Chapter 10

Rotar's External Volume

External Volume of an Electron (Conventional Model): Before presenting the spacetime based model of the external volume of a fundamental particle, we will first look at the competition. The conventional model of an electron is a point particle (or vibrating string with no volume) surrounded by an electric and magnetic field. The energy density of a macroscopic electric field from elementary charge e is: $U = (1/8\pi)(\alpha\hbar c/r^4)$. The energy in the electric field external to a given radial distance r is: $E_{ext} = (1/8\pi\varepsilon_o)(e^2/r) = ½(\alpha\hbar c/r)$. When $r = ƛ_c$, then the electric field energy external to the quantum radius $ƛ_c$ is $E_{ext} = ½(\alpha E_i)$ where E_i is the internal energy of the electron. This energy density shows that an electron's electric field is a real physical entity. An interaction with an electron's electric field does not exhibit any delay that would occur if messenger particles had to be sent out by an electron. In chapter 9 an example was given involving the magnetic field of a star. This example clearly illustrates the inadequacy of the exchange of virtual photon messenger particles to explain the electromagnetic force. In this chapter we will develop further the spacetime based explanation of electric and magnetic fields.

If the electron's radius is less than the classical radius of an electron ($\sim 10^{-15}$ m) then there is an additional problem with the point particle model because a smaller radius makes the energy in the electric field exceed the total energy of the electron. For example, if a particle or the vibrating string was considered to be contained in a volume with a radius of Planck length, then the energy in the surrounding electric field would be about 10^{20} times larger than the electron's internal energy (10^7 J compared to $\sim 10^{-13}$ J). This problem is usually ignored by saying that the electron has an "intrinsic" electric field associated with elementary charge e. If we are attempting to give conceptually understandable explanations of quantum mechanics using the properties of spacetime, then we do not have the luxury of being able to ignore such problems. It is even necessary to describe charge and electric field in terms of the properties of spacetime.

External Volume of a Rotar: We will now look at the spacetime model of the "fields" associated with a fundamental particle. A rotar has previously been described as a unit of quantized angular momentum in a sea of vacuum fluctuations. These vacuum fluctuations have superfluid properties as previously described. The vacuum fluctuations cannot possess angular momentum and therefore any angular momentum must be isolated into quantized units just like superfluid liquid helium isolates angular momentum into quantized vortices. The "rotar volume" of a rotar possesses angular momentum so this volume is in a different state than the surrounding spacetime field. While the vacuum fluctuations surrounding a rotar avoid possessing angular momentum, the surrounding volume is still affected by the presence of a rotar (quantized angular momentum) in its midst. The rotar produces disturbances in the volume external to the rotar which slightly affect the sea of vacuum fluctuations that surround a rotar. This chapter will examine the standing waves and static strain produced in the volume surrounding a rotar. These effects are responsible for not only the rotar's gravitational and electromagnetic fields but also numerous other effects including de Broglie waves and Compton scattering.

The probability of interacting with a rotar (finding a particle) does not end at the edge of the rotar volume. The edge of the rotar volume is mathematically significant because it allows us to characterize properties and dimensions, but the proposed quantum mechanical nature of a rotar is not bound by our convention. There is part of a rotar that extends far beyond the rotar radius $\lambda\!\!\!^{-}_c$. These external effects will be shown to be both oscillating standing waves and static strains distributed across the sea of vacuum fluctuations that are part of spacetime. The volume beyond the rotar radius will be called the "external volume". This external volume still possesses part of the rotar's quantized angular momentum. Therefore the external volume is still considered to be part of the rotar but the external volume has different characteristics than the rotar's quantum volume.

The dipole wave in spacetime responsible for a rotar has previously been described as rotating at its Compton angular frequency and possessing amplitude of: $A_\beta = L_p/\lambda\!\!\!^{-}_c = T_p\omega_c$. It was also proposed that the rotar is attempting to radiate away its energy into the external volume (the sea of vacuum fluctuations). The amplitude of this attempted radiation has been designated the "fundamental amplitude" A_f. This fundamental amplitude decreases with distance r such that the hypothetical amplitude would be: $A_f = L_p/r = cT_p/r$. If there were no offsetting effects, this amplitude would radiate away a rotar's full energy in a time of $1/\omega_c$ which is typically in the range of 10^{-21} to 10^{-25} s. This is the same as having no stability. The few rotar frequencies that are stable or semi-stable must produce an interaction with vacuum energy that generates a new wave that cancels energy loss but leaves oscillating standing waves. For example, an electron has long term stability therefore the probability of energy loss is zero. However, this does not mean that all of the energy of an electron is confined to its rotar's quantum volume. There is a battle going on in the external volume between the attempted emission and the cancelation waves. The residual effects that exist in the electron's external volume are responsible for the electron's gravity, the electron's electric/magnetic fields and the electron's de Broglie waves.

Gravitational and Electromagnetic Strain Amplitudes: In chapters 6 and 8 it was shown that gravity is the result of spacetime being a nonlinear medium for dipole waves in spacetime. While there is cancelation of the fundamental wave emission, the nonlinear effects remain from the battle. This results in a non-oscillating strain in spacetime which has previously been designated "gravitational magnitude β". In this chapter we are dealing with the various amplitudes associated with rotars. Therefore, the gravitational non-oscillating strain amplitude in spacetime produced by a rotar will be designated by the symbol $A_G = \beta = Gm/c^2r = A_\beta^2/\mathcal{N}$ where $\mathcal{N}$ has previously been designated as the number of reduced Compton wavelengths: $\mathcal{N} = r/\lambda\!\!\!^{-}_c$.

There was also a proposed oscillating component of gravity with strain amplitude designated A_g. It will be shown that this oscillating gravitational component in the external volume results in energy external to $ƛ_c$ that is in the range of 10^{40} times smaller than a rotar's internal energy therefore it is undetectable when dealing with individual rotars. However, the implication is that the gravitational field of massive bodies has an oscillating component that can achieve substantial energy density. This will be discussed at the end of this chapter.

As before, the simplest example used for illustration in this chapter is a single isolated fundamental particle with elementary charge e. Only electrons, muons and tauons meet this criterion. To further simplify the semantics it is easiest to use electrons in examples. Therefore, this chapter will attempt to describe the external volume of an electron. Once this is done there will be some discussion of the external volume of protons, neutrons, etc.

As previously stated, understanding the connection between electric fields (magnetic fields) and dipole waves in spacetime has been the most difficult task in developing the spacetime based model of the universe. Furthermore, the most difficult component of this explanation has been modeling the electric field of a rotar. In chapter 9 we concluded that an electron and other charged leptons with charge e produce a non-oscillating strain in spacetime. At distance r this strain corresponds to the dimensionless Planck electrical potential $\underline{\mathbb{V}} = \sqrt{\alpha} L_p / r$. So far it has not been explained how this non-oscillating strain is produced. The breakthrough occurred with the realization that gravity has an oscillating component (figure 8-1) and a static component. On close examination it was found that the electric field produced by a charged particle such as an electron must also have an oscillating component and a static component. Therefore a gravitational field has two strain components (one oscillating and one static) while the electric/magnetic field also has two strain components (one oscillating and one static). The static component of a gravitational field has already been discussed in chapters 6 and 8. This chapter will concentrate on the remaining three components

The model assumes that the electric field produced by an isolated electron possesses the classical energy density external to the rotar volume where $r > ƛ_c$. There is no continuous loss of the electron's energy, so these external oscillations must be standing waves that remain after the proposed cancelation that must take place to eliminate emission of energy at frequency ω_c and amplitude $A_f = L_p/r$. In order for the standing waves to achieve the energy density of the electric field, it is necessary for some part of the electron's energy to reside outside distance $ƛ_c$. We will calculate the oscillating "standing wave" amplitude distribution required to achieve this energy density.

$U = (½)\, \varepsilon_o \mathbb{E}^2$ energy density in an electric field $\mathbb{E}$ of a single electron

$\mathbb{E} = (1/4\pi\varepsilon_o)\, e/r^2$ electric field produced by a particle with charge e

$U = \dfrac{\alpha\hbar c}{8\pi r^4}$ substitution including $\alpha\hbar c = \left(\dfrac{e^2}{4\pi\varepsilon_o}\right)$

We also have $U = A^2\,\omega^2\,Z_s/c$ from the 5 wave-amplitude equations. Therefore we can set these two energy density equations equal to each other and ignore dimensionless constants.

$A^2\,\omega^2\,Z_s/c = \alpha\hbar c/r^4$ substitute $Z_s = c^3/G$ and $\omega = c/\lambda\!\!\!^{-}_c$, then solve for A
$A^2 = \alpha\,(\hbar G/c^3)\,\lambda\!\!\!^{-}{}_c^2/r^4$ set $\hbar G/c^3 = L_p^2$; $A = A_e$ and $\mathcal{N} = r/\lambda\!\!\!^{-}_c$

$$A_e = \frac{\sqrt{\alpha}L_p R_q}{r^2} = \left(\frac{\sqrt{\alpha}L_p}{\lambda\!\!\!^{-}_c}\right)\left(\frac{\lambda\!\!\!^{-}_c}{r}\right)^2 = \sqrt{\alpha}\,\frac{A_\beta}{\mathcal{N}^2}$$

A_e = oscillating (standing wave) amplitude component of the electric field at frequency ω_c

Note that the different Compton frequencies of an electron and a muon are absorbed into the A_β and $\mathcal{N}$ terms which both have a frequency dependence ($A_\beta = L_p/\lambda\!\!\!^{-}_c = \omega_c/\omega_p$ and $\mathcal{N} = r/\lambda\!\!\!^{-}_c = r\omega_c/c$) While this oscillating amplitude A_e gives the correct energy density, these standing waves do not directly convey force between charged rotars. If the oscillating component was responsible for electrostatic force, this would imply that oscillating energy in the external volume was propagating and energy would be continuously radiated. The standing waves in a rotar's external volume do not directly generate forces. However, they are indirectly responsible for the forces between rotars. Here is the picture that has emerged after lengthy examination.

A rotar is attempting to radiate away its energy to the surrounding sea of vacuum energy. The few fundamental particles that are stable exist at one of the few special frequencies that generate canceling waves in vacuum energy eliminating the loss of energy. Even though the loss of energy is eliminated, there are four residual effects that show that a battle has taken place. These 4 residual effects are really combined into a distortion of spacetime with oscillating and non-oscillating components, but for analysis it is convenient to separate them into component parts.

1) There is non-oscillating strain in spacetime responsible for gravity and previously discussed in chapters 6 and 8. This strain has been designated as the gravitational magnitude β, but to make a designation A_G in keeping with other amplitude terms we will also designate the non-oscillating term as $A_G = \beta = A_\beta^2/\mathcal{N}$.
2) There is an oscillating nonlinear effect associated with gravity and illustrated in figure 8-3 as the small amplitude waves on the line designated "nonlinear component". This oscillating component of gravity has previously been shown to have amplitude of A_β^2 at distance $\lambda\!\!\!^{-}_c$. It will be proposed that this gravitational oscillating term external to $\lambda\!\!\!^{-}_c$ has amplitude $A_g = A_\beta^2/\mathcal{N}^2$. This gives energy density to a gravitational field (calculated later)

3) There are standing waves (associated with the electric field) remaining in the vacuum energy that surrounds the rotar. These standing waves are at the rotar's Compton frequency ω_c and have the oscillating amplitude $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2$.
4) It is proposed that there is a non-oscillating term associated with the electric field with amplitude $A_{\mathbb{E}} = \sqrt{\alpha} A_\beta / \mathcal{N} = \mathbb{V}$. This non-oscillating component is what we usually consider to be an electron's electric field. Here is the reasoning.

The following is a summary of the electromagnetic and gravitational amplitudes generated by a fundamental particle with charge e. For example, an electron has energy $E_i = 8.2\times10^{-14}$ J. This means that it has dimensionless strain amplitude $A_\beta \approx 4.18\times10^{-23}$ and reduced Compton wavelength $\lambda_c = 3.86\times10^{-13}$ m. Distance from the electron is specified as the number $\mathcal{N}$ of reduced Compton wavelengths.

$A_e = \sqrt{\alpha}\dfrac{A_\beta}{\mathcal{N}^2} = \sqrt{\alpha}\dfrac{L_p \lambda_c}{r^2}$ = electromagnetic standing wave amplitude oscillating at ω_c (charge e)

$A_{\mathbb{E}} = \sqrt{\alpha}\dfrac{A_\beta}{\mathcal{N}} = \sqrt{\alpha}\ \dfrac{L_p}{r} =$ = electromagnetic non-oscillating strain amplitude (charge e)

$A_g = \dfrac{A_\beta^2}{\mathcal{N}^2} = \dfrac{L_p^2}{r^2}$ = gravitational standing wave amplitude oscillating at $2\omega_c$

$A_G = \dfrac{A_\beta^2}{\mathcal{N}} = \dfrac{Gm}{c^2 r} = \beta$ = gravitational non-oscillating strain amplitude (spacetime curvature)

The introduction of A_e, $A_{\mathbb{E}}$, A_g and A_G is merely a case of giving new symbol designations to the concepts previously discussed. We just derived $A_e = \sqrt{\alpha} A_\beta / \mathcal{N}^2$ as the amplitude required to produce the energy density of an electric field associated with energy density $U = (½)\ \varepsilon_o \mathbb{E}^2$ (numerical constant ½ is ignored). $A_G = A_\beta^2 / \mathcal{N} = \beta$ is the non-oscillating amplitude required to produce the gravitational field of a rotar. $A_{\mathbb{E}}$ is the symbol given to the non-oscillating strain developed in chapter 9. A_g is the symbol given to the oscillating component of gravity previously discussed and depicted in figures 8-1 and 8-3. The oscillating component of gravity A_g will be examined in more detail at the end of this chapter and shown to give energy density to a gravitational field. The picture that emerges is that both the electric/magnetic field and the gravitational field of a rotar such as an electron possess an oscillating component and a non-oscillating component. The oscillating components give energy density to these fields but the Planck amplitude oscillations are undetectable. However, the oscillating components are essential because they create the non-oscillating strains that we easily detect.

