, the rotar's Compton frequency appears to be constant while the frequency of a photon decreases when measured using proper rate of time. The standard explanation of the cosmic redshift based on expansion of the universe is proposed to be wrong. Wavelengths are not being stretched. There are no point particles. Particles with finite dimensions are also affected by the transformation of spacetime. However the effects on particles are not noticeable because there are offsetting effects on the rate of time, on the standard of energy and on other units of physics.

Maintaining the Vacuum Energy Density: Throughout this book there have been numerous references to the energy density of the spacetime field being on the order of 10^{113} J/m^3 (times an unknown numerical constant near 1). The problem is that throughout the history of the expanding universe, the proper energy density of vacuum energy would have to remain constant. The expanding volume would appear to require a mechanism to continuously add a tremendous amount of new energy to the expanding universe. For example, the Hubble parameter of $\mathcal{H} \approx 2.3 \times 10^{-18} \text{ m/s/m}$ indicates that each cubic meter in the universe is expanding and increasing its volume by $\sim 10^{-53} \text{ m}^3/\text{s}$. If the vacuum energy density required to fill this additional volume is $U_{vac} \approx 10^{112} \text{ J/m}^3$, then the additional volume generated by EACH cubic meter in the universe requires additional $10^{59} \text{ Joules/second}$. To put this in perspective, the $E = mc^2$ total observable energy of the Milky Way galaxy is also about 10^{59} Joules . Therefore it would appear that each cubic meter of volume in the universe must be supplied with about 10^{59} Joules of energy each second.

Therefore, the problem of supplying the universe with dark energy each second is trivial compared to the problem of supplying the universe with new vacuum energy each second. This all seems to be impossible, so most physicists presume that there must be some mechanism that cancels out almost all the implied vacuum energy density in the universe. However, this hypothetical cancelation mechanism has several problems. 1) Zero point energy, vacuum fluctuations, and the uncertainty principle must remain and these all imply that vacuum energy

has not been canceled. 2) The canceling mechanism must be careful to leave the one part in 10^{122} that constitutes our observable universe. 3) The effect capable of canceling 10^{113} J/m³ must be equally as large. 4) No mechanism has been suggested that is capable of causing this enormous cancelation.

The spacetime transformation model says that there is no canceling mechanism. The enormous vacuum energy is present in spacetime. It is dipole wave energy that lacks angular momentum and therefore only interacts with our observable universe (fermions and bosons) through subtle quantum mechanical mechanisms. This vacuum energy is the most perfect superfluid possible. It forms the single universal field that is responsible for all other fields. It also gives the following properties to spacetime: $Z_s, c, \epsilon_0, \mu_0, \hbar, G, l_p, t_p$, etc.

New Transformations of Units: Recall that in chapter 3 we made a table of transformations of the units of physics showing the difference between a “zero gravity” location and a location with gravity. In chapter 3 we designated the “zero gravity” location as having $\Gamma = 1$. Now it is necessary to realize that this designation incorporated a simplification. We were ignoring any change in the background gravitational gamma of the universe Γ_u . Another way of saying this is that we defined a “zero gravity location” as having $\Gamma = 1$. Now that we are talking about the evolution of the universe it is necessary to be more precise. The length transformation was previously expressed as: $L_o = L_g$. However, to put this in the bigger perspective that incorporates Γ_u and \mathcal{R} , we can now say:

$$L_o = L_g = \mathcal{R}/\Gamma_u$$

This equation says that what we were previously calling L_o and L_g were both changing relative to our absolute length standard \mathcal{R} that was present at the start of the universe when $\Gamma_u = 1$. When we are dealing with the universe and time scales where the effects of a changing background Γ_u are significant, then it is no longer possible to adopt proper length as the coordinate unit of length. A different coordinate length transformation is required to characterize the relationship between the units of physics when they are compared at the same location but at substantially different ages of the universe. The value of Γ_u increases with the age of the universe.

In chapter 3 we were able to obtain all the other transformations using dimensional analysis once we had the transformations for length, time and mass. Previously these three transformations were expressed as:

$L_o = L_g$	unit of length transformation
$T_o = T_g/\Gamma$	unit of time transformation
$M_o = M_g/\Gamma$	unit of mass transformation

In these transformations the symbols L_o , T_o and M_o represented coordinate (zero gravity) units of length, time and mass respectively. Now it is necessary to adopt new coordinate units to represent a unit of coordinate length, coordinate time and coordinate mass at the start of the Big Bang when the universe was one unit of Planck time old ($\tau_u = 1$) and had $\Gamma_u = 1$. We have previously been using \mathcal{R} to represent one unit of coordinate length in a universe where $\Gamma_u = 1$. However, now it is necessary to add a subscript "1" to this designation to conform to a pattern where all units of physics need to be specified when $\Gamma_u = 1$. For example, E_1 , Q_1 and U_1 will be used to specify a unit of energy, charge and energy density respectively when $\Gamma_u = 1$. The symbols \mathcal{M}_1 and \mathcal{T}_1 will be used to specify a unit of mass and time respectively at the start of the Big Bang when $\Gamma_u = 1$.

In chapter 3 the subscript "g" was used to specify a location in gravity. The analogous condition when dealing with the evolution of the universe is to specify the unit of physics when it feels the effect of a background gravitational gamma that is greater than 1 ($\Gamma_u > 1$). This condition will be specified by the subscript "u". For example, a unit of length, time and mass when $\Gamma_u > 1$ will be designated as L_u , T_u and M_u respectively. For the evolution of the universe the time and mass transformations are similar to those in chapter 3 but with new symbols. Only the length transformation equation is not analogous to $L_o = L_g$ from chapter 3. The new length transformation equation needs to specify the fact that we are now recognizing the change in a unit of length that scales with Γ_u . Therefore we have:

$$\begin{aligned} \mathcal{R}_1 &= \Gamma_u L_u && \text{unit of length transformation} \\ \mathcal{T}_1 &= T_u / \Gamma_u && \text{unit of time transformation} \\ \mathcal{M}_1 &= M_u / \Gamma_u && \text{unit of mass transformation} \end{aligned}$$

In utilizing the mass transformation $\mathcal{M}_1 = M_u / \Gamma_u$, it is important to recall the assumption stated in chapter 3 that the same rate of time must be used to quantify both \mathcal{M}_1 and M_u . Mass is a measurement of inertia, which in turn involves force and acceleration. All of these imply the use of a rate of time. Mass is not synonymous with matter. In chapter 3 we often assumed that coordinate time would be used. However, in the current universe with $\Gamma_{u0} \approx 2.6 \times 10^{31}$, the rate of coordinate time on the $\Gamma=1$ clock is about 2.6×10^{31} times faster than the rate of time on the cosmic clock, so it might not be convenient to use coordinate rate of time. All that is important is that we remember that the transformation of units requires that we use the same rate of time to express both \mathcal{M}_1 and M_u or other units of physics at different ages of the universe with different values of Γ_u .

Because of the change in the length transformation, it is necessary to recalculate the other transformations using the dimensional analysis procedures established in chapter 3. Using the above transformations for units of length, time and mass we obtain:

Impedance of Spacetime Z_s : $Z_{s1} \rightarrow M_1 / T_1 = \frac{\left(\frac{M_u}{\Gamma_u}\right)}{\left(\frac{T_u}{\Gamma_u}\right)} \rightarrow Z_{su}$

$Z_{s1} = Z_{su}$ impedance of spacetime transformation

Energy E : $E_1 \rightarrow {}_1\mathbb{R}_1^2 / T_1 = \frac{\left(\frac{M_u}{\Gamma_u}\right)(L_u^2 \Gamma_u^2)}{\frac{T_u}{(\Gamma_u)^2}} \rightarrow \Gamma^3 E_u$

$E_1 = \Gamma_u^3 E_u$ units of energy transformation

Energy Density U : $U_1 \rightarrow {}_1/\mathbb{R}_1 T_1^2 = \frac{(M_u/\Gamma_u)}{(L_u \Gamma_u)(T_u^2/\Gamma_u^2)} \rightarrow U_u$

$U_1 = U_u$ units of energy density transformation

Coordinate Speed of Light \mathcal{C} : $\mathcal{C}_1 \rightarrow \mathbb{R}_1 / T_1 = \frac{L_u \Gamma_u}{T_u / \Gamma_u} \rightarrow \Gamma^2 \mathcal{C}_u$

$c = \mathcal{C}_1 = \Gamma_u^2 \mathcal{C}_u$ coordinate speed of light transformation

These are the most important transformations and some of them will be used to determine the current vacuum energy density and analyze the 10^{120} mystery. First, the impedance of spacetime should be unaffected by a change in Γ_u . The fact that the transformation gave $Z_{s1} = Z_{su}$ shows that the length, time and mass transformations are correct. This acts as a check on the transformation process. Above we assumed the mass transformation was the same as chapter 3. In truth, this was not a foregone conclusion. However, the impedance of spacetime should remain constant. Assuming the length and time transformations, there is only one possible mass transformation that achieves a constant impedance transformation.

Energy and Energy Density Transformations: Next, the units of energy transformation $E_1 = \Gamma_u^3 E_u$ will be illustrated with an example. Suppose that there was an electron in a hypothetical universe with $\Gamma = 1$. The energy of the electron in the $\Gamma_u = 1$ universe would be 8.19×10^{-14} Joules measured locally which is the same energy we would measure for the electron in our current universe. However, the measurement in the $\Gamma_u = 1$ universe used a local clock that is running 2.6×10^{31} times faster than the cosmic clock in our current universe. Furthermore, a meter in the $\Gamma_u = 1$ universe is 2.6×10^{31} times larger than a meter in our current universe. Both of these factors combine to make 1 Joule in the $\Gamma_u = 1$ universe equivalent to $\Gamma_u^3 \approx 1.8 \times 10^{94}$ joules in our current universe. Therefore, even though both electrons have the same energy measured locally, different standards of energy are being used. When we correct for this difference, the electron in the $\Gamma_u = 1$ universe has $\Gamma_u^3 \approx 1.8 \times 10^{94}$ more energy.

Using the rotar model, suppose that we wanted to compare the energy density of the $\Gamma_u = 1$ electron and an electron in the universe today. The transformation of units of length is $\mathbb{R}_1 = \Gamma_u L_u$.

This says that a meter in the $\Gamma=1$ universe would be about 2.6×10^{31} times longer than a meter stick in our current universe because we are living in a universe with $\Gamma_u \approx 2.6 \times 10^{31}$. Therefore, the rotar radius of the electron in the $\Gamma=1$ universe would be 2.6×10^{31} times bigger and the rotar volume of that electron would be $\Gamma_{uo}^3 \approx 1.8 \times 10^{94}$ times greater than the rotar volume of an electron in our universe. The result is that both electrons would have the same energy density because the 1.8×10^{94} difference in the electron's energy is offset by the factor of 1.8×10^{94} difference in the sizes of the rotar volumes. The transformation of energy density is shown above and results in $U_1 = U_u$.

This illustrates how the proper energy density of the universe (including vacuum energy) remains constant even when the universe experiences a vast increase in Γ_u .

This is a fantastic result because it is a key component in solving the mystery of the 10^{122} difference between vacuum energy density and currently observed energy density. When the universe was Planck spacetime, it had energy density of 5.53×10^{112} J/m³. The spacetime transformation model of the universe views the current universe as the same size and same energy density as Planck spacetime. Therefore, the transformation $U_1 = U_u$ says that the proper energy density of the universe equals the tremendously large energy density of the universe obtained when the energy density is expressed in coordinate units. It is not necessary to add energy to the universe to keep the energy density of vacuum energy constant. Instead, nature uses two different standards for a unit of proper energy (in addition to different standards of length, force, the rate of time, etc.) This difference in energy standards exactly offset the change in proper volume thereby maintaining a constant energy density. The total proper energy density of the universe (including vacuum energy) has remained constant at 5.53×10^{112} J/m³ since the beginning of time (since the Big Bang). Today almost all of this energy of the universe is in the form of vacuum energy.

