Chapter 5

Spacetime Particle Model

"Think of a particle as built out of the geometry of space; think of a particle as a geometrodynamic 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 (~ 10^{113} J/m^3). One point of possible confusion is that ~ 10^{113} J/m^3 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/m^3. 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 (~ 10^{113} J/m^3) 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, $\hbar$, ε_0, G, Z_s, etc.

From our current perspective, space appears to be an empty void. However, as John Archibald Wheeler[1] 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 (∼ 10^{32} °K).

Even though 10^{113} J/m^3 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 (ω_p = Planck frequency) and the largest possible amplitude ($A = 1$).

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

$U = \dfrac{c^7}{\hbar G^2} \approx 4.6 \times 10^{113}$ J/m^3 = 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/m^3 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/m^3 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 ½ $\hbar$. 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 ^{4}He 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 ^{4}He 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 ^{4}He or Bose-Einstein condensate. This effect was first discovered with superfluid liquid helium[2]. 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].

[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 exists 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 ½$\hbar$ 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 ½ $\hbar$ 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 ½ $\hbar$ 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' 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 chaptes 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 ½ ħ or ħ. The same way that a superfluid Bose Einstein condensate isolates angular momentum into discrete vorticies, each with ħ 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 ½ ħ of angular momentum appear to be particles because they respond to a pertibation 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 ($Z_s = c^3/G \approx 4 \times 10^{35}$ 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.*

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 ½ħ, 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.

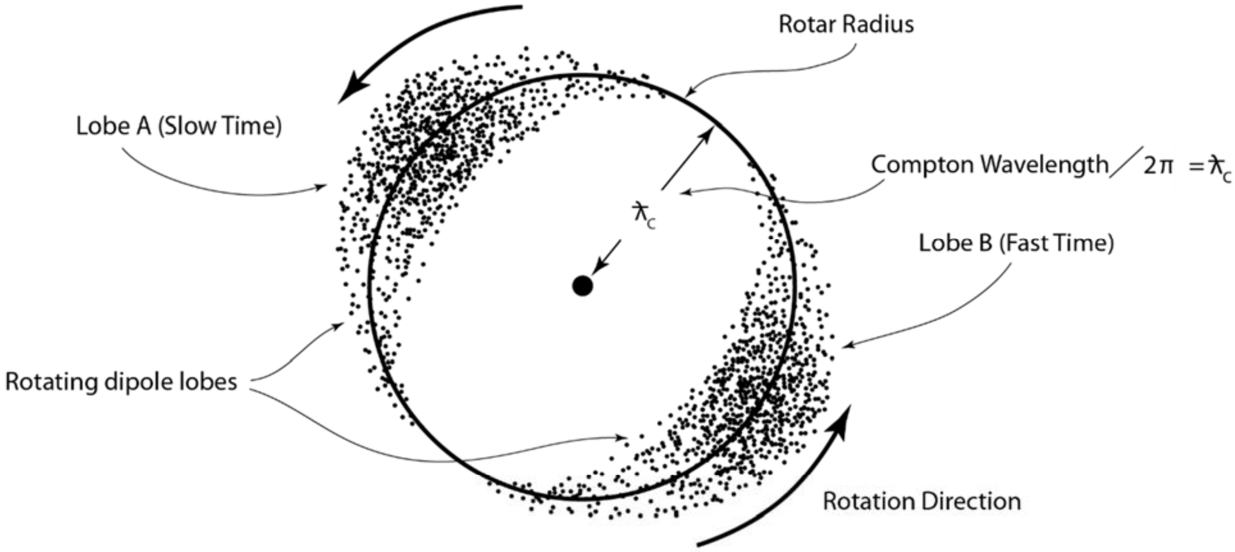

FIGURE 5-1 Depiction of the Rotar Model Emphasizing the Rotating Lobes
This is a rotating spacetime dipole that is one wavelength in circumference.