Non-Oscillating Strain Amplitude $A_{\mathbb{E}}$: The proposed electromagnetic non-oscillating strain amplitude A_E is responsible for what we consider to be the electric field of charged leptons such as an electron or muon. The strain $A_{\mathbb{E}} = \sqrt{\alpha}\ A_\beta / \mathcal{N}$ looks similar to the fundamental amplitude $A_f = A_\beta / \mathcal{N}$ which is the theoretical oscillating strain amplitude that is being canceled in the rotars that are stable enough to be considered fundamental particles. However, there are several key differences. First is the obvious difference of $\sqrt{\alpha}$ which reduces the amplitude by a factor of about 11.7 at any given value of $\mathcal{N}$. Second, $A_{\mathbb{E}}$ is a non-oscillating strain while A_f is a hypothetical oscillating amplitude at frequency ω_c that is attempting to radiate away the rotar's energy. Third, the type of displacement of spacetime produced by an electric field is different from the type of displacement of spacetime produced by dipole waves in spacetime. Recall that dipole waves modulate the rate of time and the distance between points as well as having the Planck length/time amplitude limitation. The electric field component designated $A_{\mathbb{E}}$ is the non-oscillating strain which produces the non-reciprocal characteristic previously discussed (difference in the one way travel time for a time of flight). The magnitude of this effect can greatly exceed the Planck length limitation of oscillating components.

Electrostatic Force Calculation: We will next check to see if the non-oscillating strain amplitude A_E gives the correct electrostatic force between two charged leptons (two electrons). When we calculated the gravitational force on a rotar produced by another rotar creating the non-oscillating strain $A_G = A_\beta^2/\mathcal{N}$, we calculated the implied difference in the rate of time across the radius of a rotar and converted this to the difference in gravitational magnitude $\Delta\beta$ across the rotar. This was necessary because for force generation, it is only the gradient in β or Γ that is important, not the absolute value.

The proposed characteristic of an electric field is different in the sense that the difference is between opposite directions, not the gradient across a rotar. In fact, the difference across the width of a rotar is insignificant compared to the difference between opposite directions at the average location of the rotar feeling the force. Imagine the rotar model presented in chapter 5 rotating in otherwise homogeneous spacetime. Now imagine this rotar rotating in polarized spacetime where there is a difference in the time required for speed of light propagation in opposite directions across the rotar. The strain in spacetime producing this effect is static, but the interaction with the rotar is dynamic. The interaction occurs at a frequency equal to ω_c and the interaction modulates the rotar at amplitude of $A_{\mathbb{E}} = \sqrt{\alpha}A_\beta/\mathcal{N} = \underline{\mathbb{V}}$. This in turn affects the interaction with vacuum energy/pressure surrounding the rotar. This creates a pressure imbalance that can appear to be either attraction or repulsion. The magnitude of the force is:

$$F = \frac{A^2\omega^2 Z_s \mathcal{A}}{c}$$

set $A^2 = \alpha\dfrac{A_\beta^2}{\mathcal{N}^2} = \alpha\left(\dfrac{L_p^2}{\lambda_c^2}\right)\left(\dfrac{\lambda_c^2}{r^2}\right) = \alpha\left(\dfrac{\hbar G}{c^3 r^2}\right)$; $\quad \omega = \dfrac{c}{\lambda_c}$; $\quad Z_s = \dfrac{c^3}{G}$; $\quad \mathcal{A} = \lambda_c^2$; $\quad \alpha = \dfrac{e^2}{4\pi\varepsilon_o\hbar c}$

$$F = \alpha\left(\frac{\hbar G}{c^3 r^2}\right)\left(\frac{c^2}{\lambda_c^2}\right)\left(\frac{c^3}{G}\right)\left(\frac{\lambda_c^2}{c}\right) = \alpha\left(\frac{\hbar c}{r^2}\right) = \left(\frac{e^2}{4\pi\varepsilon_o\hbar c}\right)\left(\frac{\hbar c}{r^2}\right) = \frac{e^2}{4\pi\varepsilon_o r^2} \quad \text{Success!}$$

This explanation is far from complete. For example, there is no explanation for the difference between a force of attraction and repulsion. Also, there is no explanation for the difference between an electron and a positron. However, the explanations offered here do make a first step towards developing a physically understandable explanation of electric fields and electrostatic force. The standard approach is to merely accept the existence of mysterious "fields" with no attempt to find an underlying causality.

Electric Field Cancelation: The non-oscillating component of the electric field produced by an electron does not have any inherent energy density. Only the oscillating component producing standing waves oscillating at ω_c possess energy density. These two components of the electric field are connected so it is not possible to have an electric field (the measurable non-oscillating component) without also having the energy density provided by the oscillating component. The oscillating component produces the non-oscillating effect.

It is possible to cancel out the non-oscillating strain of an electric field when two opposite charges are brought together. However, exactly what happens to the oscillating portion when opposite charges are brought together has not been exactly determined. For example, bringing an electron and proton together to form a hydrogen atom in its lowest energy state releases 13.6 eV of energy. This energy probably came from a reduction in the Compton frequencies of the fundamental particles. However, there might have also been a reduction in the amplitudes A_e for each particle compared to the value of A_e if each oppositely charged particle was isolated. This is part of the unknown.

However, even a neutron still has de Broglie waves as demonstrated by a double slit experiment using neutrons. Therefore, not all the oscillating portion of energy in the external volume has been eliminated. Also, there has clearly been some additional change because the 3 quarks that form a neutron have lost their individual Compton frequencies and instead a neutron with rest energy of 939.6 MeV exhibits de Broglie wave characteristics of the composite frequency. Therefore the bonding process must include some unknown mechanism for frequency addition of component parts. We will not speculate on this any further since this chapter is primarily about the external volume of the 3 charged leptons and about the electron's external volume in particular. This is a subject that needs further analysis.

Energy in the External Volume: As previously calculated, the energy in a charged lepton's external volume caused by the oscillating component of the electric field is equal to $\alpha/2$ (roughly 0.4%) of the charged lepton's total energy. Hadrons do not have a fixed percentage of their energy external to their radius but even a neutron has some of its energy external to its radius. The three quarks that form a neutron have addition/subtraction of the static strain components of the quark's electric fields. A short distance from the neutron there is effectively charge cancelation. However, this is the non-oscillating component of the electric field that results in vector addition or subtraction. The oscillating part is proposed to remain and produce standing waves in the neutron's external volume. These standing waves become the neutron's de Broglie waves when the neutron is observed in a moving frame of reference. For example, a neutron produces a diffraction pattern when it is passed through a double slit experiment. The implied frequency is equal to the sum of the frequencies of the three quarks. No effort has been expended to develop a model of frequency addition in hadrons and other composite particles.

A muon and an electron both have the same charge and same fraction of their total energy in their external volumes. However, a muon has about 200 total times more energy and 200 times smaller radius. Almost all of the muon's extra external energy is contained in the small difference between the rotar volume of a muon and the rotar volume of an electron. At a distance larger than the electron's rotar radius, they both generate the same electrostatic force because they both generate the same non oscillating strain in space. This can be shown by the following:

$$A_{\mathbb{E}} = \sqrt{\alpha}\,\frac{A_\beta}{\mathcal{N}} = \sqrt{\alpha}\left(\frac{\mathrm{L_p}}{\lambda\!\!\!{}^-_c}\right)\left(\frac{\lambda\!\!\!{}^-_c}{\mathrm{r}}\right) = \sqrt{\alpha}\,\frac{L_p}{r}$$ this is the same for all rotars with charge *e.*

The equation $A_{\mathbb{E}} = \sqrt{\alpha}L_p/r$ has lost all terms which relate to a specific Compton frequency or a specific rotar radius size. Therefore the non-oscillating strain (the detectable electric field) produced by a muon is exactly the same as the non-oscillating strain produced by an electron. The oscillating components of an electron and muon retain their frequency dependence but these oscillating components are only detectable as de Broglie waves and other quantum mechanical wave characteristics.

Internal Electric Field: Even though this chapter is about the external volume of a rotar, we are going to take a brief diversion and talk about the extension of the non-oscillating strain of the electric field into the interior of a lepton's rotar volume. If rotars are slight distortions of spacetime that can partially overlap, does the electric field (the non-oscillating strain) continue to increase inside the rotar's rotar radius? The problem is that when two electrons collide relativistically, the repulsion force exceeds the force that could be generated if the electric field ended at the surface of the rotar volume. In chapter 9 it was determined that the strain in spacetime produced by charge e at distance r is: $\Delta L/L = \underline{\mathbb{V}} = \sqrt{\alpha}L_p/r$. I suspect that this equation changes gradually when $r < \lambda\!\!\!{}^-_c$ if only because of the uncertainty of designating the location to specify as the central location to serve as the point where $r = 0$. However, the point is that the strain can continue to increase into the internal volume of a rotar such as an electron. Therefore, there is no reason why colliding two electrons together should reveal any internal structure. The strain in spacetime, and therefore the repulsive force continues to increase as the two electrons overlap. Furthermore, the collision of two rotars causes both rotars to convert the kinetic energy to internal energy. For example, colliding two electrons with kinetic energy of 50 GeV causes both electrons to momentarily gain 100,000 times their original energy and shrink by a factor of 100,000 at the point of closest approach. This decrease in size combined with the strain equation ($\Delta L/L = \underline{\mathbb{V}} = \sqrt{\alpha}L_p/r$), permits an electron to appear to be a point particle in relativistic collisions.

Accelerating Charged Leptons: We will now return to the external volume discussion and focus on the electromagnetic properties, temporarily ignoring the gravitational effects. The external volume of a non-accelerating, isolated electron is a combination of standing waves at frequency ω_c with oscillating amplitude $A_e = \sqrt{\alpha}\ A_\beta/\mathcal{N}^2$ and a non-oscillating strain of spacetime with amplitude $A_\mathbb{E} = \sqrt{\alpha}\ A_\beta/\mathcal{N}$. Previously the electric field energy in a rotar's external volume was calculated at $E_{ext} = ½\ \alpha E_i$. To be precise, this is the limiting case of an isolated rotar that has not interacted with anything for an infinitely long time. In this idealized case a rotar's external volume has had sufficient time at speed of light communication to become fully established. In practice, the extent of a rotar's external volume (its undisturbed electric field) is limited by the length of time an isolated electron has remained undisturbed in a condition that does not radiate electromagnetic radiation.

Therefore what is commonly considered to be the electric field of a particle can be considered part of the rotar's external volume. However, in a larger sense both the electric "field" produced by the rotar and indeed the rotar itself are just strains in the sea of vacuum energy of spacetime. In chapter 4 it was said that there was only one truly fundamental field since all fields are just different distortions of vacuum energy/fluctuations. Keeping this in mind, we will use the term "electric field" to indicate the disturbance in vacuum energy that results in electromagnetism. The part of a rotar's external volume that produces the electromagnetic disturbance has speed of light communication back to the rotar's rotar volume. In chapter 9 a thought experiment involving the magnetic field of a star illustrated the fact that a magnetic field has the ability to exert a force before communication is established back to the source of the field (the star). Similarly, an electron's electric field (spacetime disturbance) can interact "before" communication is established back to the electron (frame of reference dependent).

There is an obvious objection to the concept that an electron's external volume can extend many meters from the rotar volume. This objection is that accelerating an electron would break contact (at speed of light) with a distant part of the external volume thereby abandoning a small part of an electron's structure and energy. However, rather than being a defect, this is actually a strength of this concept because it provides a mechanism for the emission of electromagnetic radiation (a photon with a quantized unit of angular momentum) when an electron is accelerated. The acceleration introduces a modulation *($\omega > 0$)* into what was previously a static strain *($\omega = 0$).* Also, a portion of the standing wave energy in the external volume loses contact when the rotar volume. The energy abandoned by the acceleration is converted to the energy of the photon that is formed when an electron is accelerated. The acceleration initially introduces a distortion into the waves of the rotar's external volume. This distortion both launches a photon and gives energy to reestablish the lost portion of the external volume. Chapter 11 will discuss freely propagating photons in more detail.

Another test of an electron's distributed energy is whether a test can be devised that distinguishes between the rotar model with its distributed energy and the currently accepted model of a charged point particle. It takes time to measure energy or inertia. The more accurate the measurement needs to be, the more time is required. This allows time for the energy in the external volume to communicate its presence at the speed of light and add to the total energy or inertia of the electron. It is possible to do a plausibility calculation to see if it would ever be possible to do an experiment that would give a different answer for the rotar model of an electron compared to a point particle model of an electron which has all of its energy localized but also experiences a retardation as part of the emission of a photon.

The energy in an electron's electric field external to radius r is: $E_{ext} = \alpha\hbar c/2r$. This is energy that is in the form of standing waves external to the electron's rotar volume. From the uncertainty principle $(\hbar/2 = \Delta E \Delta t)$, it is possible to calculate the integration time Δt that would be required to detect an energy uncertainty of $\Delta E = E_{ext}$.

$$E_{ext} = \frac{\alpha\hbar c}{2r} \qquad \text{set } \frac{\hbar}{2} = \Delta E \Delta t$$

$$E_{ext} = \left(\frac{\alpha c}{r}\right) \Delta E \Delta t \qquad \text{set } E_{ext} = \Delta E$$

$$\Delta t = \frac{r}{\alpha c} \approx 137\frac{r}{c}$$

Therefore, it would take an integration time 137 times longer than the time r/c to detect this energy discrepancy. However, this is 137 times longer than it takes for the discrepancy to be corrected to a degree that is undetectable. Therefore, a model of an electron with the proposed distribution of energy in the external volume is indistinguishable from a point particle.