Additional Transformations: If we carry these transformations further, we obtain a few counter-intuitive results. For example, the transformations of charge (Q) and momentum (p) are:

$$Q_1 = \Gamma_u Q_u \quad \text{unit of charge transformation}$$

$$p_1 = \Gamma_u p_u \quad \text{unit of momentum transformation}$$

At first these transformations seem to be saying that neither charge (Q) nor momentum (p) is conserved when the universe ages and Γ_u increases. However, these are the transformations required to preserve charge, momentum and the laws of physics when measured locally (proper measurement) and assuming a CMB rest frame which has the distance between points increase with the Hubble flow. The momentum transformation ($p_1 = \Gamma_u p_u$) will be used to illustrate this point.

We will start with a thought experiment. Suppose that there is a hydrogen atom in an excited state that is at rest relative to the CMB and also at rest at the origin of a coordinate system. The hydrogen atom emits a photon in the +Y direction and the photon's momentum causes the hydrogen atom to recoil in the - Y direction carrying the opposite momentum. As shown in chapter 5, the momentum imparted to the atom by the emission of a photon results in the atom having a de Broglie wavelength that equals the wavelength of the emitted photon. If we view this from a rigid frame of reference that does not expand with the Hubble flow, then there is no loss of momentum over time. However, if we view both the recoiling atom and the propagating photon from a coordinate system that expands with the Hubble flow, then relative to this coordinate system there is a loss of momentum. Both the photon and the de Broglie waves of the atom undergo a redshift (lose momentum) relative to a coordinate system that expands with the Hubble flow. The coordinate system used by the spacetime transformation model is rigid but the effect of an increasing Γ_u produces effects similar to adopting an expanding coordinate system. Therefore the equation $p_l = \Gamma_u p_u$ is merely expressing this difference in perceived momentum between the two coordinate systems. Similarly, the charge transformation $Q_l = \Gamma_u Q_u$ keeps the proper laws of physics unchanged in both an expanding coordinate system and in the spacetime transformation coordinate system as Γ_u increases.

10¹²⁰ Calculation: Now we are going to calculate the current ratio of vacuum energy density to observable energy density. A Planck sphere originally contained about a billion Joules measured using the coordinate energy standard of energy because the universe started as Planck spacetime with $\Gamma_u = 1$. The Planck sphere started with radius of Planck length and today the proper value of this radius has increased by a factor of $\Gamma_{u0} \approx 2.6 \times 10^{31}$ to 0.42 mm radius or a volume of $3.1 \times 10^{-10} \text{ m}^3$. The 10^9 J of coordinate energy when $\Gamma_u = 1$ has had an apparent increase so that currently this much energy would appear to have increased by a factor of Γ_{u0}^3 . The objective of the following calculation is to find the current vacuum energy density U_{vac} .

$$\begin{aligned}
 10^9 \text{ J} \times \Gamma_{u0}^3 &= 1.8 \times 10^{103} \text{ J} && \text{conversion of coordinate energy to proper energy} \\
 (4\pi/3) l_p^3 \Gamma_{u0}^3 &= 3.18 \times 10^{-10} \text{ m}^3 && \text{current proper volume of Planck sphere} \\
 1.8 \times 10^{103} \text{ J} / 3.18 \times 10^{-10} \text{ m}^3 &\approx 5.5 \times 10^{112} \text{ J/m}^3 = U_{vac}
 \end{aligned}$$

Ignoring vacuum energy, the current critical energy density of the universe depends on the value of the Hubble parameter used. Using $\mathcal{H} \approx 70.8 \text{ km/s/Mpc}$ the critical energy density of the universe U_{crit} is about $8.5 \times 10^{-10} \text{ J/m}^3$ if we include hypothetical dark energy. If we exclude dark energy which represents about 72.1% of the total energy density, then we have observable energy density U_{obs} of about $2.36 \times 10^{-10} \text{ J/m}^3$.

$$\begin{aligned}
 U_{vac}/U_{crit} &\approx 5.5 \times 10^{112} \text{ J/m}^3 / 8.5 \times 10^{-10} \text{ J/m}^3 \approx 6.5 \times 10^{121} && \text{ratio including dark energy} \\
 U_{vac}/U_{obs} &\approx 5.5 \times 10^{112} \text{ J/m}^3 / 2.4 \times 10^{-10} \text{ J/m}^3 \approx 2.3 \times 10^{122} && \text{ratio excluding dark energy}
 \end{aligned}$$

Either of these numbers qualifies as the famous 10^{120} discrepancy between the theoretical energy density of the universe and the observed energy density. Here is how we achieve spherical Planck energy density using one of the 5 wave-amplitude equations ($U = H^2 \omega^2 Z/c$). Using the proper rate of time on the cosmic clock, the frequency appears to be Planck angular frequency ω_p . Furthermore, strain amplitude is a dimensionless number that does not change with Γ_u . Therefore we will insert $H = 1$. Finally we must insert the constant k' to convert from cubic to spherical with the factor of $1/2$ associated with zero point energy.

$$U = H^2 \omega_p^2 Z_s/c \text{ set } \omega_p = 1.855 \times 10^{43} \text{ s}^{-1}; Z_s = 4.038 \times 10^{35} \text{ kg/s}; H = 1 \text{ and add } k' = 3/8\pi$$

$$U_{ps} = k' H^2 \omega_p^2 Z_s/c = (3/8\pi) 1^2 (1.855 \times 10^{43})^2 (4.04 \times 10^{35})/3 \times 10^8$$

$$U_{ps} = 5.53 \times 10^{112} \text{ J/m}^3$$

$$U_{ps} = U_{vac} + U_{obs}$$

The spacetime transformation model of the universe proposes that over the age of the universe there has been no change in the total energy density of the universe. Today virtually all of the energy density of the universe is in the form of vacuum energy U_{vac} which lacks quantized angular momentum. However, at the start of the Big Bang all the energy density of Planck spacetime U_{ps} was observable energy density U_{obs} because all the energy possessed quantized angular momentum. Over time the transformation of spacetime has resulted in a dramatic decrease in the observable energy density of the universe and an equal increase in vacuum energy density of the universe. Today $U_{vac} \approx 10^{122} U_{obs}$ but the total energy density has not changed: $U_{vac} + U_{obs} = U_{ps}$.

Today we perceive the maximum frequency of the waves that form vacuum energy to be equal to Planck angular frequency. However, this is a proper frequency that has been slowed by a factor of $\Gamma_{u0} \approx 2.6 \times 10^{31}$ compared to the coordinate frequency that occurred when the universe was Planck spacetime. How is it possible for today's vacuum energy to possess virtually the same energy density as Planck spacetime if the current maximum frequency of the dipole waves is a factor of about 2.6×10^{31} times slower than the dipole waves that formed Planck spacetime? The answer to this question is analogous to the answer given previously in the section titled "Energy and Energy Density Transformations". There it was shown how the energy density of an electron remains constant even when there is a big increase in Γ_u . The energy scales proportional to $1/\Gamma_u^3$ but the volume also scales with $1/\Gamma_u^3$ so the energy density of the electron remains constant. This holds true for any dipole wave in spacetime that has a specific frequency and strain amplitude. The highest frequency dipole waves have a proper frequency equal to Planck angular frequency ω_p and a proper volume that is Planck length in radius. However, this volume is $1/\Gamma_u^3$ times smaller than it was in Planck spacetime. The wavelets that form vacuum energy are continuously forming new wavelets as previously explained. These wavelets adapt to the changing scale of length.

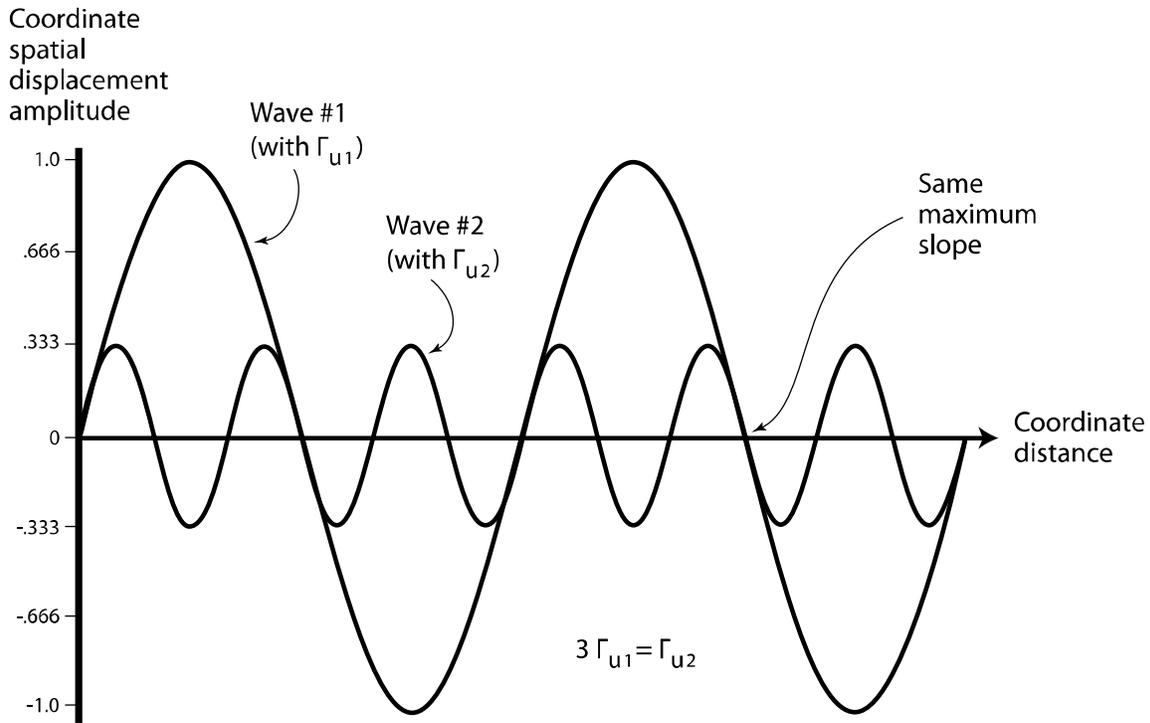


FIGURE 14-2 Two sine waves with different displacement amplitudes and different coordinate speeds of light but the same strain amplitude. The strain amplitude is $\Delta L/L$ and therefore related to the maximum slope.

Illustrations Showing the Effect of Γ_u on Waves: Next, we want to see what happens to the waves in spacetime that form vacuum energy when there is an increase of Γ_u . The mystery to be explained is how the wave structure of vacuum energy changes to result in an increase in proper volume as the universe ages. In figure 14-2 we have two sine waves designated wave #1 and wave #2. These are crude representations of the dipole waves in spacetime responsible for vacuum energy. Since the nonlinearity is particularly strong in the early part of the evolution of the universe, instead imagine these as representing vacuum energy at more recent times. In fact, wave #2 can be thought of as representing vacuum energy today with $\Gamma_{u0} \approx 2.6 \times 10^{31}$ and wave #1 representing vacuum energy when the comoving grid was $1/3$ its current size which is equivalent to $\Gamma_u \approx 10^{31}$. Therefore, it is important to remember that there is a factor of 3 difference between the value of Γ_u for wave #1 compared to the background gamma present for wave #2. This is written as $3\Gamma_{u1} = \Gamma_{u2}$.

