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 $ƛ_c$. 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 ($\sim 6 \times 10^{-10}$ J/m^3) distributed throughout the universe that counteracts gravity. This is completely different than the very large energy density ($\sim 10^{113}$ 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 (~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 $\lambda\!\!\!^{-}_c$. 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 ½ radian each (1 radian total) in a time of $1/2\omega_c = \hbar/2mc^2 \approx 6.4\times10^{-22}$ 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 $\Delta x = ƛ_c$. 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/m^3. 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 (½ ħ) 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 ($\mathbb{P}$) both have units of M/T^{2}L and on a fundamental level they are both the same ($U = k\mathbb{P}$). 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 $\mathbb{P}_q$. 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: $U = \mathbb{P} = kA^2\omega^2Z/c$. Using the substitution: $A = A_\beta = (T_p\omega_c) = \sqrt{\hbar G/c^5}\ \omega_c$ and previous substitutions:

$$U_q = \mathbb{P}_q = \frac{A_\beta^2\omega_c^2 Z_s}{c} = \left(\frac{\hbar G\omega_c^2}{c^5}\right)\omega_c^2\ \left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \frac{\hbar\omega_c^4}{c^3} = \frac{m^4c^5}{\hbar^3} = \frac{E_i}{ƛ_c^3} = \frac{F_m}{ƛ_c^2} = A_\beta^4 U_p = A_\beta^4\mathbb{P}_p$$

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/m^3 and 10^{24} N/m^2 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/m^2 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/m^3 and the pressure must exceed 10^{45} N/m^2 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/m^3. 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/m^3 (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_o, $\hbar$, 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]
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> "Physical space and aether are only different terms for the same thing; fields are physical states of space."[2]
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> "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]

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[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 Puthoff[6] 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."

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[4] A. Einstein, *Ather und Relativitatsheorie* (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 = 2.77x10^{-8} J, frequency of $\omega_c \approx$ 3x10^{26} s^{-1}, energy density of about 10^{46} J/m^3 and internal pressure of about 10^{46} N/m^2. To offset this internal pressure a top quark cannot exist in a frame of reference beyond about $\gamma =$ 7x10^{16} relative to the CMB rest frame. Similarly, an electron cannot exist at a frame beyond about $\gamma =$ 3x10^{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 $\lambda\!\!\!^{-}_c$) has been given as $A_\beta = L_p/\lambda\!\!\!^{-}_c$. A simple extrapolation of this amplitude to distances beyond $\lambda\!\!\!\!-_c$ would result in a fundamental wave amplitude of $A_f = L_p/r$ where distance r is greater than $\lambda\!\!\!\!-_c$. 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 $\lambda\!\!\!\!-_c$ 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: $\mathcal{A} = kr^2$.

$P = A^2\,\omega^2\,Z\,\mathcal{A}$ set $A = A_f = L_p/r$, $Z = c^3/G$ and $\mathcal{A} = kr^2$ (ignore k)

$$P = \left(\frac{L_p}{r}\right)^2 \omega_c^2 \left(\frac{c^3}{G}\right) r^2 = \left(\frac{\hbar G}{c^3}\right)\omega_c^2\left(\frac{c^3}{G}\right) = \omega_c^2\hbar = P_c$$

$P = P_c$ radiated power = 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 "wiggle 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: $\mathbb{P} = m^4c^5/\hbar^3$ and applying this pressure over an area of $k\lambda\!\!\!^{-}_c{}^2$ produces a force equal to the rotar's maximum force $(F_m = m^2c^3/\hbar)$ 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 (~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 $F_m = \mathbb{P}_q \lambda_c^2$).

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 $F_m = m^2c^3/\hbar$ 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:

$\mathbb{P} = (k)\,\hbar c/r^4$ Casimir Pressure $\mathbb{P}$ for parallel metal plates separated by "*r*"

This should be compared to the pressure $\mathbb{P}$ exerted by vacuum energy on a rotar with rotar radius $ƛ_c$:

$\mathbb{P} = (k)\,\hbar c/ƛ_c^4$ $\mathbb{P}$ = pressure exerted by vacuum energy on rotar with radius $ƛ_c$

It can be seen that these are the same form if gap size "*r*" is equated to rotar radius $ƛ_c$ 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 ħ of quantized angular momentum (orbital angular momentum can add multiples of ħ, 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 ½ $\hbar$ 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 *(½ ħ)* 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 *ħ* 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 *ħ*. 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 $\lambdabar_c$ 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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