Chaotic Waves: The transition from the rotar volume to the external volume of a rotar is actually ill defined because the rotar volume has a chaotic, probabilistic quality. The rotating dipole in spacetime is at the limit of causality. The rotar volume is attempting to radiate its full energy in a time of $1/\omega_c$. A fundamental amplitude of $A_f = \lambda\!\!\!^{-}_c/r$ is actually attempting to carrying away the full energy. It is only the return wave generated in vacuum energy that is somehow canceling this emission. However, the chaotic process at the limit of causality can reconstruct the rotar (reconstruct the quantized angular momentum) at a different location described by the uncertainty principle. Also a double slit experiment can interfere with the normal reconstruction and result in the rotar being reconstructed on the other side of the double slit. This will be discussed later.

The point is that all of the quantum mechanical properties which seem mysterious for a point particle become conceptually understandable if a particle is a vortex of quantized angular momentum in a sea of vacuum fluctuations.

We have previously discussed that all rotars must satisfy a soliton condition in spacetime. This means that the few fundamental particles that exist must exhibit a combination of characteristics that offset the tremendous emission of dipole waves in spacetime that leave the vicinity of the rotar volume. The few leptons and hadrons that exist somehow achieve a soliton condition where the emission is offset by the generation of waves in vacuum energy that effectively cancel the emission from the rotar's rotating dipole core.

Model of the External Volume: Figure 10-1 is a simplified representation of the standing dipole waves that surround a rotar. Recall that the rotar is attempting to radiate away its energy and emits dipole waves with frequency ω_c and amplitude $A_f = L_p/r$. The few rotars that are stable or semi-stable must form a resonance with the surrounding vacuum energy that eliminates the energy loss but leaves both standing waves and non-oscillating strains in spacetime as previously discussed. All the figures in this chapter deal with the standing waves associated with the oscillating part of the electric field. These standing waves have amplitude $A_e = L_p/\mathcal{N}^2$ and angular frequency ω_c. Figure 10-1 is the first in this series of figures and this figure has been greatly simplified compared to an actual rotar. The rotating dipole has been replaced by a simple monopole source of waves. In fact, we will use a monopole emitter for the first series of figures because the initial illustrations are easier to understand without the added complexity of a rotating dipole source. The figures will later be illustrated using a dipole source when this source becomes important to the illustration.

Initially we will imagine that figure 10-1 represents sound waves being emitted by a monopole emitter of sound waves at the center circle and being reflected by a spherical reflector outside of the area shown in the figure. The interaction between the emitted and reflected waves forms the standing waves depicted in figure 10-1 and subsequent figures. An acoustic monopole emitter can be thought of as a sphere that expands and contracts its radius at an acoustic frequency.

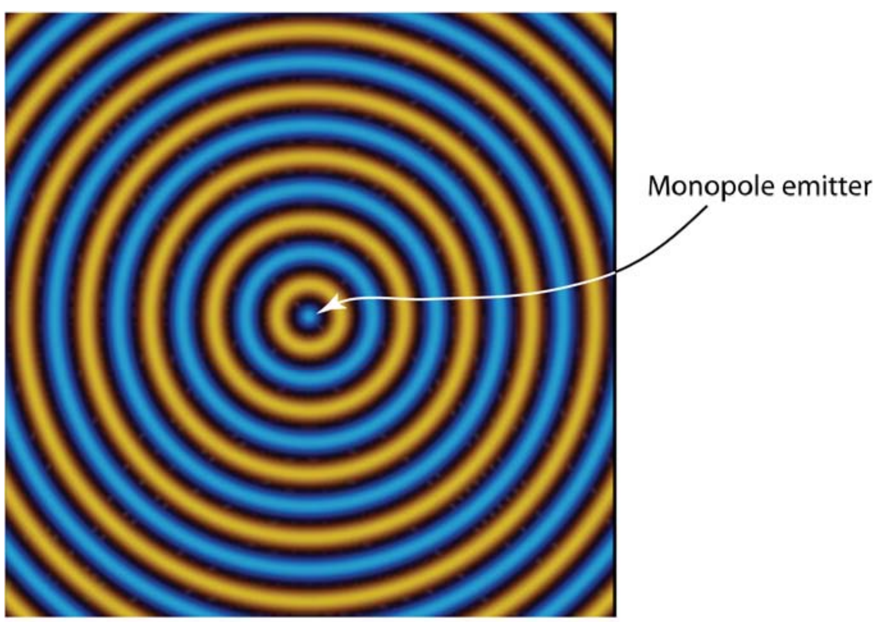

FIGURE 10-1 Monopole emission pattern

Figure 10-1 shows standing waves in an acoustic medium depicted at a moment in time. The blue regions can represent regions of maximum acoustic pressure and the yellow regions can represent regions of minimum acoustic pressure. A half cycle later the standing waves will reverse and regions that previously had maximum pressure will have minimum pressure. The black regions between the yellow and blue regions would be the wave nulls in this representation, but there is another way of depicting this standing sound wave.

The black regions have the maximum pressure gradient. This means that the black regions have the maximum kinetic energy of the acoustic medium. Therefore, there is another way of representing the standing acoustic wave where we emphasize the kinetic energy of molecules. In this type of representation the black regions would be depicted as regions of maximum kinetic energy, not the nulls shown above. In fact the energy in the standing acoustic wave is just being transferred between energy in compression/rarefaction and kinetic energy.

We will now switch to considering figure 10-1 as representing standing waves in spacetime. The vacuum fluctuations that form spacetime have a vastly larger energy density than the energy density of a rotar. As previously discussed, the pressure of vacuum energy is stabilizing the rotar and exerting the necessary pressure to confine the energy density of the rotar. Figure 10-1 represents a moment in time where the disturbance caused by the presence of the rotar results in standing waves in the surrounding vacuum energy. These standing waves fluctuate both the rate of time and proper volume. Regions of fast time are shown in blue and regions of slow time are shown in yellow. A half cycle later the fast and slow time regions will reverse. The black regions between yellow and blue have the maximum gradient in the rate of time. These regions are equivalent to the grav field previously explained. Just like the standing sound wave, there really are no nulls in the standing wave in spacetime. The regions of fluctuating rate of time have the same energy density as the regions of maximum grav field (maximum rate of time gradient). The total wave energy is constant $(sin^2\theta + cos^2\theta = 1)$.

Wavelets: All dipole waves in spacetime are proposed to have propagation characteristics that are similar to the Huygens Principle in optics. The Huygens principle assumes that every point on an advancing wavefront of an electromagnetic wave is the source of a new disturbance. The electromagnetic wave may be regarded as the sum of these secondary waves (called "wavelets"). Reflection, diffraction and refraction are explained by assuming that all parts of an electromagnetic wave are the source of these new wavelets. The surface that is tangent to any locus of constant phase of wavelets can be used to determine the future position of the wave.

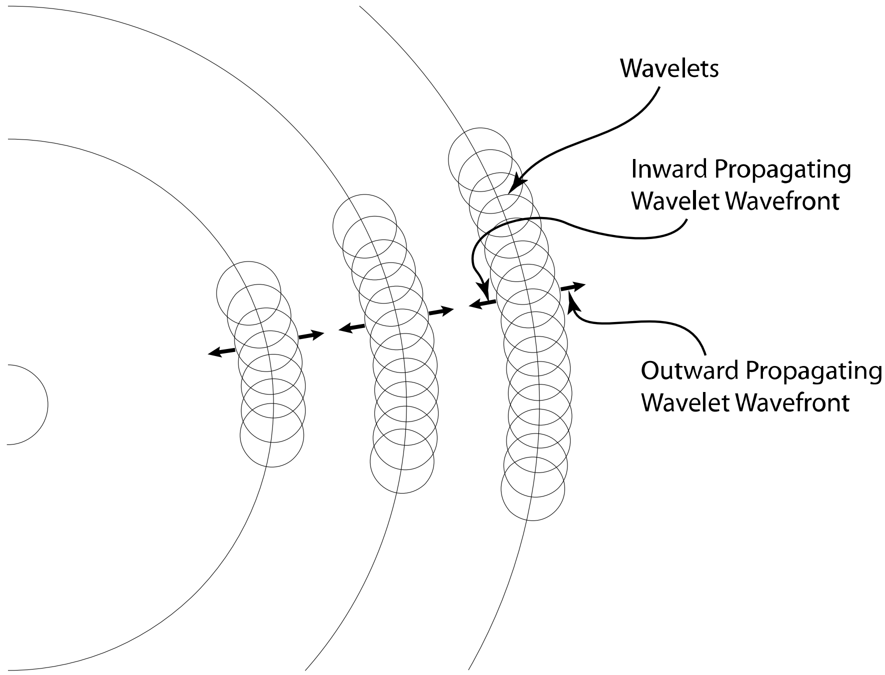

FIGURE 10-2 Simplified representation of waves propagating in spacetime. Each component becomes the source of a new wavelet.

As originally formulated by Christiaan Huygens, the Huygens Principle requires that the wavelets are hemispherical and only radiate into the forward hemispherical direction of the propagation vector. A modification of this was made by Gustav Kirchhoff where the wavelets emit into an amplitude distribution of $\cos^2(\theta/2)$. This distribution has maximum amplitude in the forward direction and zero amplitude in the reverse direction. The result is the classical Huygens-Fresnel-Kirchhoff principle that accurately describes diffraction, reflection and refraction. This will be discussed in more detail in chapter 11.

It is proposed that the few frequencies that form rotars interact with vacuum energy in a way that allows them to emit wavelets that propagate into a complete spherical pattern as shown in Figure 10-2. With this hypothesis the $\cos^2(\theta/2)$ amplitude distribution of the wavelets of light is not shared by the wavelets of vacuum energy that stabilizes rotars. The conditions that stabilize rotars require that both a forward propagating wave and an equal backwards propagating wave be formed in the external volume. This is accomplished if each wavelet propagates into a spherical disturbance pattern as shown in figure 10-2. These spherical wavelets add together to produce the next generation of dipole waves in spacetime. This results in wavefronts propagating in both the forward and backward radial directions. These new wavefronts are labeled inward propagating and outward propagating. In the tangential direction there is incoherent addition that produces cancellation. If the energy flow is equal in both directions, the result is standing waves in the external volume of a rotar. Standing waves are oscillating waves that have fixed regions of nodes and antinodes. They possess energy, but there is no continuous energy drain.

Path Integral: A key point here is that the wavelets of dipole waves in spacetime explore all possible paths between two points. Furthermore, the amplitude at any point is the coherent sum (amplitude and phase) of these waves. The intensity at any point is the square of the amplitude sum. This concept gives a physical interpretation to the path integral operation of quantum electrodynamics. It is a stretch to explain how point particles explore all possible paths between events, but waves in spacetime that form new wavelets intrinsically accomplish this task. Again, this proposed spacetime based explanation makes quantum mechanical operations conceptually understandable while the point particle model has numerous mysteries.

This explanation that involves backwards propagating waves sounds good, but there is a problem. If this was the only mechanism stabilizing a rotar, the residual standing waves would be much larger than the calculated amplitude of $A_e = \sqrt{\alpha}\ L_p/\mathcal{N}^2$ required for the standing wave part of the electric field. There appears to be an additional unknown mechanism generated in vacuum energy that forms a wave that provides additional cancelation. These standing waves remain even when the non-oscillating component of the electric field has been canceled. If others choose to model these standing waves, it should be noted that accurate modeling of the Huygens Principle in optics requires that the modeling must be done in three spatial dimensions[1]. If the Huygens's Principle is modeled in only 2 spatial dimensions, there is incomplete cancelation of waves that do not contribute to a wavefront.

de Broglie Waves: In chapter 1 it was shown that a laser contains light traveling in opposite directions. When the waves in this laser are observed from a stationary frame of reference, the bidirectional light forms standing waves. In other words, the standing waves are stationary relative to the laser mirrors. When the laser is translated relative to an observer, the standing light waves are still stationary relative to the moving mirrors, but the moving frame of reference means that the observer sees the light being Doppler shifted up in frequency in the direction of travel and being Doppler shifted down in frequency in the opposite direction. The superposition of these two Doppler shifted beams of light produces what appears to be a moving envelope of waves.

[1] http://www.mathpages.com/home/kmath242/kmath242.htm

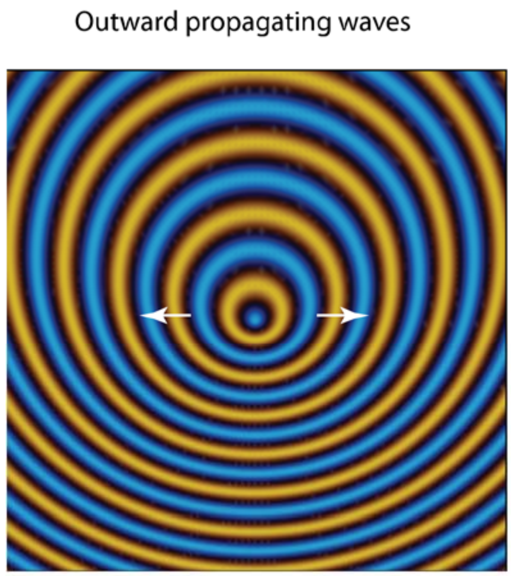

FIGURE 10-3 Doppler shift on outward propagating waves.