Both of these waves would be exactly the same if they were drawn using proper units of length. The displacement amplitude of both waves is dynamic Planck length when the displacement of spacetime is expressed in units of proper length. However, figure 14-2 uses coordinate length for both the x and Y axis. Therefore, the spatial displacement amplitude of wave #1 is 3 times larger than the spatial displacement amplitude of wave #2 because of the factor of 3 difference between Γ_{u1} and Γ_{u2} . The displacement amplitude (Y axis) is set so that wave #1 has amplitude of 1. This makes the coordinate amplitude of wave #2 equal to 0.333. If the displacement

amplitude was expressed using the absolute coordinate scale where Planck length equals 1 when $\Gamma_u = 1$, then wave #1 would have a displacement amplitude of 10^{-31} . This is because wave #1 is presumed to exist in a universe with a background value of $\Gamma_u \approx 10^{31}$. This large value of Γ_u contracts proper length compared to a unit of coordinate length \mathbb{R}_L .

The maximum slope of a sine wave occurs when the sine wave crosses the zero line. The arrow shows one of many points where the two waves have the “same maximum slope”. This slope is a dimensionless number that is the strain amplitude of the sine wave. The point of this figure is to show that the maximum slope is the same even though the waves have a different scale. The strain produced by waves in spacetime is proportional to the maximum slope. Therefore both waves have a strain amplitude of $H = 1$. Naturally, the slope would also be the same if the waves were drawn using proper length because both waves would then be exactly the same in displacement, wavelength and maximum slope. The waves that form vacuum energy can maintain the same strain amplitude even when Γ_u is increasing. The frequency, measured locally, remains the same so the proper energy density also remains constant when Γ_u increases. The point is that the strain amplitude is always $H = 1$ for all values of Γ_u . This is a key component in maintaining the total energy density of the universe at 10^{113} J/m³ throughout the age of the universe.

It is interesting to note what these waves would look like if they were plotted in the temporal domain rather than the spatial domain. The Y axis would be labeled “Coordinate Temporal Displacement Amplitude” and the x axis would be labeled “Coordinate Time”. The figure would physically look the same as figure 14-2 except that the labels for wave #1 and #2 would be

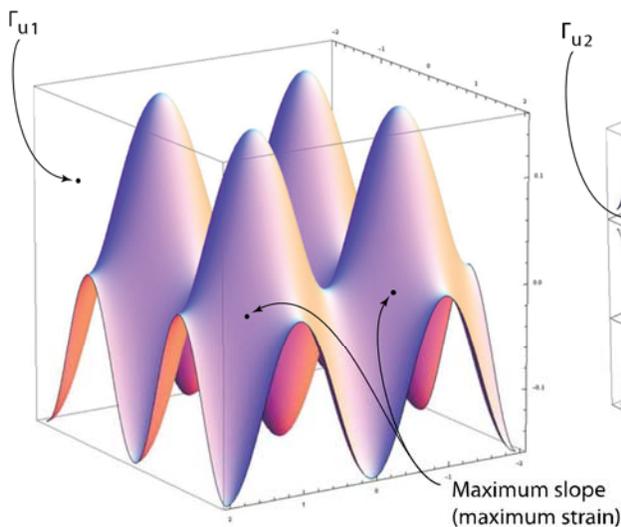


FIGURE 14-3

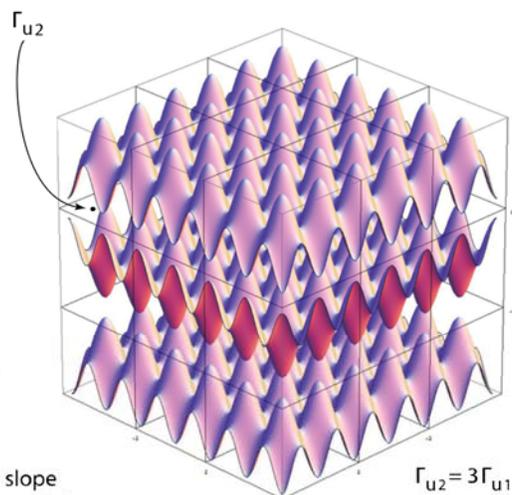


FIGURE 14-4

Figures 14-3 and 14-4 show a simplified representation of chaotic dipole waves in spacetime that form vacuum energy. These figures depict different ages of the universe when there is a factor of 3 difference in Γ_u .

reversed. Wave #2 (larger value of Γ_u) would have the larger temporal displacement amplitude when measured in coordinate units of time. This comparison helps to illustrate how a change in Γ_u exchanges the temporal properties of spacetime for the spatial properties of spacetime.

Figure 14-3 shows a 3-dimensional plot of wave #1 in figure 14-2 and figure 14-4 shows a 3-dimensional plot of 3 layers of wave #2 in figure 14-2 (original definitions of Γ_u). These two figures are oversimplified. The wave structure should be more chaotic and unsymmetrical. Imagine the waves in figure 14-4 as oscillating at $1/3$ the frequency of the waves in figure 14-3. The grid pattern in figure 14-4 is only $1/3$ the coordinate length so each grid cube has only $1/27$ the coordinate volume of the grid cube in figure 14-3. However, each grid cube also only contains $1/27$ the coordinate energy as the grid cube in figure 14-3, so the energy density is the same no matter whether it is assessed using the proper standard of energy density or the coordinate standard of energy density.

Quantum mechanics has been telling us that the vacuum energy density should be constant even as the universe ages and the proper volume increases. Now it is possible to see that the spacetime based model of the universe shows that this is possible. In fact, in order for the laws of physics to remain constant, it is necessary that the vacuum energy density remains constant. If the vacuum energy density decreased as the proper volume of the universe expanded, then the high frequency virtual particle pairs would eventually be lost and this would be detectable.

Does Dark Energy Exist? Dark energy is supposedly a homogeneous form of energy that forms as the volume of the universe expands. Everything about hypothetical dark energy conflicts with the concepts presented in this book. There is no single explanation for dark energy, but the simplest explanation given for the existence of dark energy that scales with volume is that dark energy is “the cost of having space”. Each time cosmic expansion somehow creates an additional cubic meter of spacetime; this volume is supposedly left with an energy deficit of about 6×10^{-10} Joules of “negative energy” that is considered to be dark energy. In the early universe, when the energy density of matter and photons was higher, $6 \times 10^{-10} \text{ J/m}^3$ was insignificant. However, today the proper volume of the universe has increased. The density of matter and light has fallen so that today dark matter supposedly makes up about 73% of the energy density of the universe.

In this concept, gravity is attempting to collapse the universe, but dark energy opposes gravity and causes an accelerated expansion of the universe. The exact mechanism used to accomplish this accelerating expansion is vague. If it is the opposite of gravity, then this creates a problem for the model of the universe. Recall that it was previously shown that gravitational acceleration requires a gradient in the rate of time. Therefore, anything that causes an anti-gravity repulsion must accomplish this by a rate of time gradient that opposes gravity. However, the observed redshift of galaxies would require a large scale gradient in the rate of time. The problem is that a large scale time gradient in the universe is incompatible with the concept that the universe is homogeneous both spatially and temporally on the large scale.

The Λ -CDM model does not respect the conditions that must be met to create a cubic meter of “new” space. Creating even a cubic meter of new space requires a lot of conditions to be met. This new space must have the impedance of spacetime $Z_s = c^3/G$ and the interactive bulk modulus of spacetime $K_s = F_p/\mathcal{A}^2$. The new space must be filled with zero point energy at energy density of 10^{113} J/m³. Therefore, each new cubic meter requires more energy than the annihilation energy of entire observable universe. As before, the problem is in the physical interpretation of observations and equations. If the proper distance between galaxies increases, this can be interpreted different ways. The model proposed here is actually the simplest because it does not demand any new physics or new energy to be added to the universe. It does not require mysterious dark energy.

There is no direct experimental evidence that dark energy exists. Dark energy is a theoretical concept is postulated to explain the apparent acceleration of the expansion of the universe and also to explain that the energy density of the universe has fallen below the “critical density”. Baryonic matter, dark matter and radiation only achieve about 28% of the energy density calculated to be necessary to achieve flat spacetime. However, this calculation depends on the accuracy of the model of the universe being used. The concept of “critical density” of the universe assumes that the universe possesses a gravitational gradient. This does not exist in the condition previously described as “immature gravity”. It does not make any difference whether the immature gravity occurs in the low gravitational Γ of the dust cloud thought experiment or the high gravitational Γ_u of the universe. The important point is that immature gravity produces an increasing gravitational Γ_u and a uniform instantaneous rate of time in the CMB rest frame. If there is no large scale rate of time gradient from the midpoint observer perspective, then there is no large scale gravitational acceleration and nothing that demands an explanation that incorporates anti-gravity.

The concept of critical density of the universe assumes that there is a gravitational acceleration that is attempting to collapse the universe. If the universe is pictured as the homogeneous and static distribution of galaxies with proper volume increase because of the spacetime transformation of the rate of time and of proper length, then the universe is not struggling to expand against gravity. There is no such thing as a critical density. The dust cloud thought experiment did not meet the conditions of “critical density” and yet there was no gravitational acceleration in the first few milliseconds after gravity was “turned on”.

As long as the universe has no detectable boundary (no edge), the mature gravity condition cannot be established. It takes a density change at a boundary to establish a rate of time gradient and gravitational acceleration. The proposed model of the universe started with Planck spacetime that had a uniform rate of time. At speed of light communication, we still have no detectable boundary. The rate of time has slowed down but there still is no large scale rate of time gradient. Gravitational acceleration and curved spacetime both require a rate of time

gradient. Therefore, the universe has never possessed large scale curved spacetime or gravitational acceleration. New mass/energy will continue to appear on the particle horizon of the observable universe. The background Γ_u of the universe will continue to increase towards infinity and there will be no rate of time gradient on the scale of universal homogeneity unless one day we become aware of a large scale density discrepancy that is the equivalent of a boundary condition that gives an “edge” to the universe.

Dark Energy Not Needed: What is being proposed is that the spacetime transformation model does not require the invention of dark energy to provide the missing critical density and does not need any mysterious force with anti-gravity properties that is causing the apparent expansion of the universe to accelerate. When viewed from the proposed coordinate rate of time and coordinate unit of length, there is no expansion of the universe. No work is being done against gravity. The immature gravity condition previously discussed eliminates the tendency for the universe to have a gravitational contraction. The coordinate volume of the universe has never changed and the coordinate energy density (including vacuum energy) has remained constant at the large scale of 300,000 light years. At a smaller scale matter has formed stars and galaxies which distort the homogeneous energy density of vacuum energy. We call this distortion “curved spacetime”. Our perception of the volume of the universe indicates continuous expansion. However, this is the result of a continuous increase in the background Γ_u of the universe. What we perceive as acceleration of the expansion is due instead to an acceleration in the rate of change of $d\Gamma_u/d\tau_u$.

All the factors that determine $d\Gamma_u/d\tau_u$ (the rate of change of Γ_u in proper time) are not known. This would be a function the age of the universe, but it probably also includes other factors relating to the composition and the observable energy density of the universe. For example, when the universe was radiation dominated, a substantial amount of the observable energy was being converted to vacuum energy. This process resulted in $d\Gamma_u/d\tau_u$ being proportional to $\underline{t}^{1/2}$. During the matter dominated epoch the electromagnetic radiation was a small percentage of the observable energy of the universe and $d\Gamma_u/d\tau_u$ was proportional to $\underline{t}^{2/3}$. Today we have an increase in proper volume that is acceleration. If this is viewed as an acceleration in the rate of change of $d\Gamma_u/d\tau_u$, then a mystery still exists, but it does not demand the invention of dark energy for an explanation. The solution is to be found in the properties of spacetime that create the acceleration of $d\Gamma_u/d\tau_u$ for the current condition of the universe.