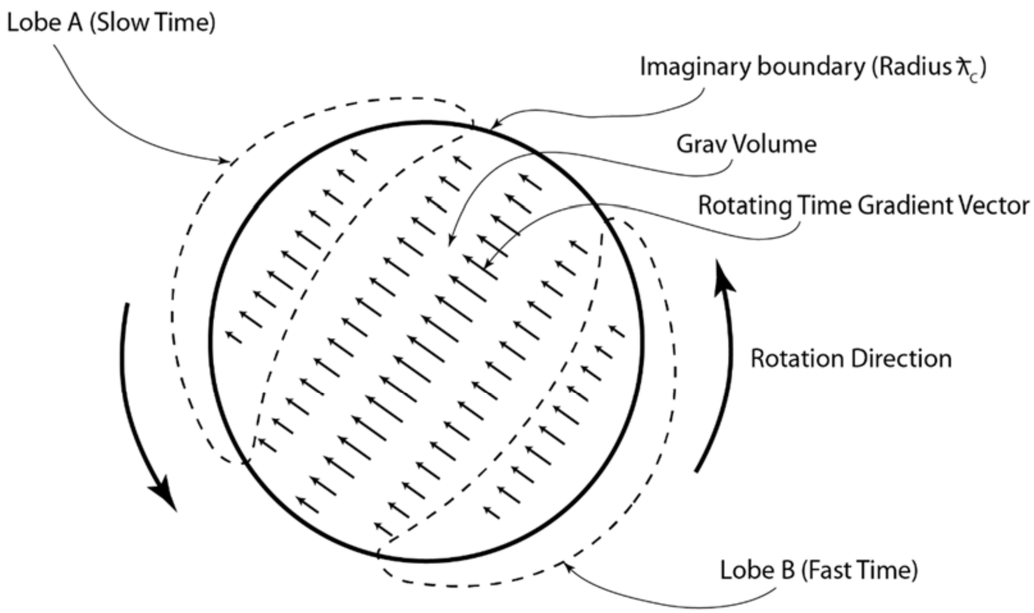

FIGURE 5-2 Depiction of the Rotar Model Emphasizing the Rotating Time Gradient Called a "Grav Field"

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 $\lambda\!\!\!^{-}_c$. This circle and radius $\lambda\!\!\!^{-}_c$ 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 nd temporal variuations 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:

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

For example, a 1 m/s^2 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 snall 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.

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

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

$$\omega = \omega_c = \frac{mc^2}{\hbar} = \frac{c}{\lambda\!\!\!^-_c} = \frac{E_i}{\hbar} = \text{Compton angular frequency}$$

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.

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

$\lambda_c \approx \lambda_d \gamma$ 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?

$\lambda_d = h/p$ 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 $\omega_c = 2\pi\, \nu_c = 7.76 \times 10^{20}\ \mathrm{s}^{-1}$
Electron's Compton wavelength $\lambda_c = 2.43 \times 10^{-12}$ m
Electron's reduced Compton wavelength $\bar{\lambda}_c = 3.86 \times 10^{-13}$ m ($\bar{\lambda}_c = c/\omega_c$)

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 $\bar{\lambda}_c$.
$\bar{\lambda}_c = c/\omega_c = \lambda_c/2\pi = \hbar/mc = \hbar c/E_i$
Where:, $\bar{\lambda}_c$ = reduced Compton wavelength = rotar's radius; λ_c = Compton wavelength,
E_i = rotar's internal energy

In quantum mechanics, this distance $\bar{\lambda}_c$ 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 $\bar{\lambda}_c$. A particle can go out of existence, or come into existence, for a time equal to $\bar{\lambda}_c/c$. Essentially, the distance $\bar{\lambda}_c$ 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 an 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.