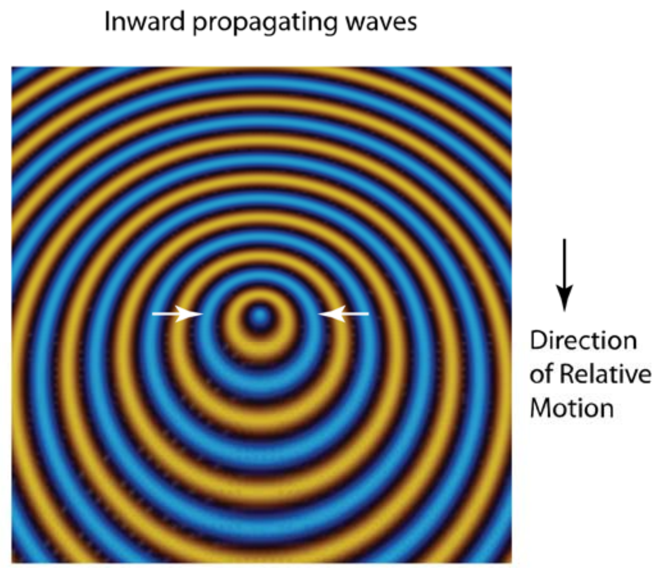

FIGURE 10-4 Doppler shift on inward propagating waves.

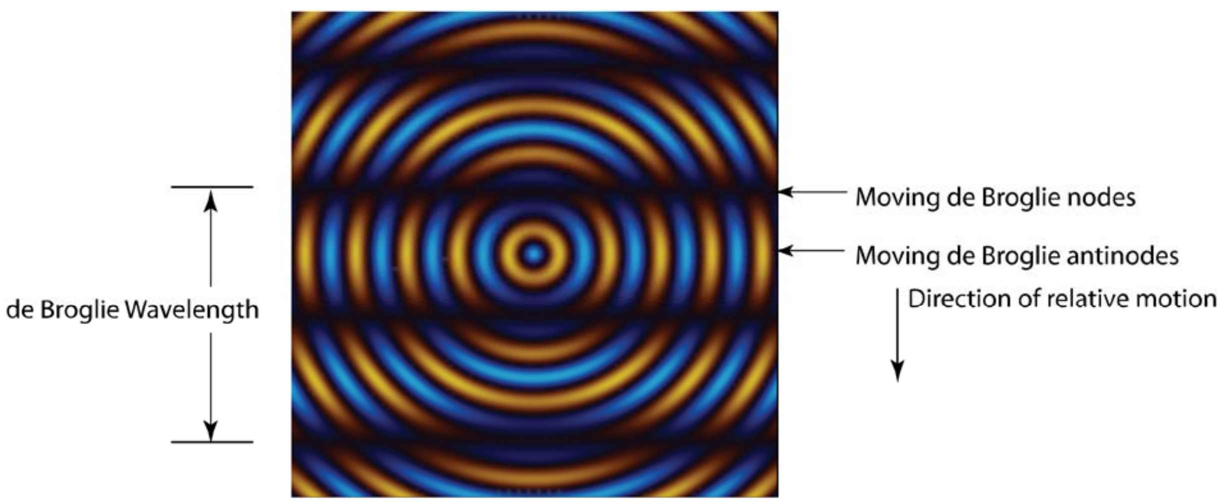

FIGURE 10-5 Linear de Broglei waves obtained from the translation of the rotar model (except monopole source)

Figure 1-1 shows the moving envelope of waves and moving laser mirrors. An analogy is proposed to be present when a rotar is observed in a moving frame of reference. It is desirable to examine the de Broglie waves of a rotar in greater detail. Figure 10-3 is similar to Figure 10 - 1, but there are two differences. First, Figure 10-3 shows waves propagating only away from the monopole source (arrows pointing away from the source). Second, Figure 10-3 shows the monopole source moving downward relative to the observer. The combination of these two factors produces the Doppler wave pattern shown. Figure 10-4 also has a downwards moving frame of reference, but the difference is that only waves propagating towards the source (inward propagation) are shown with arrows pointing towards the source.

The wavelets previously shown in figure 10-2 means that waves are simultaneously propagating both towards the source and away from the source. This means that a moving source will produce a wave pattern that is a superposition of figures 10-3 and 10-4. When we add these two patterns together we obtain the result shown in Figure 10-5. It is surprising to see that we obtain a linear wave pattern from the superposition of spherical waves in a moving frame of reference. These are the rotar's de Broglie waves. They have all the correct characteristics – correct de Broglie wavelength, correct de Broglie phase velocity and the correct de Broglie group velocity. Moving the rotar model produces the rotar equivalent of de Broglie waves.

This figure is not static. Not only is there translation relative to the observer, but the dark interference fringes are moving at a speed faster than the speed of light. For example, if the rotar model is moving at 1% of the speed of light relative to an observer, then the interference pattern is moving in the same direction as the relative motion, but at 100 times the speed of light $(w_d = c^2/v)$. Also notice that there is a phase shift going across the dark interference pattern. This is represented by a reversal of color following a wave across the dark de Broglie null.

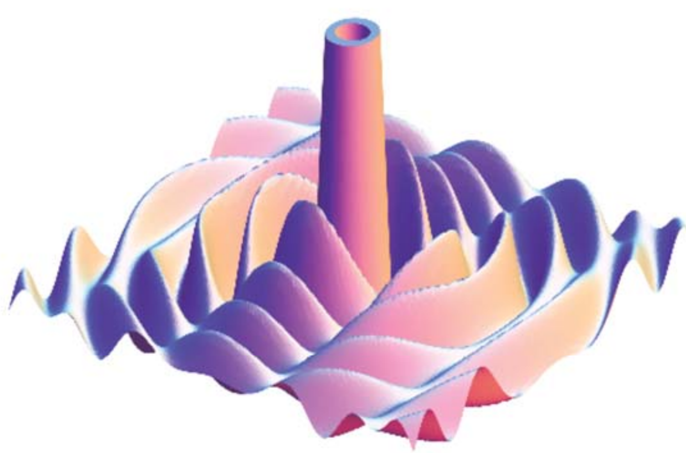

FIGURE 10-6 Three Dimensional Wave Plot Showing DeBrogle Waves and a Radial Amplitude Dependence

Figure 10-5 makes no attempt to show that the amplitude decreases with radial distance from the source. Figure 10-6 is a 3-dimensional graphical representation of Figure 10-5 with the added feature of a *1/r* amplitude dependence. The actual amplitude should fall off proportional to $1/r^2$, but this sharp decrease in amplitude makes it difficult to see the de Broglie modulation wave.

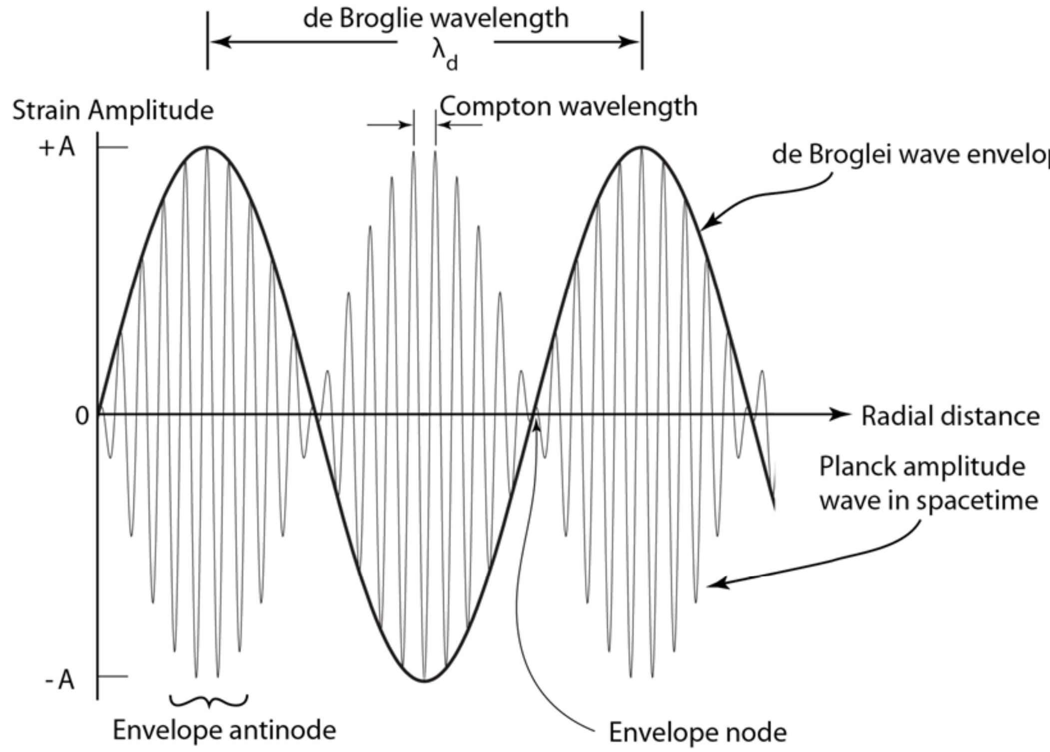

FIGURE 10-7 Graphical representation of a portion of the spacetime waves that form the external volume of a moving rotar.

Strain Amplitude Graph: It is easiest to explain the de Broglie modulation wave using Figure 10-7. This figure is a graph of the waves in figure 10-5 (radial cross-section). In figure 10-7, the high frequency waves are designated as "dipole waves in spacetime". When a rotar is stationary relative to the observer, then all the dipole waves in spacetime have equal amplitude. At this stationary condition the frequency of these waves is the rotar's Compton frequency (~ 10^{20} Hz for an electron) and the wavelength of these waves is the rotar's Compton wavelength λ_c. When the rotar is moving relative to the observer, then the rotar's de Broglie wave appears. This is just the modulation envelope that results from the different Doppler shift for waves propagating away from the rotar's rotar volume and towards the rotar volume.

Figure 10-7 shows a graphical representation of the rotar's de Broglie wavelength λ_d. This graph plots strain amplitude versus radial distance *r.* Only a short radial segment is shown. There should be a radial decrease in amplitude, but the short radial distance depicted does not show this decrease in amplitude. In the external volume of a rotar the fundamental traveling wave with amplitude L_p/r has been canceled leaving behind the standing wave responsible for the rotar's electric charge with amplitude of $A_e = \sqrt{\alpha}\, A_\beta/\mathcal{N}^2$. The nonlinear effect responsible for the oscillating portion of gravity is too small to be shown. Therefore, the Y axis of this graph is the strain amplitude A_e. The maximum value of A_e is the value given by the equation $A_e = \sqrt{\alpha}\, A_\beta/\mathcal{N}^2 = \sqrt{\alpha}\, L_p ƛ_c/r^2$.

To give an idea of scale, the approximate Compton wavelength λ_c is shown. An electron's Compton wavelength is about 2.43×10^{-12} m. The de Broglie wavelength λ_d depends on relative velocity (v) and is illustrated as being approximately 20 times longer than the Compton wavelength in this example. Therefore, the de Broglie wavelength would be approximately 5×10^{-11} m in this example. The Compton wavelength λ_c and the de Broglie wavelength λ_d are related as follows: $\lambda_c = (v/c)\lambda_d$ (approximation $v << c$). Therefore, this figure illustrates the de Broglie wave pattern if an electron is traveling at about 5% the speed of light ($\lambda_d \approx 20\lambda_c$ in this figure).

The Y axis of this graph is strain amplitude which can be expressed either as a spatial strain (meters/meter) or as a temporal strain (seconds/second). Both ways of expressing this give the same dimensionless number for a specific point in space and instant in time. Suppose our observation point at a particular instant is one micrometer (10^{-6} meters) from an electron that is moving past us at 5% the speed of light. We can then quantify the strain amplitude depicted in Figure 10-7. Using $A_e = \sqrt{\alpha}\, A_\beta/\mathcal{N}^2 = \sqrt{\alpha}\, L_p ƛ_c/r^2$ and substituting $r = 10^{-6}$ m and $ƛ_c = 3.86 \times 10^{-13}$ m for an electron, we obtain: $A_e = 5.3 \times 10^{-37}$. This is the maximum value of A_e above and below the zero strain line (the "x" axis).

It is possible to calculate the displacement of spacetime required to produce this amount of dimensionless strain. This strain exists over approximately one radian of the wave which is a distance equal to $ƛ_c$. For an electron $ƛ_c = 3.86 \times 10^{-13}$ m therefore $A_e \times ƛ_c \approx 2 \times 10^{-49}$ m. Therefore, the spatial displacement of spacetime (displacement amplitude) which causes the strain amplitude illustrated here is smaller than Planck length by a factor of about 10^{14}. If we would have chosen to work in the temporal domain we would obtain the same dimensionless strain which could be thought of as seconds/second. The temporal displacement amplitude causing this strain would then be $A_e/\omega_c \approx 6.8\times10^{-58}$ s. This is smaller than Planck time and the difference is again a factor of about 10^{14}.

Ψ Function: It is not obvious in figure 10-7 but there is a 180 degree (π radian) phase shift between each de Broglie lobe. Therefore one complete de Broglie wavelength includes two lobes as shown. This 180 degree phase shift between lobes is a fundamental property of standing waves viewed from a moving frame of reference. This phase shift gives rise to the de Broglie wave interpretation shown in figure 10-7. Perhaps most important, **the wave designated de Broglie wave envelope is really the moving rotar's Ψ function.** It is sometimes said that the Ψ function has no physical interpretation. However, figure 10-7 is the proposed physical interpretation of the quantum mechanical Ψ function. This is another example of how the proposed spacetime based model makes quantum mechanical mysteries conceptually understandable.

Relativistic Contraction: Above it was stated that λ_c illustrated in figure 10-7 is "approximately" equal to the rotar's Compton wavelength. The reason that this is not exact is that this figure depicts a moving rotar and there is relativistic length contraction in the Compton wavelength. If the rotar was stationary, there would be no de Broglie wave modulation envelope and the dipole waves would be exactly equal to the Compton wavelength.