Offsetting the Rate of Change of Γ_u : Returning to the increase in Γ_u , how fast would an object need to be raised in the earth’s gravitational field in order for the decrease in the earth’s Γ to offset the increase in Γ_u of the universe? In other words, what rate of increase in elevation achieves $(d\Gamma/dt)/\Gamma = \mathcal{H} \approx 2.29 \times 10^{-18} \text{ s}^{-1}$ in the earth’s gravitational acceleration of 9.8 m/s^2 ?

$$g = c^2 \left(\frac{d\beta}{dL_R} \right) \approx c^2 \left(\frac{d\Gamma}{\Gamma dL_R} \right) \quad \text{set } \frac{d\beta}{dL_R} \approx \frac{d\Gamma}{\Gamma dL_R} \text{ weak gravity approximation}$$

$$\frac{d\Gamma}{\Gamma d\tau_u} = \left(\frac{g}{c^2}\right) \left(\frac{dL_R}{d\tau_u}\right) \quad \text{set } \frac{d\Gamma}{\Gamma d\tau_u} = \mathcal{H} \quad \text{and } g = 9.8 \text{ m/s}^2$$

$$\left(\frac{dL_R}{d\tau_u}\right) \approx \mathcal{H} \frac{c^2}{g} \approx .021 \text{ m/s} \quad \left(\frac{dL_R}{d\tau_u}\right) = \text{vertical velocity}$$

Therefore an elevation velocity of about 2.1 cm/s or about 75 meters per hour in the earth's gravity offsets the temporal effects of an increase in the Γ_u of the universe. Obviously this is only a temporary reprieve made possible because an object in the earth's gravity starts off at a lower energy state (larger total Γ) than the same object if it was isolated on the comoving coordinate system. Still, this example gives a physical feel for the rate of change that is currently taking place in the universe.

All physical objects are losing energy each second when measured with an absolute energy scale that does not decrease as Γ_u increases. For example, the sun is currently radiating about 4×10^{26} watts of electromagnetic radiation but the sun is losing about 1000 times this energy per second as the energy in the sun's rotar's is being converted to vacuum energy. This is an undetectable effect using the proper energy standard which does not acknowledge the effect of an increasing Γ_u on everything in the universe.

There is another interesting way of looking at the changing rate of time as the universe ages. An electron has two different rates of time in its two lobes as explained in chapter 5. These rates of time differ by $\alpha_\beta = 4.18 \times 10^{-23}$. How many seconds does it take for Γ_u to change by a factor of 4.18×10^{-23} ? In other words, what difference in the age of the universe produces a rate of time difference equal to the rate of time difference in an electron?

$$A_\beta/\mathcal{H} = 4.18 \times 10^{-23}/2.29 \times 10^{-18} \text{ s}^{-1} = 1.8 \times 10^{-5} \text{ second}$$

Time's Arrow: The equations of physics seem to be reversible in time. Except for entropy, it appears as if it should be possible to go backwards in time. However, if the background Γ_u of the universe is increasing continuously and all matter is converting energy into vacuum energy, then it is not possible to go backwards in time. Yesterday all the rotars and photons in the universe had more energy than they possess today (measured on the scale of coordinate energy). Also, the lower background Γ_u of yesterday also affects many other things such as the units of force, velocity, voltage, etc. Even though the laws of physics are the same today and yesterday, all the components that makeup the universe are different. The universe is undergoing a transformation and this makes Time's arrow only point one direction – to the future.

Black Holes: *The following discussion of black holes is more speculative than the rest of this book. Therefore the following should be considered just a few preliminary thoughts about black holes.*

Do black holes have a different structure in a spacetime based universe than they would have if the universe is populated by point particles? So far the general relativity analysis of black holes has indirectly assumed the standard model of particles. With the point particle assumption, a black hole has an accretion disk, an event horizon, a volume inside the event horizon and finally a singularity at the center. This singularity supposedly has infinite energy density (the same as point particles). The volume inside the event horizon supposedly has modulation of the properties of spacetime that would require in excess of 100% depth of modulation of spacetime. Clearly these conditions cannot be achieved by the spacetime based model of the universe proposed here. The event horizon of a black hole supposedly has a rate of time that is stopped and a coordinate speed of light equal to zero. It is questionable whether a complete stoppage of the rate of time and stopping the propagation of light can be achieved by the wave-based model of hadrons and bosons proposed here.

If your model of a fundamental particle is a point particle with no physical size and no structure, then such a particle would be able to survive the plunge past the event horizon of a black hole. However, if we assume the rotar model of matter, then a preliminary analysis seems to indicate a different answer. As previously explained, a rotar is just a slight distortion of spacetime that has a specific frequency, rotar radius, and displacement amplitude. It seems as if a spacetime based explanation of the universe cannot form a true black hole event horizon. This is because such an event horizon would eliminate the waves in spacetime required for its formation. If a mass collapsed to a degree that the rate of time is slowed down by an enormous amount such as 10^{20} or more (compared to the comoving rate of time), then externally this would be indistinguishable from a conventional black hole. In this scenario, after a black hole forms, all additional mass/energy that falls towards the black hole adds to the orbiting accretion disk and never reaches an event horizon. The spacetime wave properties of rotars and photons would have to be taken into consideration in order to properly characterize the accretion disk that never quite reaches an event horizon. If hadrons and bosons never quite reach a true event horizon, then this would explain how it is possible for information about the black hole's charge, magnetic field, mass and rotational direction can be communicated to the rest of the universe outside of the black hole.

Like any gravitational capture, mass must shed some energy in order to be captured by a pseudo black hole. This shedding of energy is done by the emission of radiation and by the energy emitted by the polar jets associated with black holes. The energy that is captured can change its form but its gravitational effect remains constant. Recall the example previously given of a planet in a highly elliptical orbit around a star. The total gravitational effect of the combination of the star and the planet is constant even though the energy in the planet changes form. Similarly, a

photon falling into a pseudo black hole would appear to be blue shifted if the photon could be observed locally in a region with a high gravitational gamma Γ . A rotar would gain kinetic energy to offset the loss of internal energy associated with a high Γ . In neither case does the energy pass an event horizon where contact with the outside universe would be lost.

The model of spacetime currently accepted is that the effects of curved spacetime can somehow transcend an event horizon. We can obviously accurately measure the mass, spin and charge of a black hole. These are examples of communication that appears to be coming from inside an event horizon. The spacetime based model of gravity requires waves in spacetime to produce a nonlinear interaction in spacetime. When the energy density of matter and radiation approaches the energy density that would require 100% modulation of the spacetime field then we are approaching the conditions of a black hole. However, the spacetime based model never actually reaches 100% modulation of spacetime. Time never quite stops compared to coordinate time and length never quite contracts to zero compared to coordinate length. The singularity associated with the conventional black hole requires energy density in excess of Planck energy density. This is usually “explained” by saying that “the laws of physics break down”. The spacetime based model of the universe never requires that the laws of physics break down.

I visualize the volume near the center of a wave based black hole to be primarily photons that have been highly blue shifted relative to the local rate of time. Matter falling into the accretion disk will undergo highly energetic collisions. While new particles would be formed, repeated collisions and decompositions would eventually result in a high percentage of the energy being photons. Therefore, photon density would increase with depth. There would be no event horizon, but energy in the accretion disk would cause the gravitational gamma Γ to approach infinity. For example, suppose that this energy density achieves a rate of time that is 10^{20} times slower than the surrounding volume of the universe. This would look like a black hole, but information about charge, mass and rotational direction could still be communicated to the surrounding space.

The Spacetime Transformation Model Versus The Inflationary Model: In chapter 13 we performed several calculations to find the value of Γ_{u0} . However, the same data can be rearranged to support the contention that the proposed spacetime transformation model of the universe is correct and that there was not an inflationary phase. Here is the reasoning. When we calculate the change in scale factor starting from one unit of Planck time ($\sim 5 \times 10^{-44}$ s) and ending with 13.7 billion years, we obtained scaling factors of 2.1, 2.6, 2.95 and an upper limit of 3.4 (all $\times 10^{31}$). These numbers are approximately the same yet they were obtained from diverse sources such as the currently observable energy density of the universe, the observed CMB temperature and the CMB photon energy density.

Now we will reverse the thought process and extrapolate back in time to when the universe was 5×10^{-44} seconds old (1 unit of Planck time). Starting with the currently observable energy

density, CMB temperature and CMB photon energy density of today's universe we always arrive at the properties of Planck spacetime using an average value of $\Gamma_{uo} \approx 2.6 \times 10^{31}$. This extrapolation makes the assumption that there was no inflationary phase in the expansion of the proper volume of the universe.

However, suppose that we include inflation in this backwards extrapolation. Between about 10^{-35} seconds and 10^{-32} seconds we have to deviate from the radiation dominated condition that scales with $\underline{\tau}^{1/2}$ and insert the inflationary exponential scaling factor. This inflation factor is unknown, but it is usually considered to be in excess of 10^{25} . At an age of 5×10^{-44} second, including inflation implies that the energy per photon exceeds Planck energy by a factor of at least 10^{25} . Similarly the implied temperature exceeds Planck temperature by more than 10^{25} and the implied energy density exceeds Planck energy density also by a similar factor. These are impossibilities according to the known laws of physics. Therefore physicists casually disregard this by saying that the laws of physics must "breakdown" under these conditions. Even the idea that the inflationary expansion greatly exceeded the speed of light requires a breakdown of the laws of physics.

There is no experimental proof that it is possible for the laws of physics to "breakdown". This is merely a term used when a particular theory gives an impossible answer according to the known laws of physics. Instead, when a theory requires a breakdown in the laws of physics, this should be a strong indication that the theory is wrong. The beauty of assuming that the universe is only spacetime is that there should be no cases where the theory needs to revert to saying that the laws of physics must breakdown in order to explain a particular implied result.

Cosmic inflation is an *ad hoc* solution required by a model of the universe that has point particles and forces carried by the exchange of virtual particles. If the universe is only spacetime, then it was only spacetime (the composite quantum mechanical and relativistic spacetime model) even at the beginning of the Big Bang. Extrapolating backwards from today results in the "Planck spacetime" homogeneous state. This is the highest observable energy density the spacetime field can support. The laws of physics never break down. For example, there are no singularities in this spacetime based model of the universe. All the steps are conceptually understandable and accessible to physicists today. Planck spacetime is as homogeneous as quantum mechanics allows, so there is no need for inflation to expand spacetime to achieve local homogeneity.

Unity and Entanglement Revisited: It was previously proposed that quantized waves in spacetime such as rotars and photons can have internal communication faster than the speed of light. This property also extends to communication between two entangled photons or rotars. No information can be imposed on this internal communication so there is no violation of the prohibition against faster than light communication. Still there is a question about how spacetime accomplishes the faster than speed of light internal communication. One possibility is that this internal communication might be taking place at the speed of light characteristic of

Planck spacetime. This speed would be about 2.6×10^{31} times faster than the proper speed of light. At this speed, internal communication within a photon distributed over one light year would only take about 10^{-24} second and a CMB photon generated 380,000 years after the Big Bang would collapse within about 10^{-14} seconds. The microwave photons that make up the CMB have a peak frequency of about 1.6×10^{11} Hz. Therefore a collapse with a time delay of about 10^{-14} s would meet the conditions of being virtually instantaneous. Perhaps the internal communication is actually instantaneous, but communication at 2.6×10^{31} times faster than c is indistinguishable from being instantaneous.

Are All Frames of Reference Really Equivalent? A basic assumption of relativity is that all frames of reference are equivalent. The CMB rest frame is clearly the preferred frame for cosmological purposes, but the laws of physics are presumed to work equally well in all frames of reference. Experimental observations have not detected any preference for frames of reference, but does this mean that ultra-relativistic frames relative to the CMB rest frame are equivalent? Recall that in chapters 4 and 11 the subject of the spectral energy density of zero point energy (quantized harmonic oscillators) was discussed. It was stated:

“This spectrum with its ω^3 dependence of spectral energy density is unique in as much as motion through this spectral distribution does not produce a detectable Doppler shift. It is a Lorentz invariant random field. Any particular spectral component undergoes a Doppler shift, but other components compensate so that all components taken together do not exhibit a Doppler shift.”

