Energetic Spacetime: The New Aether

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ABSTRACT

A model of the universe based on energetic spacetime (zero point energy) is expanded. The energy density of spacetime is calculated using only general relativity and acoustic equations. This energetic spacetime is shown to possess the properties required to be the new aether (Lorentz invariance, quantization of angular momentum, impedance, and quantum mechanical energy density.) The contradictory wave-particle duality properties of a photon are resolved by a model where a photon is a wave propagating in energetic spacetime but appearing to have particle properties because it possesses quantized angular momentum. Compton scattering and the photoelectric effect are examined and found to be compatible with the proposed wave-based photon model.

Keywords: spacetime field, photon, aether, Compton scattering, zero point energy, impedance of spacetime

1. INTRODUCTION

The word "aether" (ether) is usually associated with a 19th century disproven theory. However, Nobel Laureate, Robert Laughlin gives the following insight: "Large particle accelerators have now led us to understand that space is more like a piece of window glass than ideal Newtonian emptiness. It is filled with 'stuff' that is normally transparent but can be made visible by hitting it sufficiently hard to knock out a part. The modern concept of the vacuum of space, confirmed every day by experiment, is a relativistic ether. But we do not call it this because it is taboo." [1]

This work makes the case that the quantum mechanical model of energetic spacetime achieves the properties required to be the new relativistic aether and be the medium for photon propagation. Photons are usually described as possessing "wave-particle duality". However, this phrase is just a name given to something that we do not understand. The essence of a wave is that it is an oscillating disturbance with a definable wavelength and distributed over a substantial volume. A wave transfers liner momentum and some waves are capable of transferring angular momentum. Any wave disturbs the medium through which it is propagating such that energy is being converted between different forms.

The essence of a particle is that it is a single unit that differs from its surroundings. A fundamental particle is usually assumed to be energy concentrated at a point with no internal structure. A point particle or even a Planck length vibrating string is incapable of possessing $\hbar$ of angular momentum as a conceptually understandable physical rotation. The implied infinite energy density of a point particle also defies a physical explanation. Saying a photon has "wave-particle duality" is like saying that it has "top-bottom duality". These are contradictory properties which cannot be equal partners. A photon must either be a particle that somehow exhibits wave properties or a wave that is somehow quantized so that it exhibits particle properties. An informal survey of scientists has indicated that a photon's contradictory properties are usually just tolerated without visualizing a specific unified model.

This paper is an extension of the model of the universe and the model of a photon previously presented in two papers and a book. The papers are titled: *Spacetime based foundation of quantum mechanics and general relativity* [2] and *Spacetime-based model of EM radiation* [3]. The book titled *The Universe is Only Spacetime* [4] is available online. A brief summary of pertinent parts of these papers will be given next but a more detailed description of some points will require referencing these papers.

Both papers show that it is possible for everything in the universe – all particles, fields and forces – to be derived from 4 dimensional spacetime. The key to this model is that the vacuum is characterized as actually possessing the tremendous energy density implied by quantum mechanics (QM). The biggest numerical conflict in all of physics is the approximate 10^{120} difference between the "critical" energy density of the universe (about 10^{-9} J/m^3) obtained from general relativity (GR) and the energy density of the vacuum obtained from QM and its related fields. Names such as vacuum energy, zero point energy and vacuum fluctuations are used to represent the implied vacuum energy density of about 10^{113} J/m^3 obtained from QM [5]. The ~ 10^{120} difference between these two numbers is usually believed to require an unknown cancelation to eliminate the implied tremendous energy density of the vacuum. However, the spacetime-based model of the universe [2-4] proposes that both numbers are correct. They are describing two different types of energy density which can peacefully coexist. The QM energy density is a property of the vacuum itself and gives the vacuum constants such as G, c, $\hbar$ and ε_o.

Reference [2] makes the argument that QM permits undetectable small amplitude waves to exist in spacetime provided that the maximum spacial displacement does not exceed Planck length $L_p = (\hbar G/c^3)^{1/2} \approx 1.6\text{x}10^{-35}$ m and the maximum temporal displacement in flat spacetime (difference between perfect clocks) does not exceed Planck time $T_p = (\hbar G/c^5)^{1/2} \approx 5\text{x}10^{-44}$ s. It is argued that these waves actually exist and are the basic building blocks of everything in the universe – all particles, all fields and all forces. These Planck length/time amplitude waves in spacetime form a type of "background noise" since the distance between two points is modulated by $\pm L_p$. Indeed, Planck length has been found to be the theoretical maximum accuracy (device independent) that the distance between two points can be measured [6 - 10]. If spacetime itself contains waves which modulate distance by $\pm L_p$, then Planck length is an understandable limit. Similarly, Planck length/time waves in spacetime are modulating the rate of time such that perfect clocks in flat spacetime can differ by $\pm T_p$ (device independent) [7, 8]. The picture which emerges is that spacetime is a sea of these Planck length/time amplitude waves. They do not create gravity – they are the property of spacetime that is being distorted by matter to create curved spacetime. All the mysteries of QM and GR are proposed to be clarified if the wave-based model of the universe is adopted.