The reason for bringing up this point is that it is possible to see the physical cause of relativistic length contraction when there is relative motion. A moving rotar has waves that are Doppler shifter up in frequency and Doppler shifted down in frequency as previously explained. When these Doppler shifted waves are combined, the resultant wave has a shorter wavelength than the original wavelength without Doppler shifts. This was proven mathematically in Appendix A at the end of chapter 1. This analysis applies equally to standing waves in a moving laser cavity or to standing waves in the external volume of a rotar. The combination of the two Doppler shifts in the two oppositely propagating waves produces a net decrease in the Compton wavelength by a factor of: $\sqrt{1 - v^2/c^2}$. This is proposed to be the source of relativistic contraction. A moving meter stick will appear to decrease in length because all the waves that make up the meter stick decrease their wavelength because of this effect.

Rotating Dipole Model: We will now attempt to give a crude model of the standing waves present in the external volume of rotating spacetime dipoles. An accurate model of this requires high level computer modeling. It involves modeling a large number of wavelets that are added together and then become the source of new wavelets that form the next generation. This process is repeated a large number of times. This task is beyond the scope of this book. Furthermore, the simplest modeling would probably make no distinction between the infinite number of frequencies that do not form stable rotars and the few frequencies with the unusual characteristics that combine to form stable rotars. Also, how do we handle the chaotic spin distribution characteristics of spin ½ particles? The following modeling is a best guess model of the external volume of an electron. This can then serve as a starting point for others that can improve on this model.

Before attempting to model the external volume of rotars, it is desirable to first describe the chaotic spin properties exhibited by isolated rotars. Because a rotar is at the limit of causality, it should not be a surprise that a rotar has probabilistic characteristics. The displacement of spacetime is so small that dipole waves in spacetime do not violate the conservation of momentum. Recall the examples given previously comparing the minute volume and rate of time changes required to form an electron's spacetime dipole. (expanding the radius of Jupiter's orbit by a hydrogen atom or slowing the rate of time by several microseconds over the age of the universe.)

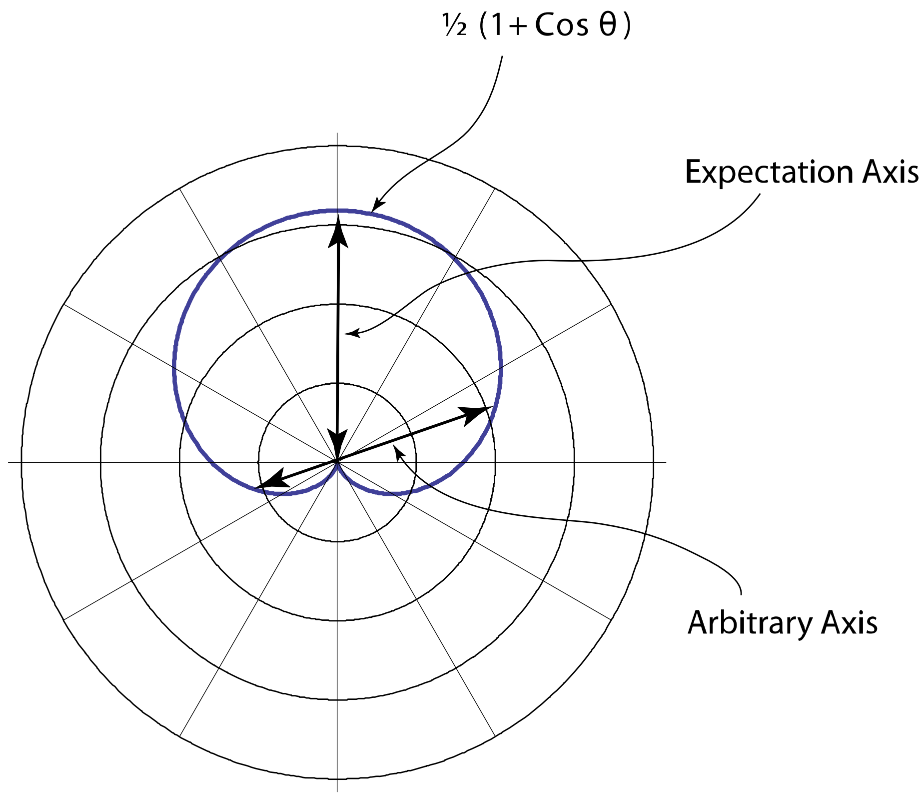

FIGURE 10-8 Probability of Spin Direction

Figure 10-8 shows a plot in spherical coordinates of the probability of spin being oriented in the direction θ. This spin direction probability is proportional to $\cos^2(\theta/2)$. Suppose that we concentrate not on the spin direction, but on the axis of spin. Figure 10-8 specifies the expectation axis and an arbitrary axis. The point of this is to show that a rotar can have a spherical distribution averaged over time even though the rotar has an expectation spin direction. The rotating dipole shown in figure 5-1 would not have a spherical distribution if the axis of rotation were fixed. However, figure 10-8 shows that the probability of spin direction is such that all axis orientations are equally probable. In other words, the expectation axis shown in figure 10-8 is the same length as the arbitrary axis when opposite spin probabilities are added together. If we consider the length of the spin axis probability as ζ, then we have:

$$\zeta = \cos^2(\theta/2) + \cos^2[(\theta + \pi)/2] = \cos^2(\theta/2) + \sin^2(\theta/2) = 1$$

With this being said, we will simplify the modeling by looking at the equatorial plane of the expectation rotation axis. For example, the expectation axis can be set by placing an electron in a magnetic field. This is the simplest to model and one step better than assuming a monopole emitter.

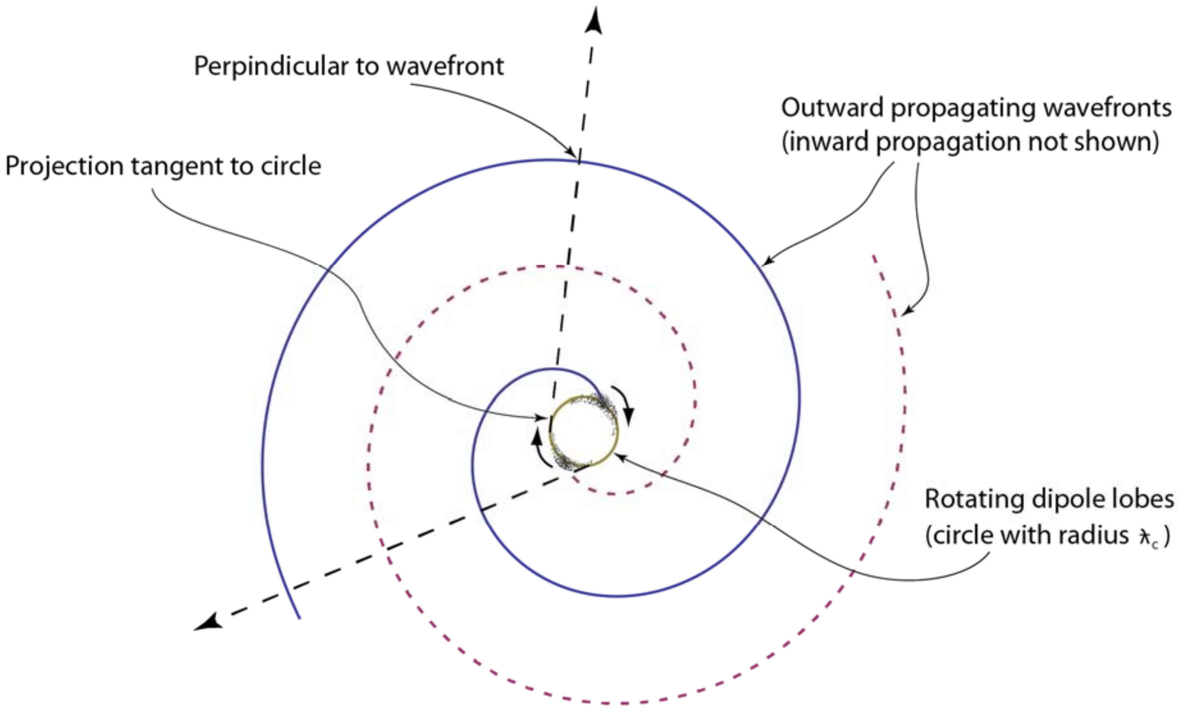

FIGURE 10-9 Rotating dipole and Archimedes Spiral dipole wave

Figure 10-9 shows a rotating dipole designated "rotating dipole lobes". The two lobes depicted represent the two dipole lobes discussed and depicted in chapter 5. When the lobes move around the imaginary circle at the speed of light, any disturbance propagates away from these lobes at the speed of light and forms the outward propagating Archimedes spirals shown. This simplified description does ignore the fact that every part of the wave forms new wavelets, but we will proceed with this description and attempt to include wavelets later.

For discussion, we will initially assume that the solid lines represent regions where the rate of time is faster than normal and the dashed lines represent regions where the rate of time is slower than normal. Since the rate of time affects all 3 spatial directions equally, these waves are neither longitudinal nor transverse. They are simply time waves. Besides affecting the rate of time, these waves also represent a spatial distortion.

So far, we have ignored the fact that the model calls for every point on the wavefront to be the source of a new wavelet. An extremely simplified model takes the outgoing wave pattern shown in figure 10-9 and generate the backwards propagating waves by assuming that the outward propagating waves are reflected off a concentric spherical reflector. These reflected waves then propagate back towards the rotating dipole. This makes another pair of Archimedes spirals that in a static image are the mirror image of figure 10-9. They have the same rotational direction when viewed from the perspective of figure 10-9, but they are propagating inward.

When the outgoing waves and incoming waves are added together we obtain an interference pattern shown in Figure 10-10. This is a cross-section view of the equatorial plane of the external volume of a rotar. This also depicts an instant in time. The actual pattern is rotating at the same rate as the rotating dipole (the Compton frequency). For an electron, this image would rotate about 1.24×10^{20} revolutions per second. This is currently the best representation of an isolated rotar such as an isolated electron. We are assuming a stationary frame of reference for Figure 10-10 (no de Broglie waves superimposed). Note that there is a 180 degree phase change at the destructive interference bar (black bar) that goes across the center of this figure. This phase change can be seen because there is a reversal of color (yellow to blue or blue to yellow) at this region of destructive interference.

Even though this figure was made using some questionable simplifications, it is a reasonable first attempt. The amplitude of the waves should drop off with a $1/r^2$ decrease in amplitude from the center. For illustration purposes, this figure depicts uniform radial wave amplitude. The reader should mentally adjust for the radial decrease in amplitude.

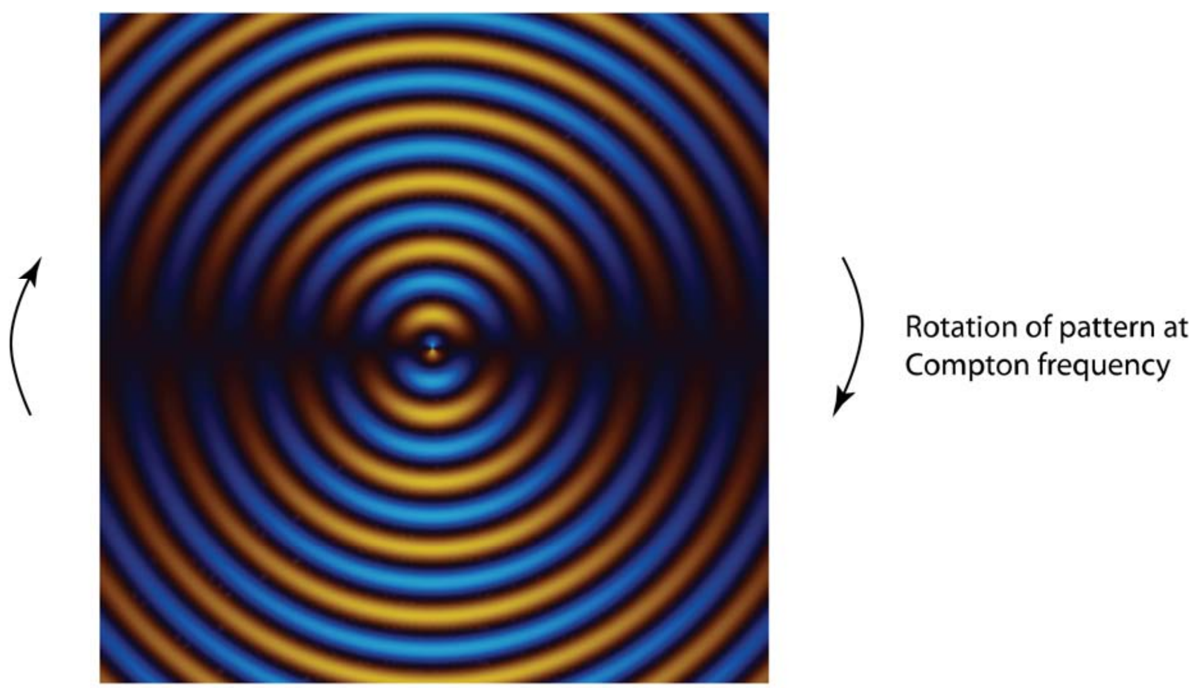

FIGURE 10-10 Interference pattern obtained by adding outward and inward propagating Archimedes spiral waves. (stationary frame of reference)