There is one problem with this concept. Vacuum fluctuations have a cutoff frequency equal to Planck frequency ω_p . If this cutoff frequency is symmetrical when viewed from the CMB rest frame, then there must be an ultra-relativistic frame of reference (relative to the CMB) where the asymmetry becomes obvious. An example will help to define this question. We can currently accelerate an electron to energy of 50 GeV. This is a relativistic Lorentz factor of $\gamma \approx 10^5$ relative to the CMB rest frame. However, a frame of reference with $\gamma = 10^5$ does not come close to testing the questions related to the limits of extreme ultra relativistic frames of reference. Imagine an electron with an ultra-relativistic speed with $\gamma \approx 2.4 \times 10^{22}$ as seen from the CMB rest frame. This is the Lorentz factor where the electron's de Broglie wavelength λ_d would be shorter than Planck length ($\lambda_d \approx \lambda_c/\gamma$ approximation valid when $\gamma \gg 1$). This is very close to the speed of light but it does not equal the speed of light. Therefore, it is hypothetically a permitted frame of reference for an electron.

However, in the CMB rest frame the electron would have a de Broglie wavelength less than Planck length and de Broglie frequency exceeding Planck frequency. According to the premise of this book, spacetime is not capable of producing this wavelength and frequency. Also, in the electron's frame of reference there would be an extreme redshift in one direction of the dipole waves in spacetime required to stabilize the energy density (pressure) of the electron. This

redshift would prevent the vacuum energy from exerting the pressure required to stabilize an electron in this frame of reference. If the universe is only spacetime, then this frame of reference is not permitted for an electron. Instability would appear as an electron approached the Planck length/frequency limit as seen from the CMB rest frame. The electron would exhibit properties in this ultra-relativistic frame of reference that the electron does not possess in the CMB rest frame. Other particles would exhibit unusual properties and instabilities at different ultra-relativistic frames relative to the CMB rest frame.

For another example, in chapter 9 we determined that photons are quantized waves propagating in the medium of the spacetime field. This implies that a photon is not permitted in any frame of reference which would appear to have a wavelength shorter than Planck length in the CMB rest frame. There is only one spacetime field for all frames of reference. This field is not capable of propagating waves shorter than the shortest wavelength wave in the field. The current record for the highest energy photon ever observed is a 12 TeV gamma ray ($\sim 2 \times 10^{-6}$ J) which has wavelength of about 10^{-19} m. This energy photon is permitted in our frame of reference, but it would not be permitted in any frame of reference which exceeded about $\gamma \approx 10^{16}$ relative to the CMB. The reason is that this photon would have a wavelength less than Planck length when viewed in the CMB rest frame and the energy would exceed Planck energy. This implies that the laws of physics change in these extreme frames of reference.

String theory is based on three starting assumptions which are expressed as mathematical equations. These are 1) Lorentz invariance, [the laws of physics are the same in all uniformly moving frames of reference] 2) analyticity [a smoothness criteria for the scattering of high energy particles after a collision] and 3) unitarity [all probabilities always add up to one]. The speed of light is the same in all uniformly moving frames of reference, but the laws of physics are not. Therefore the contention is that Lorentz invariance is not a valid assumption for all uniformly moving frames of reference. String theory incorporates this erroneous assumption and all the conclusions based on this assumption are questionable.

Lorentz Was Correct: Even though today we often assume that Einstein did not believe in the aether, he actually continued to refer to the aether or “physical space” until his death². He merely declared that the aether must have relativistic properties with no preferred frame of reference. Lorentz also believed in the aether, but his calculations (Lorentz transformations) assumed that the aether had a preferred frame of reference. Lorentz transformations did not confer and detectable special properties to this preferred frame of reference since the transformations made the laws of physics the same in “all” frames of reference. However, Einstein and Lorentz disagreed about whether the aether had some special reference frame which served as the standard for all other reference frames.

² L. Kostro, *Einstein and the Ether*, (2,000) Apeiron, Montreal, Canada

The spacetime field can be thought of as a type of aether. Since all particles, forces and fields are made from this spacetime field, there is a conceptually understandable reason why experiments using currently technology cannot detect motion relative to the spacetime field. The particles and forces merely undergo the transformations required to achieve Lorentz invariance. However, Lorentz was correct. The spacetime field does have a preferred frame of reference. It is the CMB rest frame. No experiment capable of being performed using current technology would be able to experimentally prove this because it would require accelerating a particle to a speed where its de Broglie wavelength approaches Planck length. For example, an electron could be accelerated to a special relativity gamma of $\gamma = 2.4 \times 10^{22}$ if the experiment is done in the CMB rest frame. The electron would then have $\lambda_c = L_p$. The electron's internal pressure would be equal to Planck pressure and the ability of the spacetime field to stabilize the internal pressure of the electron would be at its limit. All other frames of reference would not be able to achieve this value of γ because the electron would become unstable at a lower value of γ . Therefore, the spacetime field does have a preferred frame of reference, but it is currently undetectable.

The Fate of the Universe: The currently accepted model of the universe has mysterious dark energy becoming more dominant and accelerating the expansion of the universe until we lose sight of distant galaxies. In the most extreme extension of this process, a Big Rip eventually occurs when the expansion becomes so extreme that gravitationally bound objects such as galaxies and stars are dispersed by the expansion of space. Finally even atoms are ripped apart and the universe dies as subatomic particles are eventually converted to photons.

The model proposed here has not been developed sufficiently to have a clear prediction about the eventual fate of the universe. However, as previously explained, the near term (a few billion years) has distant galaxies getting dimmer but also the currently observed redshift of any particular distant galaxy will decrease. This counter intuitive prediction is actually a continuation of the process that has occurred throughout the history of the universe.

Over the longer term the spacetime transformation model of the universe offers an intriguing possibility. The total energy density of the universe (observable energy + vacuum energy) remains the same over the lifetime of the universe. Presently observable energy (including dark matter) represents only about 1 part in 10^{122} of the total energy in the universe. As previously explained, we only can observe and interact with waves in spacetime that possess quantized angular momentum (fermions and bosons). Furthermore, the fraction of the total energy that possesses angular momentum (10^{-122}) is dropping daily and the rate of change of $d\Gamma_u/d\tau_u$ appears to be accelerating.

If fundamental particles eventually decay into photons in the far distant future of the universe, then an intriguing possibility exists. When the quantized angular momentum of the photons becomes homogeneously distributed throughout the universe, then this condition of spacetime begins to look like Planck spacetime. The energy density is the same and the average distribution

of the quantized angular momentum is the same. The major difference is that Planck spacetime has $\Gamma_u = 1$ and this final state of the universe has Γ_u approaching infinity.

Perhaps the energy in these photons becomes such a small fraction of the vacuum energy density of the universe that quantum mechanics allows the background gamma of the universe to round off to $\Gamma_u = \infty$. The rate of time would stop and the hybrid speed of light would stop. This is a discontinuity that would allow a rebirth of the universe. All that has to happen is that the background gamma of the universe has to change from $\Gamma_u = \infty$ to $\Gamma_u = 1$. No collapse is required because the universe is already at the required energy density. Also, the required quantized spin units would be preserved and evenly distributed. All that has to change is the rate of time and the spatial characteristics must revert back to the $\Gamma_u = 1$ condition. This would produce Planck spacetime and the universe would start a new cycle with a new "Big Bang".

Closing Thoughts: Einstein's greatest contributions to science happened when he combined insightful new assumptions with mathematical analysis. Later in his life he tended towards more advanced mathematical analysis of the same old assumptions and his contributions to science diminished. I see an analogy to all of physics. The greatest advances in physics occurred when insightful new assumptions were first introduced. This introduction of new ideas was followed by "golden ages" of physics. However, over time the pace of advancement slowed when the same assumptions were just mathematically analyzed in more detail. The objective of this book is to propose a series of new ideas based on the simplest starting assumption: The universe is only spacetime.

While working on the ideas contained in this book, there were times that I questioned whether I should be undertaking this large project. Was there really a conceptually understandable solution to a particular problem? Why should I be the one attempting to find this solution? At those times I thought about and received encouragement from the following quote by John Archibald Wheeler. Predicting a new revolution in physics, he said:

"And when it comes, will we not say to each other, Oh, how beautiful and simple it all is! How could we ever have missed it so long?"

-John Archibald Wheeler

Chapter 15

Equations and Definitions

Properties of a Single Rotar

$$A_\beta = \frac{L_p}{\lambda_c} = T_p \omega_c = \sqrt{\frac{Gm^2}{\hbar c}} = \frac{m}{m_p} = \frac{E_i}{E_p} = \frac{\omega_c}{\omega_p} = \sqrt{\beta_q} = \sqrt{\frac{P_c}{P_p}} \quad A_\beta = \text{rotar strain amplitude}$$

$$\lambda_c = \frac{\hbar}{mc} = \frac{c}{\omega_c} = \frac{\hbar c}{E_i} = \frac{L_p^2}{R_s} = \frac{L_p}{A_\beta} \quad \lambda_c = \text{rotar radius (Compton radius)}$$

$$\omega_c = \frac{mc^2}{\hbar} = \frac{c}{\lambda_c} = A_\beta \omega_p \quad \omega_c = \text{Compton angular frequency}$$

$$E_i = mc^2 = \omega_c \hbar = \frac{\hbar c}{R_q} = \frac{P_c}{\omega_c} = F_m \lambda_c = A_\beta E_p \quad E_i = \text{internal energy}$$

$$m = \frac{E_i}{c^2} = \frac{\hbar}{\lambda_c c} = \frac{\omega_c \hbar}{c^2} = T_p^2 \omega_c Z_s = A_\beta m_p \quad m = \text{rotar mass}$$

$$P_c = E_i \omega_c = \omega_c^2 \hbar = \frac{E_i^2}{\hbar} = \frac{\hbar c^2}{\lambda_c^2} = \frac{m^2 c^4}{\hbar} = A_\beta^2 P_p \quad P_c = \text{circulating power}$$

$$F_m = \frac{m^2 c^3}{\hbar} = \frac{\hbar c}{\lambda_c^2} = \frac{\hbar \omega_c^2}{c} = A_\beta^2 F_p \quad F_m = \text{maximum force at distance } \lambda_c$$

$$U_q = \frac{E_i}{\lambda_c^3} = \frac{m^4 c^5}{\hbar^3} = \frac{a_g^2}{G} = A_\beta^4 U_p \quad U_q = \text{rotar volume energy density}$$

$$\beta_q = \frac{Gm^2}{\hbar c} = A_\beta^2 \quad \beta_q = \text{gravitational magnitude at rotar radius}$$

$$\mathcal{N} = \frac{r}{\lambda_c} = \frac{r m c}{\hbar} \quad \mathcal{N} = \text{distance } (r) \text{ from a rotar expressed as the number of } \lambda_c \text{ units}$$

$$A_e = \frac{\sqrt{\alpha} L_p \lambda_c}{r^2} = \sqrt{\alpha} \frac{H_\beta}{\mathcal{N}^2} \quad A_e = \text{electromagnetic standing wave strain amplitude (oscillating)}$$

$$A_E = \sqrt{\alpha} \frac{L_p}{r} = \sqrt{\alpha} \frac{H_\beta}{\mathcal{N}} \quad A_E = \text{electromagnetic non-oscillating strain amplitude}$$

$$A_g = \frac{L_p^2}{r^2} = \frac{H_\beta^2}{\mathcal{N}^2} \quad A_g = \text{gravitational standing wave strain amplitude oscillating at } 2\omega_c$$

$$A_G = \beta = \frac{Gm}{c^2 r} = \frac{H_\beta^2}{\mathcal{N}} \quad A_G = \text{gravitational non-oscillating strain amplitude}$$

$$A_f = \frac{L_p}{r} \quad A_f = \text{hypothetical fundamental amplitude before cancelation}$$