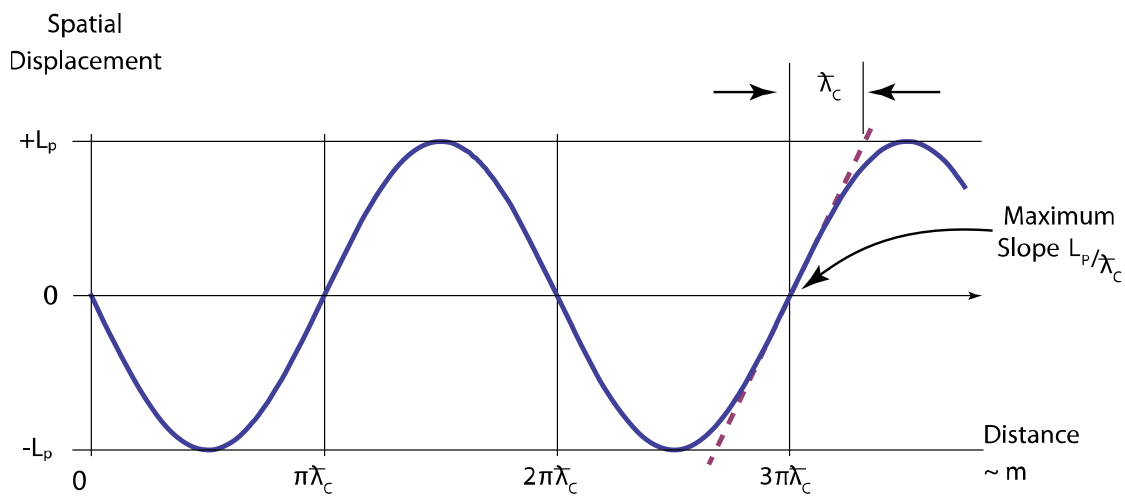

FIGURE 5-3

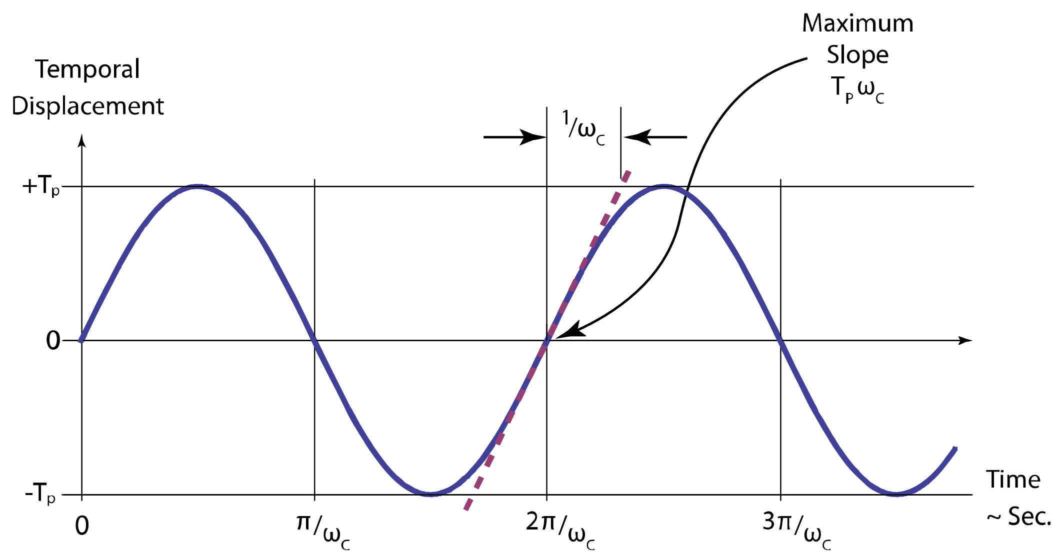

FIGURE 5-4

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 = $\lambda\!\!\!^{-}_c$) and the distance between two points on the Compton circle also fluctuates.

All quantized dipole waves have maximum spatial displacement amplitude equal to ± 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 $\lambda\!\!\!^{-}_c$ (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 $\lambda\!\!\!^{-}_c$. 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 $\lambda\!\!\!^{-}_c$ 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 $\lambda\!\!\!^{-}_c$. 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 $L_p/\lambda\!\!\!^{-}_c$. 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:

$A_\beta = L_p/\lambda\!\!\!^{-}_c$ = 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:

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

Therefore the dipole waves strain amplitude can be expressed either as a strain of space ($L_p/\lambda\!\!\!^{-}_c$) 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 $\omega_c \approx 7.76\times10^{20}$ 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 $\lambda\!\!\!^{-}_c$. 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 $L_p/\lambda\!\!\!^{-}_c$ 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 solitons[5].

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).