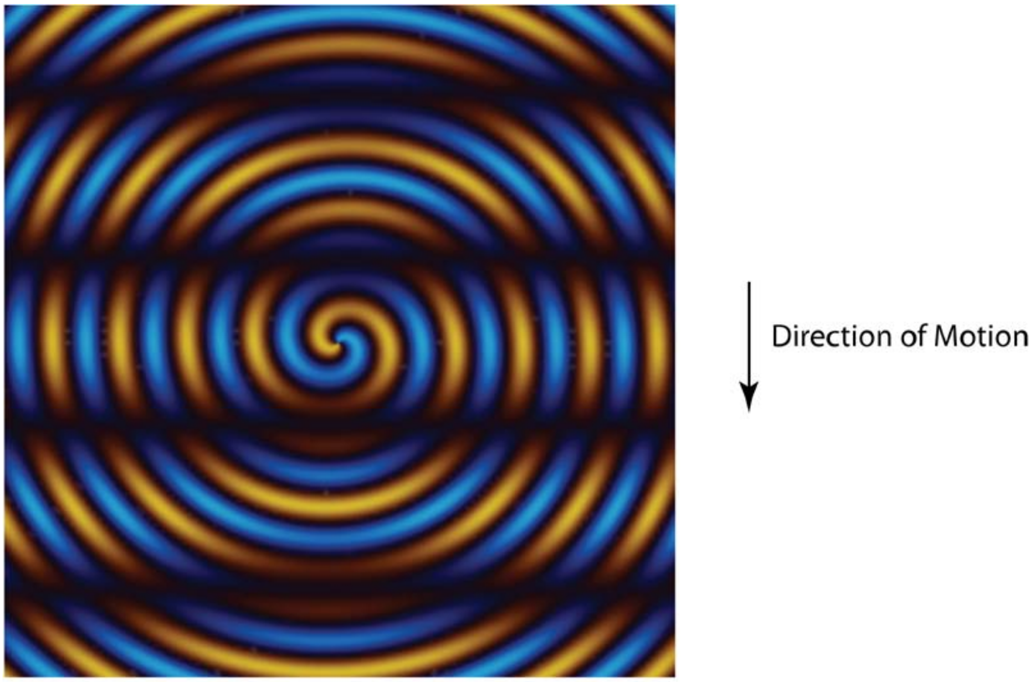

FIGURE 10-11 Interference pattern obtained by viewing Fig 10-10 from moving frame of reference

Conservation of Angular Momentum: Figure 10-10 looks similar to a rotating disk, but this is the wrong interpretation. There is no violation of the conservation of angular momentum as this pattern enlarges. This is best explained by returning to figure 10-9. We will assume that all of the energy and angular momentum starts off in the region designated "rotating dipole lobes". If some energy leaves this region, its outward propagation follows the Archimedes spiral pattern shown in figure 10-9. This is the pattern that maintains constant total angular momentum.

Proving this statement would represent a substantial diversion, but one brief point supports this contention. Figure 10-9 shows an arrow drawn perpendicular to the Archimedes spiral in the far field of the spiral pattern. In the limit of the far field the projection of this perpendicular line back towards the center results in the projected line being tangent to the imaginary circle with radius of λ_c. This implies a conservation of the angular momentum for energy that leaves this circle. The pattern shown in figure 10-10 is a super position of two Archimedes spiral patterns, both of which can be shown to individually exhibit conservation of angular momentum. The rotating pattern in figure 10-10 has a tangential speed faster than the speed of light for any radial distance greater than $r = \lambda_c$. This is permitted because this is just an interference effect that can move faster than the speed of light.

In Figure 10-11 we are looking at this same pattern of figure 10-10 from a moving frame of reference. To obtain this picture we added together the Doppler shifter outgoing and incoming wave patterns. This is similar to adding together Figures 10-3 and 10-4 to get figure 10-5. To obtain figure 10-11 we added together Doppler shifted outgoing and incoming Archimedes spirals rather than the concentric circles. Like figure 10-5, Figure 10-11 is a snap-shot of a moving interference pattern. The interference pattern would be moving faster than the speed of light as previously explained for Figure 10-5. In fact, the de Broglie wavelength and translation speed is the same whether we model a monopole source or a dipole source provided that we assume the same Compton frequency.

Figure 10-11 is actually a large spiral pattern, but the spiral characteristic is only obvious near the center of the figure. The exact center of figure 10-11 that is the initiation of the spiral is not an accurate illustration of the pattern that would be produced by a rotar. Figure 10-9 illustrates that the spiral does not extend to the exact center. Instead, there is a transition to the rotar volume that is represented by a circle with radius $\lambda\!\!\!^{-}_c$. Figure 10-11 was drawn with the two spirals (inward and outward propagating) extending all the way to the center. Therefore, a more realistic version of figure 10-11 would have a transition to black over the center ~ $1/\pi$ wavelength.

Compton Scattering: In 1905 Albert Einstein's published a paper on the photoelectric effect. This paper suggested that light exhibits particle-like properties. At the time light was considered to be only a wave phenomenon. In the early 1920's, the particle-like properties of light was still being debated. However, debate effectively ended with the observation by Arthur Compton of the scattering of x-ray photons by electrons (called Compton scattering). The scattered x-ray photons exhibit a decrease in frequency that is a function of scattering angle. The individual electrons also exhibit recoil when they scatter an x-ray photon. The decrease in the frequency of the scattered photon corresponds to the energy transferred to the recoiling electron. A simple Doppler shift of waves reflecting off the moving electron does not correspond to the correct frequency shift. All of this is perfectly explained by the model that assumes that photons are particles with energy that is a function of frequency. When a photon (point particle) collides with an electron (point particle) there is momentum transfer and energy transfer between these particles. The interaction is nicely described by Compton's equations and he received the 1927 Nobel Prize in physics for this work.

The physics community has universally adopted the wave-particle photon model. Photons clearly have wave properties, but Compton scattering, the photoelectric effect and other experiments also seem to require a particle explanation. The wave-particle description of both photons and particles works well, but the conceptual understanding of this has puzzled generations of physics students.

Schrodinger Article on the Compton Effect: Since this book proposes that fundamental particles are dipole waves in spacetime, it would be helpful to support this contention by offering a plausible explanation for Compton scattering using the proposed spacetime based model of both electrons and photons. As I was working on this explanation, I assumed that no one had been successful in proposing a purely wave based explanation for Compton scattering. To my surprise, I discovered that in 1927 Erwin Schrodinger had published a technical paper titled "The Compton Effect"[2]. This article is available in Schrodinger's book "Wave Mechanics" which has had multiple editions in English. Schrodinger did not conceive of waves in spacetime or a rotar model, but he did propose a plausible wave explanation for Compton scattering. His proposed explanation involved an electron's de Broglie waves interacting with light waves to produce the correct scatter characteristics for both the light and the electron. In this article, Schrodinger used some antiquated terminology such as the phrase "an aether wave" to describe light, but his point is valid. A brief description of his concept will be given here.

Schrodinger looked at the collision as if it was a continuous process. In this case four waves are present and continuously interacting. These four waves are 1) the electron's de Broglie wave before the interaction 2) the electron's de Broglie wave after the interaction 3) the light wave before the interaction and 4) the light wave after the interaction. Schrodinger found that the two superimposed de Broglie waves combined to make a wave that he called a "wave of electrical density". This combined wave had the perfect periodicity to reflect the incident light beam and create a reflected beam with the correct frequency shift and scatter angle. The two superimposed light waves (incident and scattered) produce an interference pattern that matches the interference pattern produced by the two superimposed de Broglie waves.

Schrodinger made an analogy between Compton scattering and light interacting with sound waves (Brillouin scattering). Sound waves produce a periodic change in the index of refraction of an acoustic medium. Light waves propagating in an acoustic medium can reflect off the sound wave which produces periodic changes in the index of refraction. The maximum reflection is obtained if the following equation is satisfied: $\lambda \approx 2\Lambda \sin \theta$

Where: $\lambda =$ light wavelength, $\Lambda =$ acoustic wavelength and $\theta =$ the angle between the light propagation direction and a plane parallel to the acoustic waves.

This equation would be exact if the acoustic wave was stationary. Since the acoustic wave has a speed much less than the speed of light, the condition of a stationary acoustic wave is approximately met. However, relativistic corrections would be required if the sound wave propagated at a significant fraction of the speed of light. The equation corresponds to the Bragg law (first order) and becomes exact when the acoustic waves are stationary. When the acoustic speed of sound is taken into consideration, then it appears as if the light waves are reflecting off a moving multi layer dielectric mirror. There is a frequency shift in the reflected light and the angle of incidence does not equal the angle of reflection because the mirror is moving.

Schrodinger considered the superposition of the two sets of an electron's de Broglie waves (before and after the interaction) to result in a "wave of electrical density" that could interact with light. Here are Schrodinger's translated words:

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[2] Annalen der Physik (4), vol 82

"According to the hypothesis of wave mechanics, which up to now has proven trustworthy, it is not the ψ-function itself, but the square of the absolute value that is given a physical meaning, namely, density of electricity. A single ψ-wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,… we see that a 'wave of electrical density' arises from the combination…"

Now it is this density wave that takes the place of the sound wave of Brillouin's paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg's law) then we shall show that our four waves (two ψ-waves and the incident and reflected light waves) stand exactly in the Compton relationship….

As all the four waves are invariant with respect to Lorentz transformation, we can bring the density wave to rest by means of such a transformation…. Bragg's relationship holds exactly if λ denotes the wavelength of the light wave, Λ that of the density wave and θ the glancing angle. It can be put in the form: $2h\lambda/\sin\theta = h/\Lambda$"

Vector Diagrams: I will elaborate on Schrodinger's point that it is possible to bring the two interacting de Broglie waves into a stationary frame of reference by a Lorentz transformation. Normally Compton scattering involves an incident photon striking a stationary electron. The momentum transfer produces a recoiling (moving) electron and reduces the energy of the scattered photon compared to the incident photon.

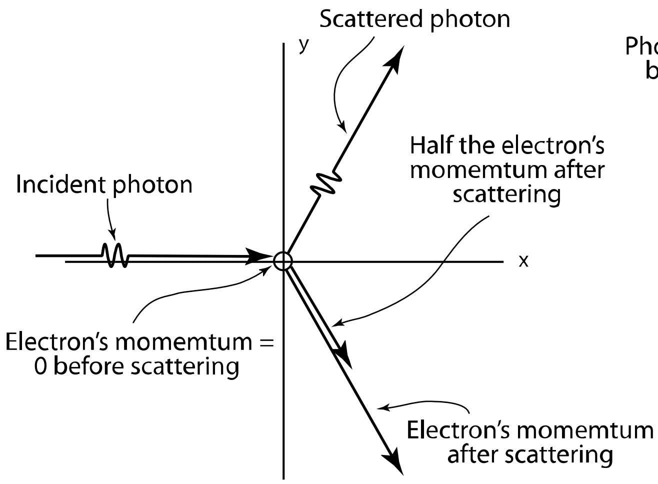

FIGURE 10-12 Compton scattering vector diagram (stationary electron before scattering)

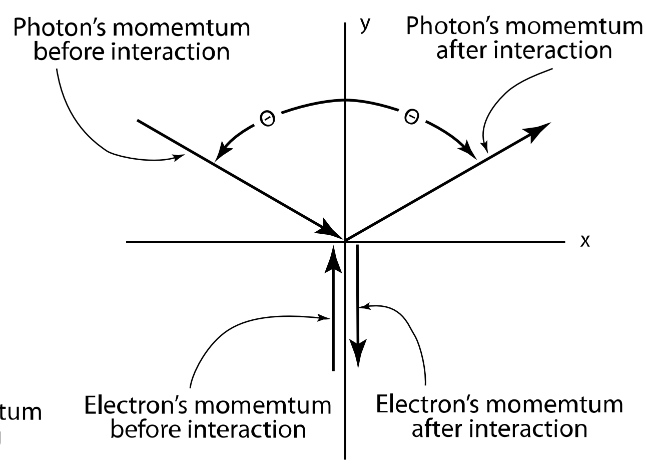

FIGURE 10-13 Compton scattering vector diagram in the frame of reference that gives zero energy transfer (moving electron before scattering)

Figure 10-12 shows a vector diagram that depicts this normal Compton scattering condition. This diagram shows the momentum vector of both the incident and the scattered photons. It also shows the electrons momentum vector after the Compton scattering. All of these are commonly included in Compton scattering diagrams, but figure 10-12 includes two additional features. First, the electron's momentum before scattering is designated (momentum = 0). Secondly, there is a momentum vector designated "half the electron's momentum after scattering". This vector should be superimposed on the parallel vector but it has been displaced slightly for clarity.

The reason for the additional designations of the electron's momentum before scattering and half the electron's momentum after scattering is that these designations will help explain the frame of reference used for Figure 10-13. In figure 10-13, we adopt a frame of reference that is required to have the electron moving with the opposite momentum as the vector designated "half the electron's momentum after scattering". If the scattered electron's velocity is non relativistic, then the moving frame of reference is simply half the scattered electron's speed and the opposite vector direction as shown in figure 10-13. In this frame of reference, the electron is moving at velocity +v before scattering and is moving at velocity –v after the scattering (the same speed but opposite direction). This is the frame of reference described by Schrodinger as the Lorentz transformation that "brings the density wave to rest". The superposition of the electron's de Broglie waves before and after the interaction results in a stationary (but oscillating) de Broglie wave pattern.

It is very easy to analyze Compton scattering from this frame of reference. There is momentum transfer between the photon and the electron, but there is no energy transferred. In this zero energy transfer frame of reference, the electron momentum moving towards the origin (before scattering the photon) is the same magnitude but opposite direction as the electron momentum moving away from the origin (after scattering the photon). The reversal in direction is the momentum transferred to the photon. The superposition of the two sets of the electron's de Broglie waves produces a stationary standing wave pattern (density wave) with periodicity of $\Lambda_d = \hbar/mv$. This stationary wave pattern effectively reflects a photon without any change in frequency. Also, the angle of incidence equals the angle of reflection – just like reflection from a stationary mirror.