5 Wave-Amplitude Equations

$$\mathcal{J} = k A^2 \omega^2 Z \quad \mathcal{J} = \text{intensity (w/m}^2\text{)}$$

$$U = k A^2 \omega^2 Z / c = \mathcal{P} \quad U = \text{energy density (J/m}^3\text{)} \quad (U = \mathcal{J}/c) \text{ and } U = \mathcal{P}$$

$$E = k A^2 \omega^2 Z V / c \quad E = \text{energy (J)} \quad (E = \mathcal{J}V/c)$$

$$P = k A^2 \omega^2 Z \mathcal{A} \quad P = \text{power (J/s)} \quad (P = \mathcal{J}\mathcal{A})$$

$$F = k A^2 \omega^2 Z \mathcal{A} / c \quad F = \text{force (N)} \quad (F = \mathcal{J}\mathcal{A}/c)$$

Planck Units

L_p = Planck length	$L_p = T_p c = \sqrt{\hbar G / c^3}$	$1.616 \times 10^{-35} \text{ m}$
m_p = Planck mass	$m_p = \sqrt{\hbar c / G}$	$2.176 \times 10^{-8} \text{ kg}$
T_p = Planck time	$T_p = L_p / c = \sqrt{\hbar G / c^5}$	$5.391 \times 10^{-44} \text{ s}$
q_p = Planck charge	$q_p = e / \sqrt{\alpha} = \sqrt{4\pi\epsilon_0 \hbar c}$	$1.876 \times 10^{-18} \text{ Coulomb}$
E_p = Planck energy	$E_p = m_p c^2 = \sqrt{\hbar c^5 / G}$	$1.956 \times 10^9 \text{ J}$
ω_p = Planck angular frequency	$\omega_p = 1 / T_p = \sqrt{c^5 / \hbar G}$	$1.855 \times 10^{43} \text{ s}^{-1}$
F_p = Planck force	$F_p = E_p / L_p = c^4 / G$	$1.210 \times 10^{44} \text{ N}$
P_p = Planck power	$P_p = E_p / T_p = c^5 / G$	$3.628 \times 10^{52} \text{ W}$
p_p = Planck momentum	$p_p = E_p / c = \sqrt{\hbar c^3 / G}$	6.525 kg m/s
U_p = Planck energy density	$U_p = E_p / L_p^3 = c^7 / \hbar G^2$	$4.636 \times 10^{113} \text{ J/m}^3$
\mathbb{P}_p = Planck pressure	$\mathbb{P}_p = F_p / L_p^2 = c^7 / \hbar G^2$	$4.636 \times 10^{113} \text{ N/m}^2 (= U_p)$
T_p = Planck temperature	$T_p = E_p / k_B = \sqrt{\hbar c^5 / G k_B^2}$	$1.417 \times 10^{32} \text{ }^\circ\text{K}$
A_p = Planck acceleration	$A_p = c / T_p = \sqrt{c^7 / \hbar G}$	$5.575 \times 10^{51} \text{ m/s}^2$
ρ_p = Planck density	$\rho_p = m_p / L_p^3 = c^5 / \hbar G^2$	$5.155 \times 10^{96} \text{ kg/m}^3$
\mathbb{V}_p = Planck electrical potential	$\mathbb{V}_p = E_p / q_p = \sqrt{c^4 / 4\pi\epsilon_0 G}$	$1.043 \times 10^{27} \text{ V}$
\mathbb{E}_p = Planck electric field	$\mathbb{E}_p = F_p / q_p = \sqrt{c^7 / 4\pi\epsilon_0 \hbar G^2}$	$6.450 \times 10^{61} \text{ V/m}$
\mathbb{B}_p = Planck magnetic field	$\mathbb{B}_p = Z_s / q_p = \sqrt{\mu_0 c^7 / 4\pi \hbar G^2}$	$2.152 \times 10^{53} \text{ Tesla}$
\mathbb{I}_p = Planck current	$\mathbb{I}_p = q_p / T_p = \sqrt{4\pi\epsilon_0 c^6 / G}$	$3.480 \times 10^{18} \text{ amp}$
Z_p = Planck impedance	$Z_p = \hbar / q_p^2 = 1 / 4\pi\epsilon_0 c$	$29.98 \text{ } \Omega$

Gravitational Γ and β (excludes cosmology equalities)

$$\Gamma \equiv \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \left(\frac{2Gm}{c^2 R}\right)}} = \frac{1}{1 - \beta} \quad \Gamma = \text{gravitational gamma}$$

$$\Gamma \approx 1 + \frac{Gm}{c^2 r} \approx 1 + \beta \quad (\text{weak gravity approximations})$$

$$\beta \equiv 1 - \frac{d\tau}{dt} = 1 - \sqrt{1 - \frac{2Gm}{c^2 R}} = 1 - 1/\Gamma \quad \beta = \text{gravitational magnitude}$$

$$\beta \approx \frac{Gm}{c^2 r} \approx \frac{gr}{c^2} \approx \frac{R_s}{r} \quad (\text{weak gravity approximation})$$

$$\beta_q = H\beta^2 = \frac{Gm^2}{\hbar c} \quad \beta_q = \text{gravitational magnitude in a rotar at } \lambda_c$$

Properties of Spacetime

$$Z_s = \frac{c^3}{G} = 4.038 \times 10^{35} \text{ kg/s} \quad Z_s = \text{impedance of spacetime}$$

$$K_s = \frac{F_p}{\lambda^2} \quad K_s = \text{bulk modulus of spacetime } (K \equiv \frac{\Delta P}{\Delta V/V})$$

$$U_i = \frac{c^2 \omega^2}{G} = \frac{F_p}{\lambda^2} = \left(\frac{\omega}{\omega_p}\right)^2 U_p \quad U_i = \text{interactive energy density of spacetime}$$

$$A_{\max} = \frac{L_p}{\lambda} = T_p \omega \quad A_{\max} = \text{maximum displacement amplitude of a dipole wave in spacetime}$$

Charge Conversion Constant

$$\eta \equiv \frac{L_p}{q_p} = \frac{\sqrt{\alpha} L_p}{e} = \sqrt{\frac{1}{4\pi\epsilon_0 F_p}} = 8.617 \times 10^{-18} \text{ m/Coulomb} \quad \eta = \text{charge conversion constant}$$

Characteristics of an Electron

$A_\beta = 4.1851 \times 10^{-23}$	$A_\beta = \text{strain amplitude}$
$\lambda_c = 3.8616 \times 10^{-13} \text{ m}$	$\lambda_c = \text{rotar radius}$
$\omega_c = 7.7634 \times 10^{20} \text{ s}^{-1}$	$\omega_c = \text{Compton angular frequency}$
$\nu_c = 1.2356 \times 10^{20} \text{ Hz}$	$\nu_c = \text{Compton frequency}$
$E_i = 8.1871 \times 10^{-14} \text{ J}$	$E_i = \text{internal energy}$
$m_e = 9.1094 \times 10^{-31} \text{ kg}$	$m_e = \text{electron's mass}$
$e = 1.6022 \times 10^{-19} \text{ Coulomb}$	$e = \text{elementary charge}$
$P_c = 6.3560 \times 10^7 \text{ w}$	$P_c = \text{circulating power}$
$F_m = 0.21201 \text{ N}$	$F_m = \text{maximum force at distance of } \lambda_c$
$R_s = 6.7635 \times 10^{-58}$	$R_s = \text{classical Schwarzschild radius}$
$U = E_i/\lambda_c^3 = 1.4218 \times 10^{24} \text{ J/m}^3$	$U = \text{energy density (cubic - ignores constant)}$
$U = (3/4\pi)E_i/\lambda_c^3 = 3.3942 \times 10^{23} \text{ J/m}^3$	$U = \text{energy density (spherical)}$
$a_q = 9.7404 \times 10^6 \text{ m/s}^2$	$a_g = \text{grav acceleration at center of rotar volume}$
$g_q = 4.0764 \times 10^{-16} \text{ m/s}^2$	$g_g = \text{gravitational acceleration at } \lambda_c$
$I_e = e\nu_c \approx 19.796 \text{ amps}$	$I_e = \text{equivalent circulating current}$
$B_e = 3.22 \times 10^7 \text{ Tesla}$	$B_e = \text{internal magnetic field}$

Some Useful Dimensional Analysis Conversions

		Dimensional Analysis Symbols:
$U \rightarrow \text{M/LT}^2$	$U = \text{energy density}$	M = mass
$G \rightarrow \text{L}^3/\text{MT}^2$	$G = \text{gravitational constant}$	L = length
$\hbar \rightarrow \text{ML}^2/\text{T}$	$\hbar = \text{Planck constant}$	T = time
$Z_s \rightarrow \text{M/T}$	$Z_s = \text{impedance of spacetime}$	Q = charge
$Z_o \rightarrow \text{ML}^2/\text{TQ}^2$	$Z_o = \text{impedance of free space}$	
$E \rightarrow \text{ML}^2/\text{T}^2$	$E = \text{energy}$	
$F \rightarrow \text{ML}/\text{T}^2$	$F = \text{force}$	
$\epsilon_o \rightarrow \text{T}^2\text{Q}^2/\text{ML}^3$	$\epsilon_o = \text{permittivity}$	
$\mu_o \rightarrow \text{ML}/\text{Q}^2$	$\mu_o = \text{permeability}$	
$E \rightarrow \text{ML}/\text{T}^2\text{Q}$	$E = \text{electric field}$	
$H \rightarrow \text{Q}/\text{LT}$	$H = \text{"H" magnetic field (ampere/meter)}$	
$B \rightarrow \text{M}/\text{TQ}$	$B = \text{"B" magnetic field (Tesla)}$	
$\Omega \rightarrow \text{ML}^2/\text{TQ}^2$	$\Omega = \text{resistance}$	
$V \rightarrow \text{ML}^2/\text{T}^2\text{Q}$	$V = \text{electrical potential (voltage relative to neutral)}$	

Normalized Transformations

(assumes coordinate rate of time and proper length is coordinate length)

$L_o = L_g$	unit of length	$M_o = M_g/\Gamma$	unit of mass
$T_o = T_g/\Gamma$	unit of time	$Q_o = Q_g$	charge (coulombs)

$\theta_o = \theta_g$	temperature	$\sigma_o = \Gamma^2 \sigma_g$	Stefan-Boltzmann constant
$C_o = \Gamma C_g$	normalized speed of light	$\mathcal{I}_o = \Gamma \mathcal{I}_g$	electrical current
$dR = dL/\Gamma$	circumferential radius	$V_o = \Gamma V_g$	electrical potential
$E_o = \Gamma E_g$	energy	$\epsilon_{oo} = \epsilon_{og}/\Gamma$	permittivity of vacuum
$v_o = \Gamma v_g$	velocity	$\mu_{oo} = \mu_{og}/\Gamma$	permeability of vacuum
$F_o = \Gamma F_g$	force	$p_o = p_g$	momentum
$P_o = \Gamma^2 P_g$	power	$\alpha_o = \alpha_g$	fine structure constant
$G_o = \Gamma^3 G_g$	gravitational constant	$\Omega_o = \Omega_g$	electrical resistance
$U_o = \Gamma U_g$	energy density	$\mathcal{B}_o = \mathcal{B}_g$	magnetic flux density
$\mathcal{P}_o = \Gamma \mathcal{P}_g$	pressure	$Z_{oo} = Z_{og}$	impedance of free space
$\rho_o = \rho_g/\Gamma$	density	$Z_{so} = Z_{sg}$	impedance of spacetime
$\omega_o = \Gamma \omega_g$	frequency		
$k_o = \Gamma k_g$	Boltzmann's constant		