All Compton scattering events involving an initially stationary electron can be looked at as a special case of the zero energy transfer Compton scattering where the frame of reference has been adjusted (Lorentz transformation) so that the electron is initially stationary. Once we understand a scattering event in this simplest frame of reference, we can easily switch back to the commonly used frame of reference depicted in figure 10-12. The frequency shift and angle change is simply the result of reflecting off a moving multi-layer dielectric mirror.

Figure 10-5 shows a rotar model in a moving frame of reference. This figure depicts an instant in time. The large black horizontal fringes are moving in the direction of translation at a velocity of $w_d = c^2/v$. This says that the interference fringes are always moving faster than the speed of light. When we superimpose two rotar models moving at the same speed but in opposite directions, we again obtain an instantaneous picture similar to figure 10-5. However, the superposition of opposite moving waves results in the de Broglie waves becoming stationary. This can be visualized as the high frequency waves (yellow and blue waves) in figure 10-5 being standing waves which are oscillating at a frequency of approximately 10^{20} Hz.

ψ Function: The envelope of these waves is a wave that is proposed to be Schrodinger's ψ function. Squaring this gives the probability of finding the electron in areas of greatest oscillation amplitude. Schrodinger calls these areas of greatest oscillation "waves of electrical density". Since these waves are proposed to be dipole waves in spacetime oscillating at the electron's Compton frequency, it is easy to see why the square of these waves represents the probability of "finding" an electron.

Schrodinger argues that when light interacts with stationary ψ-waves (de Broglie waves) they represent the equivalent of a density variation that can reflect light. Once again, his translated words are:

> "A single ψ-wave therefore produces a density distribution which is constant in both space and time. If however, we superimpose two such waves,… we see that a 'wave of electrical density' arises from the combination…"
>
> Now it is this density wave that takes the place of the sound wave of Brillouin's paper. If we assume that a light wave is reflected from it as from a moving mirror, (subject to the fulfillment of Bragg's law) then we shall show that our four waves (two ψ-waves and the incident and reflected light waves) stand exactly in the Compton relationship."

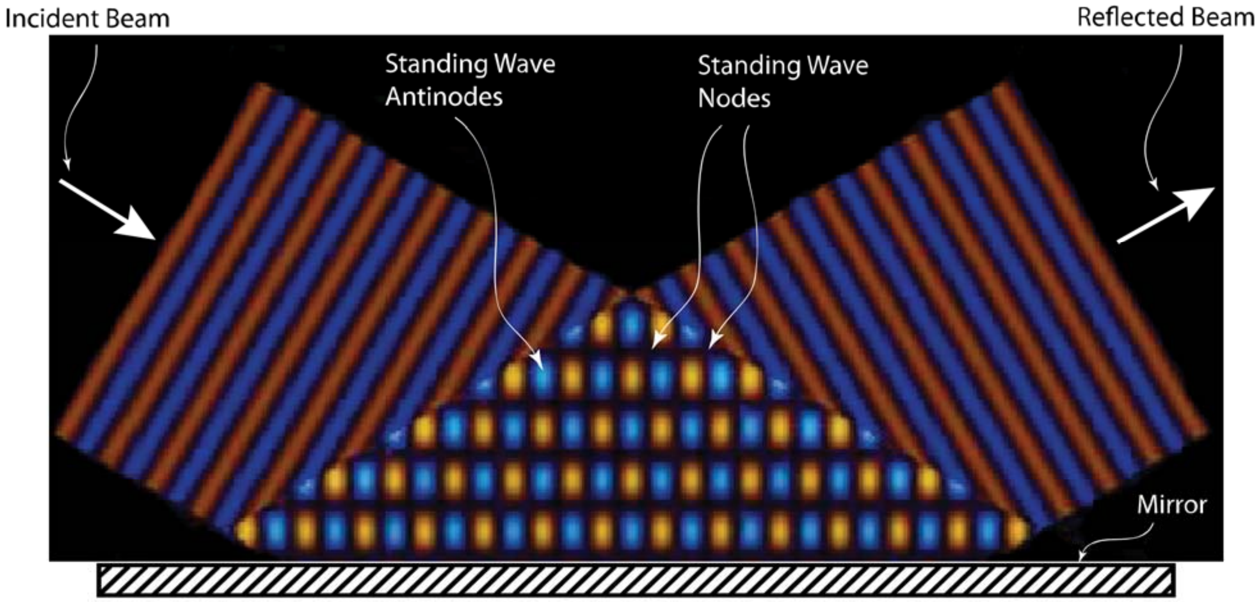

FIGURE 10-14 Standing wave pattern produced by the reflection of a beam of light off a mirror

More will be said about the physical explanation of the Ψ function in chapter 12. For now we will attempt to illustrate Schrodinger's idea of Compton scattering with the next two figures. Figure 10-14 sets the stage by illustrating the wave properties of light reflecting off a mirror (frozen in time). The beam of waves enters from the left, reflects off the mirror and leaves to the right. The area of overlap between the incident and reflected beams is the area where a standing wave pattern is created. This standing wave pattern has standing wave nulls which in this figure are horizontal bands parallel to the mirror surface where there is no electric field oscillation. The antinode bands are also illustrated and these are regions of maximum electric field oscillation. For example, if the light wave is linearly polarized with the electric field vector oscillating perpendicular to the plane of the illustration, then the blue regions might be considered regions where the electric field momentarily is pointing towards the reader and the yellow regions might be considered regions where the electric field vector is momentarily pointing away from the reader. If time was allowed to progress forward, these blue and yellow regions in the standing wave would move from left to right. The node planes would remain unchanged.

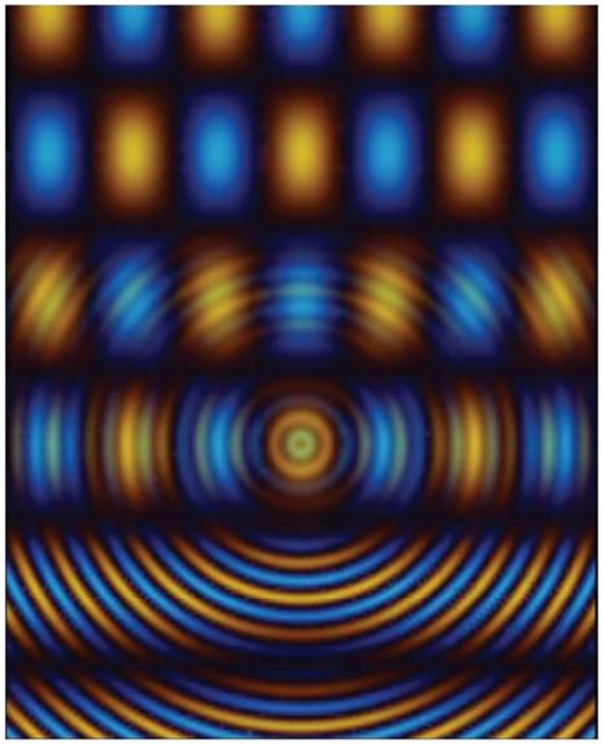

FIGURE 10-15 The superposition of 4 wave patterns produce this representation of Compton scattering. These 4 wave patterns are: 1) the incident light, 2) the scattered light, 3) the electron wave pattern before interaction, 4) the electron wave pattern after interaction.

Now figure 10-15 represents the combination of figures 10-14 and 10-5. In this case only the standing wave portion of figure 10-14 is illustrated, so the reader must imagine that the incident beam is coming in from the upper left and the reflected beam is leaving to the upper right. Also the lower portion of figure 10-15 represents the superposition of an electron before and after the scattering. We are using the zero energy transfer frame of reference, so the de Broglie wave pattern would appear stationary. The conditions that produce Compton scattering result in a perfect match between the spacing of the standing wave antinodes of the light beam and the standing wave antinodes of the electron. It is as if the light beam is reflecting off a multi layer dielectric reflector.

If we moved to a different frame of reference where we would perceive some energy transfer between the light and the electron, then the angle of incidence would not equal the angle of reflection and the wavelength of the reflected beam would be different than the wavelength of the incident beam. In the above description, some artistic license has been taken both in the illustration and the choice of words. We should really be talking about the scatter of a single photon from a single electron. The wave amplitude should not be uniform and numerous other corrections.

This spacetime wave explanation of Compton scattering is proposed to actually be <u>better</u> than the particle based explanation because several quantum mechanical mysteries are also explained by the spacetime wave explanation. For example, the spacetime wave explanation has the wave model of an electron going from its initial velocity to its final velocity without accelerating through all the intermediate velocities. An explanation of Compton scattering involving the standard point particle model of an electron would seem to imply that the electron undergoes acceleration as it transitions through intermediate velocities. This concept of intermediate velocities is not consistent with the quantum mechanical description.

Also, Schrodinger indicated that his ψ function had no physical meaning; it only gained physical meaning when it was squared to give the probability of finding a particle. I have given a proposed physical meaning to the ψ function. It is the wave envelope shown in figure 10-7 and depicted in figure 10-5. The envelope (ψ function) is undetectable because it is an interference effect with nodes and antinodes of dipole waves in spacetime with an interference pattern that propagates faster than the speed of light. Only when there is an interaction between two such envelopes of waves does the propagation slow down to a speed less than the speed of light (as depicted in figure 10-15). Squaring this then gives the probability of "finding the particle".

Plausibility, Not Proof: To successfully complete this Compton scattering analysis, it would be necessary to show that this superposition of the electron's waves in spacetime (two different velocities) produces a periodic change in the proper speed of light. Furthermore, it would also be necessary to characterize a photon using waves in spacetime and show that the combination of these models produces the correct scatter probability.

While I have proposed explanations that contain the elements required in this explanation, I cannot conclusively show that the effects on the speed of light are sufficient to accomplish Compton scattering. It is hoped that others might be able to complete this task. Schrodinger has shown that a wave explanation of Compton scattering is plausible. I show that the rotar model in a moving frame of reference is plausibly equivalent to Schrodinger's ψ-function waves. Therefore, this will be declared a successful plausibility test even though it is a long way from being conclusively proven.

Double Slit Experiment: Another plausibility test of the rotar model is to see if this model produces a diffraction pattern characteristic of sending an electron (or other particle) through a double slit. The diffraction pattern produced by sending a stream of electrons through a double slit has long been offered as proof that an electron exhibits wave-particle duality. Even before working on the ideas expressed in this book, I always found the implications of the double slit diffraction experiment to be a problem for the wave-particle duality "explanation". If an electron is also a point particle, then the point particle must have passed through only one of the two slits. Even if some wave properties of the particle explored the other slit, it seems as if the diffraction pattern should imply an unequal illumination of the two slits. A large inequality of illumination should greatly reduce the visibility of the diffraction nulls. Instead, the diffraction pattern produced by electrons implies that the electron possesses only wave properties as it passes through both slits equally and simultaneously. I find it far easier to conceptually understand how the rotar model of an electron can possess particle-like properties than understand the contradictions of wave-particle duality. Imagine an electron as a unit of quantized angular momentum with a specific rotational frequency existing in a sea of vacuum energy. With this model it is possible to see how this quantized angular momentum could possibly reassemble itself on the other side of a double slit. It would have passed through both slits and would exhibit the double slit diffraction pattern.

The following explanation will continue to use an electron as an example, but this also applies to composite particles such as neutrons or molecules. The reasoning about neutrons and other composite particles will be discussed later in the chapter about hadrons.

The diffraction pattern produced by light of wavelength λ passing through a single slit of width d_1 produces a well-known single slit diffraction pattern. The single slit intensity profile can be calculated from the Fraunhofer diffraction integral. In general, the double slit diffraction pattern can be thought of as a superposition of the single slit diffraction pattern on the diffraction pattern for two coherent narrow $(< \lambda)$ line sources of light separated by the double slit separation distance d_2.

Here we are only going to do a greatly simplified version that can illustrate some interpretations of the wave patterns that will be obtained in a double slit simulation. In this simplification, we start with the model of a moving rotar such as shown in figure 10-5. Symmetrical portions of the external volume of a rotar are presumed to pass through both slits symmetrically and become two new sources of waves. For simplification the emission pattern from each slit is spherical. An actual slit width would introduce an additional intensity distribution superimposed on this spherical emission pattern. The key difference between this model and a standard double slit experiment with light is that the waves emanating from both slits in this model have the bidirectional propagation characteristics (de Broglie waves) of a moving rotar. This means that we are interfering 4 sets of waves (2 counter propagating waves from each slit).

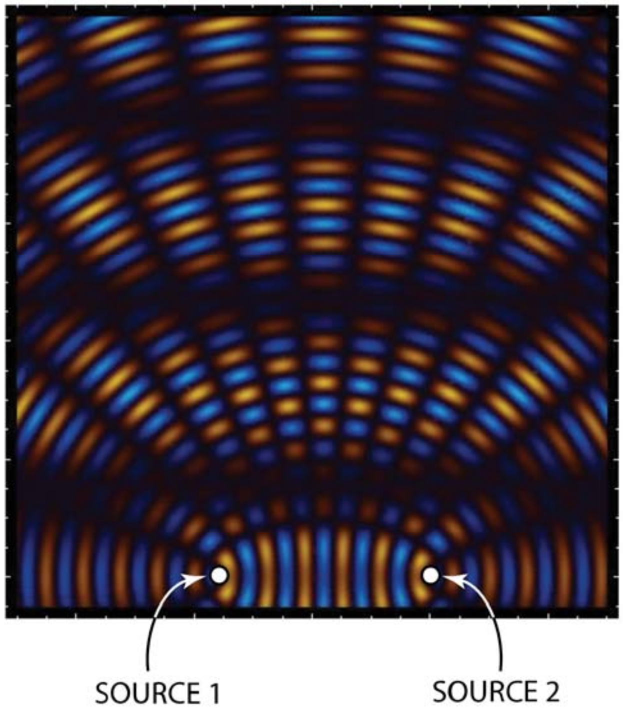

FIGURE 10-16 Illustration used to explain effects produced when a rotar encounters a double slit

Figure 10-16 shows the result of the coherent interaction of these 4 waves. The two slits are identified as "source 1" and "source 2". The resultant interference pattern is similar to what might be expected from light passing through double slits, but there are some key differences. First, the three dark horizontal bands are the result of the de Broglie waves and are similar to the bands shown in figure 10-5. These bands would be moving at faster than the speed of light $(w_m = c^2/v)$ and would not be in the pattern produced by light. Secondly, the blue and yellow wave representations would be alternating color (dipole polarity) at the electron's Compton frequency. Third, these blue and yellow wave representations would be propagating away from the slits at the electron's propagation speed $(u_d = v)$ and not at the speed of light as would occur with light. Fourth, it is impossible to detect the fine wave pattern represented by the blue and yellow waves. These have displacement amplitudes less than Planck length/time and are undetectable as discrete waves. They are at the electron's Compton frequency and the square of the time averaged waves represent the probability of "finding" the electron.