Transformation of Planck Units into Spacetime Units

Planck Units	Standard Conversion	Spacetime Conversion
Planck length	$L_p = \sqrt{\hbar G / c^3}$	$L_p = c T_p$
Planck mass	$m_p = \sqrt{\hbar c / G}$	$m_p = Z_s T_p$
Planck frequency	$\omega_p = \sqrt{c^5 / \hbar G}$	$\omega_p = 1 / T_p$
Planck impedance	$Z_p = 1 / 4\pi\epsilon_o c$	$Z_p = Z_s$
Planck charge	$q_p = \sqrt{4\pi\epsilon_o \hbar c}$	$q_p = c T_p$
Planck energy	$E_p = \sqrt{\hbar c^5 / G}$	$E_p = c^2 T_p Z_s$
Planck force	$F_p = c^4 / G$	$F_p = c Z_s$
Planck power	$P_p = c^5 / G$	$P_p = c^2 Z_s$
Planck energy density	$U_p = c^7 / \hbar G^2$	$U_p = Z_s / c T_p^2$

Transformation of Standard Units into Spacetime Units

$$\eta \equiv \frac{L_p}{q_p} = \frac{\sqrt{\alpha} L_p}{e} = \sqrt{\frac{1}{4\pi\epsilon_o F_p}} = 8.617 \times 10^{-18} \text{ m/Coulomb} \quad \eta = \text{charge conversion constant}$$

Name	Spacetime Conversion
Elementary charge (e)	$e = \sqrt{\alpha} L_p / \eta = \sqrt{\alpha} c T_p / \eta$
Planck charge (q_p)	$q_p = L_p / \eta$
Coulomb force constant ($1/4\pi\epsilon_o$)	$1/4\pi\epsilon_o = c Z_s / \eta^2$
Permeability of free space (μ_o)	$\mu_o / 4\pi = \eta^2 Z_s / c$
Electric field of EM radiation (\mathcal{E}_γ)	$\mathcal{E}_\gamma = H\omega \sqrt{Z_s Z_o} = H\omega Z_s \eta$
Magnetic field of EM radiation (\mathcal{H}_γ)	$\mathcal{H}_\gamma = H\omega \sqrt{Z_s / Z_o} = H\omega / \eta$
Impedance of free space (Z_o)	$Z_o = \eta^2 4\pi Z_s$
Planck impedance (Z_p)	$Z_p = \eta^2 Z_s$
Planck constant (\hbar)	$\hbar = c^2 T_p^2 Z_s = L_p^2 Z_s$
Gravitational constant (G)	$G = c^3 / Z_s$

Useful Cosmic Information

$\mathcal{H} = 2.29 \times 10^{-18} \text{ m/s/m} = 70.8 \text{ km/s/Mpc}$ $\mathcal{H} =$ Hubble parameter
 1 parsec (pc) = $3.086 \times 10^{16} \text{ m} = 3.262 \text{ light years}$
 1 light year (ly) = $9.4607 \times 10^{15} \text{ m} = 6.3241 \times 10^4 \text{ AU}$
 Solar mass $1.989 \times 10^{30} \text{ kg}$ Solar radius $6.96 \times 10^8 \text{ m}$
 Earth mass $5.974 \times 10^{24} \text{ kg}$
 Earth radius $6.378 \times 10^6 \text{ m}$ (equator) and $6.357 \times 10^6 \text{ m}$ (polar)
 Earth: average acceleration of gravity 9.807 m/s^2 at equator: 9.78 m/s^2
 Earth – Sun (mean radial distance) $1.496 \times 10^{11} \text{ m} = 1 \text{ AU}$
 Milky Way galaxy; mass: $(1.2 \text{ to } 3) \times 10^{42} \text{ kg}$; radius: $\sim 50,000 \text{ ly}$; rotation rate $\sim 200,000 \text{ years}$
 Sun distance to galactic center $\sim 27,000 \text{ ly}$
 CMB $\sim 2.735 \text{ }^\circ\text{K}$, $\sim 4 \times 10^8 \text{ photons/m}^3$, CMB energy density $4.2 \times 10^{-14} \text{ J/m}^3$
 Sun's motion relative to the CMB $\approx 369 \text{ km/s}$
 Planck spacetime: $U_{ps} = 5.53 \times 10^{112} \text{ J/m}^3$, quantized energy units: $\frac{1}{2}E_p = 9.78 \times 10^8 \text{ J}$

Cosmology

$$\Gamma_u(t) = a_u(t) = \frac{dt}{d\tau_u} \quad \Gamma_u = \text{background gamma of the universe}$$

$$\Gamma_u(t) = \frac{a_u(t)}{a_p} = \frac{dL}{d\mathbb{R}}$$

$$\mathcal{C} = \frac{c}{\Gamma_u^2(t)} = \frac{d\mathbb{R}}{dt} \quad \mathcal{C} = \text{coordinate speed of light in the universe}$$

$$\mathcal{C} \equiv \frac{d\mathbb{R}}{d\tau_u} = c/\Gamma_u \quad \mathcal{C} = \text{hybrid speed of light}$$

$$\mathcal{H} = \frac{da_u}{a_o d\tau_u} = \frac{d\Gamma_u}{\Gamma_{uo}} \quad \text{or} \quad \mathcal{H} = \frac{\dot{a}_u}{a_o} = \frac{\dot{\Gamma}_u}{\Gamma_{uo}} \quad \mathcal{H} = \text{Hubble parameter}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{\Gamma_{u1}}{\Gamma_{u2}} = \frac{v_2}{v_1} = \frac{a_2}{a_1} = 1 + z$$

$$\frac{U_{ps}}{U_{obs}} = \Gamma_{uo}^3 \times \Gamma_{eq} \quad \frac{U_{ps}}{U_{obs}} = \text{energy density ratio - Planck spacetime / observable spacetime}$$

$$U_{ps} \equiv \left(\frac{3}{8\pi}\right) \left(\frac{c^7}{\hbar G^2}\right) \approx 5.53 \times 10^{112} \text{ J/m}^3 \quad U_{ps} = \text{Planck spacetime energy density}$$

Symbol Definitions (Roman alphabet):

A = wave amplitude

\mathcal{A} = area

a = acceleration

A_f = fundamental amplitude of a spacetime wave prior to any cancellation $A_f = L_p/r$

A_β = strain amplitude in the rotar volume of a rotar

$A_{\beta e}$ = wave amplitude required for a rotar's electromagnetic characteristics at λ_c

$A_{\beta g}$ = amplitude of the nonlinear wave at distance λ_c ($A_{\beta g} = A_\beta^2$)

$A_{\beta w}$ = speculative amplitude of the weak force

A_e = amplitude of the wave responsible for electric field of charge e $A_e = \sqrt{\alpha} L_p \lambda_c / r^2$

A_E = electromagnetic non-oscillating strain amplitude $A_E = \sqrt{\alpha} \frac{L_p}{r} = \sqrt{\alpha} \frac{A_\beta}{\mathcal{N}} = \mathcal{V}$

A_{eq} = electric field standing wave amplitude at distance λ_c $A_{eq} = \sqrt{\alpha} L_p / \lambda_c$

A_{gw} = amplitude of a gravitational wave ($A_{gw} = 2 \Delta L / L \approx k G \omega^2 I \varepsilon / c^4 r$)

A_{max} = maximum strain amplitude permitted for a dipole wave

\mathcal{A}_o = cross sectional area in bulk modulus calculation

a_o = cosmological comoving scale factor at the present time

a_p = cosmological scale factor of Planck spacetime (when $t_u = 1$)

a_u = cosmological scale factor of the universe relative to Planck spacetime

a_{em} = cosmological scale factor at emission

a_{obs} = cosmological scale factor at observation

a_g = rotar's grav acceleration at the center of the rotar volume

\mathcal{B} = "B" magnetic field; magnetic flux density; magnetic induction

\mathcal{B}_e = electron's internal magnetic field $\mathcal{B}_e \approx 3.22 \times 10^7$ Tesla

\mathcal{B}_o and \mathcal{B}_g = normalized magnetic flux density

c = speed of light (3×10^8 m/s)

C_o = normalized speed of light in zero gravity $C_o = c$

C_g = normalized speed of light in gravity $C_o = \Gamma C_g$

C_r = speed of light in the radial direction relative to C_o

C_t = speed of light in the tangential direction relative to C_o

\mathcal{C} = hybrid coordinate speed of light $\mathcal{C} = dR/d\tau_u$

\mathcal{C}_u = cosmological coordinate speed of light $\mathcal{C}_u = dR/dt = c/\Gamma_u^2$

\mathcal{C}_1 = cosmological coordinate speed of light for $\Gamma_u = 1$

\mathcal{C}_T = coordinate speed of light in the tangential direction (Schwarzschild metric $dR = 0$)

\mathcal{C}_R = coordinate speed of light in the radial direction (Schwarzschild metric $d\Omega = 0$)

d_m = dipole moment

e = elementary electrical charge ($e = 1.6 \times 10^{-19}$ coulomb)

E = energy

\underline{E} = energy in Planck units: $\underline{E} = E/E_p$

\mathcal{E} = electric field

\mathcal{E}_γ = electric field strength in EM radiation

E_i = internal energy for a particle: $E_i = mc^2 = \omega \hbar$

E_p = Planck energy $E_p = \sqrt{\hbar c^5/G} = 1.956 \times 10^9$ J

$E_\mathcal{E}$ = energy in the electric field external to "r" for charge e $E_\mathcal{E} = \alpha \hbar c / 2r$

E_{el} = elastic potential energy in the context of bulk modulus
 E_g = energy of the mass in gravity but measured using the zero gravity standard of energy
 \bar{E}_g = normalized energy of an object in gravity but measured using zero gravity standards
 E_k = kinetic energy of mass falling from zero gravity to distance r from mass M
 E_o = energy of a mass in zero gravity measured using the zero gravity standard of energy
 E_y = Young's modulus $E_y = \text{stress/strain} = FL_o/A_o\Delta L$
 E_u = Cosmological unit of energy for $\Gamma_u > 1$
 E_1 = Cosmological unit of energy for $\Gamma_u = 1$
 F = force
 F_e = electromagnetic force - assumes charge e particles $F_e = e^2/4\pi\epsilon_o r^2$
 \underline{F}_e = electromagnetic force in dimensionless Planck units - assumes charge e particles
 \bar{F}_e = electromagnetic force - assumes Planck charge particles $F_e = q_p^2/4\pi\epsilon_o r^2$
 $\underline{\underline{F}}_e$ = electromagnetic force in dimensionless Planck units - assumes Planck charge particles
 F_g = gravitational force $F_g = (G mM)/r^2$
 \underline{F}_g = gravitational force in Planck units: $\underline{F}_g = F_g/F_p$
 \bar{F}_g = normalized force in gravity but using zero gravity standards (note symbol duplication)
 F_o = normalized force in zero gravity
 F_m = maximum force possible at a distance of $\lambda_c = m^2 c^3/\hbar$
 F_s = the strong force at distance λ_c
 F_p = Planck force $F_p = c^4/G$ $F_p = 1.210 \times 10^{44}$ N
 F_r = relativistic force $F_r = P/c$
 F_w = weak force at distance λ_c
 g = acceleration of gravity
 G = gravitational constant
 G_o and G_g = normalized gravitational constant using zero gravity standards
 $g_{oo}, g_{11}, g_{22}, g_{33}$ = general relativity matrix coefficients
 \mathbb{H} = "H" magnetic field; magnetic field strength; magnetic field intensity
 \mathbb{H}_γ = magnetic field strength in EM radiation
 \mathcal{H} = Hubble parameter currently $\mathcal{H} \approx 2.29 \times 10^{-18}$ m/s/m
 h = Planck constant $h = 6.626 \times 10^{-34}$ J s
 \hbar = reduced Planck constant: $\hbar = h/2\pi = 1.055 \times 10^{-34}$ J s
 \mathcal{I} = electrical current
 \mathbb{I}_e = electron's equivalent circulating current $I_e = ev_c \approx 19.796$ amps
 \mathcal{J} = intensity
 I = moment of inertia
 k = dimensionless constants (k_1, k_2 , etc.)
 k' = $3/8\pi$ (a constant used in cosmology)
 K_b = bulk modulus
 k_B = Boltzmann constant $\approx 1.38 \times 10^{-23}$ J/m³
 K_B = bulk modulus
 K_p = Planck bulk modulus = $c^7/\hbar G^2$
 K_s = bulk modulus of spacetime: $K_s = F_p/\lambda^2 = F_p(\omega/c)^2$
 L = dimensional analysis symbol representing length
 L_g = normalized length $dL_g = cd\tau$
 L_o = normalized length $dL_o = cdt$