When a moving electron encounters a double slit, it no longer is an isolated electron. The model must change to reflect the changed boundary conditions. Parts of the quantized wave that is the electron pass through both slits and parts of the electron encounter the matter (other waves in spacetime) that forms the blocking areas. Whether or not the electron (rotar) reforms on the other side of the double slit is a probability. Even though most of the dipole wave is blocked (perhaps 99%), apparently the remaining 1% has a probability of reconstructing the entire dipole wave on the other side of the double slit. If it does reform, it has new characteristics imposed by the interaction with the matter (waves) that surrounds the double slit openings. There are new boundary conditions that are expressed as the radial interference pattern shown in Figure 10-16.

Energy Density of a Gravitational Field: In chapter 8 we calculated the energy density in the center of the rotar model of a fundamental particle. This is a rapidly rotating time gradient (> 10^{20} Hz) which is equivalent to a rotating gravitational field. If a rotating "grav field" at the center of a fundamental particle has energy density, does the gravitational field external to the particle (external to λ_c) also have energy density? The wave-amplitude energy density equation $U = A^2\omega^2 Z/c$ seems to imply that an oscillating wave is required for there to be any energy density because if $\omega_c = 0$ then $U_q = 0$. This is reasonable because it is not possible to extract energy from the static strain component of a gravitational field. However, as previously discussed, a gravitational field has both a static component which we can easily detect and an oscillating component which we cannot detect. In figure 8-3 the sloping line with small undulations is made up of a DC-like component that does not oscillate and an AC-like component that does oscillate. The AC-like component implies an energy density to a gravitational field. It may be impossible to ever extract energy from the AC-like component of gravity the same way that it is impossible to extract energy from vacuum energy, but on the quantum mechanical level a gravitational field does appear to have energy density. If so, what are the equations? How much of a black hole's energy is in the gravitational field external to its event horizon? Is it possible to derive the curvature of spacetime at a point if we know the gravitational field energy density and interactive energy density at that point?

Gravitational Energy Density: The Oscillating Component of Gravity: Most of this chapter was spent describing the part of the external volume associated with the oscillating and non-oscillating components associated with the electric field. While there has previously been some discussion of the oscillating component of gravity, there is still several important points on this subject which have not been previously mentioned. Earlier in this chapter the two amplitude terms associated with a rotar's gravity were given as:

$$A_g = \frac{A_\beta^2}{\mathcal{N}^2} = \frac{L_p^2}{r^2} = \text{gravitational standing wave amplitude oscillating at } 2\omega_c$$

$$A_G = \frac{A_\beta^2}{\mathcal{N}} = \frac{Gm}{c^2 r} = \beta = \text{gravitational non-oscillating strain amplitude}$$

For a single particle such as an electron, this oscillating term associated with gravity is an extremely weak effect because the amplitude of this oscillating component is $A_g = A_\beta^2/\mathcal{N}^2 = L_p^2/r^2$. Furthermore, this amplitude is squared again in the energy density equation so $A_g^2 = L_p^4/r^4$ where $L_p^4 \approx 10^{-140}$ m^4. However, the implication is that a gravitational field does have energy density since it has frequency, amplitude and the impedance of spacetime.

Therefore, we will calculate the implied energy density of a gravitational field using $U = A^2\omega^2 Z/c$ and setting $A = A_g = A_\beta^2/\mathcal{N} = L_p^2/r^2$ and $Z = Z_s = c^3/G$

$$U_g = \left(\frac{L_p^2}{r^2}\right)^2 \omega^2 \left(\frac{c^3}{G}\right)\left(\frac{1}{c}\right) = \left(\frac{\hbar^2 G^2}{c^6}\right)\left(\frac{\omega^2}{r^4}\right)\left(\frac{c^2}{G}\right) = (\hbar\omega)^2 \left(\frac{G}{c^4}\right)\frac{1}{r^4} = (mc^2)^2 \frac{G}{c^4 r^4}$$

$$U_g = \frac{Gm^2}{r^4}$$ This equation ignores a numerical constant near 1

Total Energy in a Gravitational Field: Usually I have avoided including constants near 1 since even Planck length and Planck time might have a constant associated with it when exact calculations are required. However, in the case of the energy density of a gravitational field I can make an educated guess about the value of the constant. Einstein's field equation is essentially an equation of energy density equals pressure as shown in chapter 4. The constant associated with that energy density is 1/8π. Also the energy density of the electric field produced by a Planck charge is $U_e = (1/8\pi)(\hbar c/r^4)$. I see an analogy between both of these equations and the equation for the energy density of a gravitational field $U_g = Gm^2/r^4$. In both of these equations the constant is 1/8π. Therefore, I am going to restate this equation including this constant.

$$U_g = \left(\frac{1}{8\pi}\right)\frac{Gm^2}{r^4} = \left(\frac{1}{8\pi}\right)\frac{g^2}{G}$$ where gravitational acceleration is $g = \frac{Gm}{r^2}$

This calculation used the assumption that we were dealing with individual rotars. All other calculations in this book that involving fundamental particles apply even to a hypothetical Planck mass particle which would be a black hole with Schwarzschild radius (defined as $R_s \equiv Gm/c^2$) of $\lambda\!\!\!{}^-_c = L_p = R_s$ and $\omega = \omega_p$. Now the question is: Can we switch from individual particles and assume that the mass term m in the above equation can apply to massive objects with many particles such as planets, stars and black holes? The unknown is: How does the oscillating component of the gravitational fields produced by many individual particles add together? Since all other gravitational effects scale with total mass with no indication of a difference in the type or number of particles, I will assume that the above equation applies to the total mass and proceed with the analysis.

The implication is that gravity is producing a strain on the homogeneous vacuum energy that forms the spacetime field. If gravity has an oscillating component, then the indication is that we should be able to calculate the magnitude of the energy density produced by a mass at known radius r. Out of curiosity, what is the energy density produced by the earth's gravity at the surface of the earth? The earth's mass is about $6\text{x}10^{24}$ Kg and its radius is about $6.38\text{x}10^6$ m. This works out to about $U_g \approx 5.8\text{x}10^{10}$ J/m^3 at the surface. Converting this to the equivalent mass density (dividing by c^2) this is about $6.4\text{x}10^{-7}$ kg/m^3. This calculation includes the constant $1/8\pi$. To test this further, we will calculate the total energy outside of a specific radius r. Obviously for a black hole, "r" must be interpreted as circumferential radius. If we integrate the above equation to find the total energy (or mass equivalent) external to circumferential radius r (integration limits r to infinity) we obtain:

$$E_{ext} = \frac{Gm^2}{2r} = \frac{E^2}{2F_p r}$$

Set $E = E_{bh}$ = energy of a Black hole and set $r = R_s \equiv Gm/c^2$, the Schwarzschild radius

$$E_{ext} = \frac{E_{bh}^2}{2F_p R_s} = \frac{E_{bh}^2}{2E_{bh}} = \frac{E_{bh}}{2}$$

Therefore, we obtain the result that, ignoring numerical constants near 1, about half (perhaps all) of the energy of a black hole is contained in the gravitational field external to the event horizon[3]. After I independently derived the above equations, I found that others have reached the same conclusion about the energy density of a gravitational field.[4],[5] However, this is not a generally accepted idea among physicists. My approach arrived at this implied energy density of a gravitational field using the model of gravity that has both an oscillating component and a non-oscillating component. This appears to be a totally new concept. The fact that a gravitational field has energy density also implies that there should be frame dragging if the mass is rotating. The predicted magnitude of the frame dragging will have to be developed.

The oscillating component of gravity is also very important in cosmology. Chapters 13 and 14 describe how the Big Bang and the expansion of the universe can be explained as a transformation of the properties of the spacetime field. A key part of this transformation involves the oscillating component of gravity transforming the observable energy density in the early universe into the situation we have today where only about 1 part in 10^{120} is observable energy in the form of fermions and bosons.

Flat spacetime is the homogeneous energy density of the dipole waves in spacetime predominately at Planck frequency previously described. Matter experiences "interactive energy density" of spacetime $U_i = \omega^2/G$ as previously described. Introducing oscillating

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[3] **Note**: The term "event horizon" of a black hole is used because this is the easiest way to explain a concept. However, I doubt that a black hole has a true "event horizon" where the rate of time is truly stopped. It is possible to have the rate of time slowed down by a vast amount such as 10^{20} times, but having it truly stopped rate of time presents problems for spacetime particles which cannot survive having the rate of time stopped.

[4] http://www.grc.nasa.gov/WWW/k-12/Numbers/Math/Mathematical_Thinking/possible_scalar_terms.htm

[5] Lynden-Bell, D. R Astro. Soc. **213**, (1985) pp 21-25, http://adsabs.harvard.edu/full/1985MNRAS.213P..21L

standing waves into this homogeneous energy density of dipole waves produces a distortion of the energetic vacuum characteristics. We call this distortion curved spacetime.

Insight into the Creation of Curved Spacetime: We interact with the non-oscillation component of the gravitational field. However it is the oscillating component of the standing waves which create the energy density of both an electric field and the energy density of the gravitational field. Now that we have the energy density contained in a rotar's gravitational field, can we gain a new insight into the curvature of spacetime produced by a gravitational field? To understand this, recall that the interactive energy density of the spacetime field at distance r from a mass is given by $U_i = F_p/r^2$. Therefore, the gravitational field is introducing organized energy density into what was previously flat spacetime possessing energy density without quantized angular momentum.

We know that matter curves spacetime. Now that we have been able to quantify both the energy density of a gravitational field U_g and the "interactive energy density U_i" of the spacetime field, we will see if it is possible to connect the ratio U_g/U_i to the curvature of spacetime. In chapter 2 we defined $\Gamma \equiv dt/d\tau = 1/(1 - \beta)$. Where β has been named the "gravitational magnitude". For fundamental particles the weak gravity approximation is $\beta \approx Gm/c^2r$. This definition of the curvature of spacetime is accurate to better than about 1 part in 10^{40} for the weak gravity produced by known fundamental particles. Since U_i ignores numerical constants near 1, the calculation of the ratio of U_g/U_i will also ignore the numerical constant associated with U_g. Therefore we will set:

$$U_g = \frac{Gm^2}{r^4} \quad \text{and} \quad U_i = \frac{F_p}{r^2} = \left(\frac{c^4}{Gr^2}\right)$$

$$\frac{U_g}{U_i} = \left(\frac{Gm^2}{r^4}\right)\left(\frac{Gr^2}{c^4}\right) = \frac{G^2m^2}{c^4r^2} \approx \beta^2$$

$$\sqrt{\frac{U_g}{U_i}} = \frac{Gm}{c^2r} \approx 1 - \frac{d\tau}{dt} \quad \text{the curvature of spacetime (weak gravity approximation)}$$

This is a wonderful result! The distortion produced by introducing a gravitational field's energy density into flat spacetime creates a curvature of spacetime associated with the weak field gravity. I believe that a more rigorous treatment will yield general relativity since nonlinearities are being ignored in this simplified calculation.

I initially found the square in $U_g/U_i = (Gm/c^2r)^2 = \beta^2$ a bit surprising. Before I made this calculation, I was expecting the ratio to equal the gravitational beta ($\beta = Gm/c^2r$). However, I can now see that since gravity is a nonlinear effect that scales with amplitude squared, there is also a square effect that extends to U_g/U_i. I find the connection between U_g/U_i and the curvature of spacetime is so reasonable that it confirms three things. 1) It confirms that gravitational fields have energy density $U_g = k\,Gm^2/r^4 = k\,g^2/G$. 2) It confirms the accuracy of the interactive energy density of spacetime $U_i = k\,c^2\omega^2/G = kF_p/\lambda\!\!\!^-{}^2 = k(\omega/\omega_p)^2 U_p$. 3). It confirms that we have found the key to understanding the mechanism by which matter interacts with the spacetime field to produce curved spacetime.

The calculation that shows that gravity has energy density also implies that gravity is a real force. A variation of the equivalence principle is often cited to support the idea that gravity is not a true force because an inertial frame of reference can make a gravitational field disappear. However, an inertial frame of reference is really an accelerating frame of reference in a gravitational field. The opposing argument in favor of a gravity being a true force is as follows: A body in free fall in a gravitational field is just experiencing offsetting forces. The gravitational force is still present but the accelerating frame of reference causes an opposite inertial "pseudo-force" on every particle. The two opposing forces exactly offset each other creating the impression that the gravitational force has been eliminated. However, to draw this conclusion, it is necessary to assume that the "force" of inertia has also been eliminated even though acceleration is taking place. The acceleration also produces an offsetting rate of time gradient and an offsetting spatial effect. The conclusive way to resolve this argument is the proof that gravity possess energy density.