L_o = in the context of Young's modulus, L_o is the original length before stress
 \mathcal{L} = angular momentum
 \mathcal{L}_o and \mathcal{L}_g = normalized angular momentum
 L_r & L_t = proper length in the radial or tangential direction respectively
 l_p = Planck length = $\sqrt{\hbar G/c^3} = 1.616 \times 10^{-35}$ m (a static unit of length)
 L_p = dynamic Planck length (wave amplitude of l_p)
 L_u = cosmological unit of length for $\Gamma_u > 1$
 m = mass
 \underline{m} = mass in dimensionless Planck units: $\underline{m} = m/m_p$
 m_p = Planck mass $m_p = \sqrt{\hbar c/G} = 2.176 \times 10^{-8}$ kg
 m_e = mass of an electron = 9.1094×10^{-31} kg
 m_r = pseudo rest mass when index of refraction $n > 1$
 M = dimensional analysis symbol representing mass
 M_o and M_g = normalized unit of mass
 M_u = cosmological unit of mass for $\Gamma_u > 1$
 \mathcal{M}_1 = cosmological unit of mass for $\Gamma_u = 1$
 N = an integer number
 \mathcal{N} = the distance between two rotars expressed as a multiple of λ_c ($\mathcal{N} = r/\lambda_c$)
 n_k = the index of refraction which includes the optical Kerr effect contribution
 n_o = the index of refraction at zero intensity
 p = momentum
 p_p = Planck momentum $p_p = m_p c = \sqrt{\hbar c^3/G} \approx 6.525$ kg m/s
 P = power
 P_c = a Particle's circulating power: $P_c = E_i \omega_c$
 \underline{P}_c = circulating power in Planck units: $\underline{P}_c = P_c/P_p$
 \mathcal{P} = pressure
 \mathcal{P}_p = Planck pressure $\mathcal{P}_p = c^7/\hbar G^2 = 4.636 \times 10^{113}$ N/m² ($= U_p$)
 P_p = Planck power $P_p = c^5/G = 3.63 \times 10^{52}$ w
 \mathcal{P}_q = pressure generated by a rotar $\mathcal{P}_q = (\omega_c^4 \hbar/c^3) = E_i/\lambda_c^3 = U_q$
 q = electrical charge
 Q_o , & Q_g = dimensional analysis units of charge used in various transformations
 Q_1 = cosmological unit of charge for $\Gamma_u = 1$
 Q_u = cosmological unit of charge for $\Gamma_u > 1$
 q_p = Planck charge = $\sqrt{4\pi\epsilon_0 \hbar c} = e/\sqrt{\alpha} \approx 11.7e \approx 1.876 \times 10^{-18}$ Coulomb
 r = radial distance (proper length)
 R = circumferential radius from general relativity (circumference/ 2π)
 \mathcal{R} = a unit of coordinate length pertaining to cosmology $d\mathcal{R} = dL_u/\Gamma_u$
 \mathcal{R}_1 = cosmological unit of length for $\Gamma_u = 1$
 r_h = radius of the Hubble sphere
 r_{ph} = radius of the particle horizon
 R_s = classical Schwarzschild radius: $R_s = Gm/c^2$
 r_s = relativistic Schwarzschild radius $r_s = 2Gm/c^2$
 $\lambda_c \equiv$ rotar radius of a rotar $\lambda_c \equiv \hbar/mc$ (λ_c = reduced Compton radius)
 $\lambda_c =$ rotar radius in Planck units: $\underline{\lambda}_c = \lambda_c/L_p$
 t = either time or coordinate time (depends on context)

t_c = time indicated on the coordinate clock
 T = dimensional analysis symbol representing time
 T_g = normalized unit of time in gravity
 T_o = normalized unit of time in zero gravity
 T_u = cosmological unit of time for $\Gamma_u > 1$
 T_1 = cosmological unit of time for $\Gamma_u = 1$
 t_p = Planck time $t_p = \sqrt{\hbar G/c^5} = 5.391 \times 10^{-44}$ s
 T_p = dynamic Planck time (a wave amplitude with dimension of Plank time)
 \mathcal{T} = temperature
 \mathcal{T}_p = Planck temperature = $E_p/k_B \approx 1.4168 \times 10^{32}$ °K
 u_d = de Broglie wave group velocity $u_d = v$
 U = energy density
 U_{el} = energy density of elastic potential energy (bulk modulus)
 U_i = interactive energy density encountered by a wave in spacetime $U_i = c^2 \omega^2 / G$
 U_o = energy density in coordinate units (assumes $\Gamma = 1$)
 U_g = energy density in a location with gravity ($\Gamma > 1$)
 U_u = energy density in the universe when $\Gamma_u > 1$
 U_p = Planck energy density $U_p = c^7 / \hbar G^2 = 4.636 \times 10^{113}$ J/m³
 U_{ps} = energy density of Planck spacetime $U_{ps} = (3/8\pi)(c^7 / \hbar G^2) \approx 5.53 \times 10^{112}$ J/m³
 U_q = energy density of a rotar $U_q = E_i / \lambda_c^3 = (\omega c^4 \hbar / c^3) = \mathcal{P}_q$
 U_u = cosmological unit of energy density for $\Gamma_u > 1$
 U_1 = cosmological unit of energy density for $\Gamma_u = 1$
 v = velocity
 v_e = escape velocity $v_e = (2Gm/r)^{1/2}$
 V = Volume
 V_r = rotar volume $V_r = \lambda_c^3$ (cubic) $V_r = (4\pi/3) \lambda_c^3$ (spherical)
 \mathcal{V} = Electrical potential
 \mathcal{V} = Voltage (electrical potential) in Planck units: $\mathcal{V} = V / \mathcal{V}_p$
 \mathcal{V}_p = Planck electrical potential (voltage) $\mathcal{V}_p = \sqrt{c/4\pi\epsilon_0 G}$
 w_d = de Broglie wave phase velocity $w_d = c^2 / v$
 w_m = velocity of the modulation wave envelope (moving resonator) $w_m = c^2 / v$
 x = maximum displacement produced by dipole wave in spacetime
 z = cosmological redshift
 z_{eq} = cosmological redshift since the radiation/matter equality transition
 $\Gamma_{eq} = \Gamma_u$ at the radiation/matter equality transition
 Z = impedance
 Z_s = impedance of spacetime $Z_s = c^3 / G = 4.04 \times 10^{35}$ kg/s
 Z_{s1} = cosmological impedance of spacetime for $\Gamma_u = 1$
 Z_{su} = cosmological impedance of spacetime for $\Gamma_u > 1$
 Z_e = electromagnetic impedance of free space $Z_e \approx 377 \Omega$
 Z_a = acoustic impedance $Z_a = \rho c_a$ (density \times speed of sound)
 Z_{oo} = normalized impedance of free space (zero gravity)
 Z_{og} = normalized impedance of free space (in gravity)
 Z_p = Planck impedance (electromagnetic) $Z_p = 1/4\pi\epsilon_0 c \approx 29.98 \Omega$

Greek Symbols

α = fine structure constant $\alpha = e^2/4\pi\epsilon_0\hbar c \approx 1/137.036$

β = gravitational magnitude $\beta \equiv 1 - (1 - 2Gm/c^2R)^{1/2} = 1 - 1/\Gamma = 1 - d\tau/dt \approx gm/c^2r$

β_q = gravitational magnitude at distance λ_c $\beta_q = H\beta^2 = Gm^2/\hbar c$

β_u = background gravitational magnitude of the universe $\beta_u = 1 - 1/\Gamma_u = 1 - d\tau_u/dt$

Γ = gravitational gamma $\Gamma = (1 - 2Gm/rc^2)^{-1/2}$

Γ_q = gravitational gamma at distance of λ_c $(\Gamma_q - 1) \approx (Gm^2/\hbar c)$

Γ_u = background gravitational gamma of the universe $\Gamma_u = dt/d\tau_u = a_u/a_p$

Γ_{uo} = the current value of Γ_u where: $\Gamma_{uo} \approx 2.6 \times 10^{31}$

$\Gamma_{obs} = \Gamma_u$ at the time an observation of a photon is made

$\Gamma_{em} = \Gamma_u$ at the time of emission of a photon

$\Gamma_{eq} = \Gamma_u$ at the radiation/matter equality transition

γ = special relativity gamma $\gamma = (1 - v^2/c^2)^{-1/2}$

ε = asymmetry of an object - uniform sphere has $\varepsilon = 0$, two equal point masses have $\varepsilon = 1$

ϵ_0 = permittivity of vacuum

ξ = spin axis probability

ξ_a = acoustic amplitude (particle displacement)

η = charge conversion constant $\eta \equiv L_p/Q_p = 8.617 \times 10^{-18}$ meters/Coulomb

θ_o and θ_g = normalized temperature

θ = angle symbol

λ = wavelength

λ = reduced wavelength: $\lambda_{bar} = \lambda = \lambda/2\pi = c/\omega$

λ_d = De Broglie wavelength $\lambda_d = h/mv$

λ_{dd} = wavelength of confined photon in moving frame of reference (relativistic contraction)

λ_m = modulation envelope wavelength; $\lambda_m = \lambda_o c/v$

λ_c = Compton wavelength $\lambda_c = h/mc$

λ_c = reduced Compton wavelength $\lambda_c = \hbar/mc = \lambda_c/2\pi$

λ_o = original wavelength or wavelength in zero gravity

λ_g = wavelength in gravity (blue shifted)

λ_{em} & λ_{obs} = wavelength at emission and observation respectively

λ_γ = wavelength of confined light (chapter 1)

λ = wavelength of light when measured in units of coordinate length.

Λ = cosmological constant

μ_B = Bohr magnetron = $e\hbar/2m_e = 9.274 \times 10^{-24}$ J/Tesla

μ_o = permeability of vacuum $\mu_o = 4\pi \times 10^{-7}$ m kg/C² = 1.257×10^{-6} m kg/C²

ν = frequency

ν_c = Compton frequency $\nu_c = mc^2/h$

ν_{obs} & ν_{em} = cosmological observed frequency & emitted frequency

ρ = matter density

ρ_p = Planck density $\rho_p = c^5/\hbar G^2$

σ = Stefan-Boltzmann constant: $\sigma = 5.670373 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
 τ = proper time – time interval on a local clock
 τ_d = time indicated on the dipole clock
 τ_{obs} = (cosmological) proper age of the universe at the time an observation is made
 τ_{em} = (cosmological) proper age of the universe at the time of emission of a photon
 τ_u = (cosmological) proper age of the universe at arbitrary time (cosmic time)
 τ_{uo} = (cosmological) current proper age of the universe (cosmic time)
 $\underline{\tau}_u$ = (cosmological) age of the universe in nondimensional Planck units $\underline{\tau}_u = \tau_u/t_p$
 \mathcal{T} = emission lifetime
 χ = distance in comoving coordinates
 Ψ = psi function
 ω = angular frequency
 ω_c = Compton angular frequency of a Particle ($\omega_c = mc^2/\hbar$)
 $\underline{\omega}_c$ = Compton angular frequency in Planck units: $\underline{\omega}_c = \omega_c/\omega_p$
 ω_p = Planck angular frequency $\omega_p = \sqrt{c^5/\hbar G} = 1.855 \times 10^{43} \text{ s}^{-1}$
 Ω = a solid angle in a spherical coordinate system ($d\Omega^2 = d\theta^2 + \sin^2\theta d\Phi^2$)
 Ω = symbol representing electrical resistance
 Ω_M = matter density parameter
 Ω_Λ = cosmological constant density parameter

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