In fact, it is shown [2] that these Planck amplitude waves fit the requirements to explain zero point energy which field theory says fills the vacuum. The waves are primarily at Planck frequency, but other lower frequencies are also present. There are resonant conditions which favor some lower frequencies. We know these resonances as the Compton frequencies of the various particles of the standard model. The virtual particle pairs which are forming and annihilating in the vacuum are proposed to be just different manifestations of the resonances of energetic spacetime. While the virtual particle pairs have a limited lifetime, the dipole waves in spacetime can exist indefinitely because the Planck length and Planck time displacements are undetectable even with infinite integration time. Even the standard model is a field theory in which all 17 of the named particles are characterized as "excitations" of their respective fields [11]. Rather than the unappealing prospect of 17 overlapping fields, these can be replaced by the single "spacetime field" which is the proposed name for the sea of Planck length/time amplitude waves which is proposed to be the basis for everything in the universe. Resonances in the spacetime field are responsible for the various particles and virtual particles.

Before addressing photons, there are a lot of important concepts which can be obtained by first discussing gravitational waves. While QM and general relativity (GR) are usually described as being incompatible, it is actually possible to use GR to support the contention from QM that the vacuum is filled with tremendous energy density. Gravitational waves were predicted and characterized by GR. While gravitational waves have not yet been directly detected, their existence has been experimentally confirmed. The 1993 Nobel Prize was awarded to Hulse and Taylor for proving that a binary neutron star system was slowing down because it was emitting gravitational waves. The amount of observed slowing is within 0.2% of the amount predicted by GR. Gravitational wave equations can be used to determine both the impedance of spacetime and the energy density of spacetime. These are also important parts of the photon model.

2. SPACETIME FIELD CHARACTERISTICS

2.1: Impedance of Spacetime: The same way that it is possible to determine the impedance (Z) of an acoustic medium by examining its acoustic properties, it is also possible to determine the impedance of spacetime by examining gravitational wave equations obtained from GR. The impedance of spacetime (Z_s) was first reported by D. G. Blair in the 1991 book titled: Detection of Gravitational Waves [13]. This impedance is:

$$Z_s = c^3/G \approx 4.04\text{x}10^{35} \text{ kg/s} \qquad (1)$$

For example, the impedance of spacetime can be obtained from a gravitational wave equation which describes an idealized condition. The intensity of gravitational waves can be complex because of nonlinearities and radiation patterns. However, the intensity of gravitational waves can be expressed simply if we assume plane waves and the weak gravity limit [12]. Equation (2) below is the normal form while Eq. (3) is a rearrangement of terms used to illustrate a point.

$$I = \left(\frac{\pi c^3}{4G}\right) \upsilon^2 \left(\frac{\Delta L}{\lambda\!\!\!^-}\right)^2 \tag{2}$$

$$I = k \left(\frac{\Delta L}{\lambda\!\!\!^-}\right)^2 \omega^2 \left(\frac{c^3}{G}\right) \tag{3}$$

Where: I = intensity of a gravitational plane wave; υ = frequency; ω = angular frequency; $\lambda\!\!\!^- = \lambda/2\pi = c/\omega$ = lambda bar ($\lambda\!\!\!^-$), the reduced wavelength of the gravitational wave and ΔL is the maximum displacement produced by the gravitational wave over distance $\lambda\!\!\!^-$. A gravitational wave distorts the two spatial dimensions transverse to the propagation direction. A spherical volume of spacetime appears to become an oscillating ellipsoid. One transverse dimension enlarges the distance between points while the orthogonal transverse dimension shortens the distance between points. There is no change in the total volume of the spherical volume and there is no modulation in the rate of time. The amplitude of the gravitational wave is usually expressed as a dimensionless strain amplitude which will be defined as: $A_s \equiv \Delta L/\lambda\!\!\!^-$. Therefore, Eq. (3) can be rewritten as $I = kA_s^2\omega^2(c^3/G)$ which should be compared to an equation from acoustics: $I = kA^2\omega^2 Z$, It is obvious that c^3/G from Eq. (3) corresponds to the impedance of spacetime $Z_s = c^3/G$ determined by Blair.

2.2: Energy Density from General Relativity: It is possible to also extract the energy density (U) encountered by gravitational waves using Eq. (3) and analogies to acoustic equations. In acoustic equations the acoustic wave amplitude A_a is particle displacement $A_a = \Delta L$ (units m) and the acoustic impedance is $z = \rho c_a$ (units kg/m^{2}s) where ρ is density and c_a is acoustic speed of sound. The waves that fill spacetime do not have rest mass, but waves that propagate in energetic spacetime encounter a tremendous energy density which exhibits some of the properties of an acoustic medium with density. Therefore, this quasi-density will be called "interactive density ρ_i" and the quasi-energy density will be called the "interactive energy density U_i. The relationship is: $U_i = \rho_i c^2$. The following will set two different versions of the intensity equation $I = k\,A^2\omega^2 Z$ equal to each other. We can then solve for ρ_i and U_i. Before proceeding, it is necessary to explain one point about the compatibility of units. Gravitational waves use strain amplitude (maximum slope: $A_s = \Delta L/\lambda\!\!\!^-$) as dimensionless wave amplitude and the impedance of spacetime $Z_s = c^3/G$ has units of kg/s. We want to be able to access density from the acoustic equation $z = \rho c_a$ but this requires accommodating the different units used in acoustics and gravitational wave equations. This can be done by setting the two different forms of the intensity equation equal to each other. Substitutions include: $A_a = \Delta L$; $c_a = c$; $z = U_i/c$; $A_s = \Delta L/\lambda\!\!\!^- = \Delta L\omega/c$; $Z_s = c^3/G$; $F_p = c^4/G$ = Planck force, $U_p = c^7/\hbar G^2 \approx 10^{113}$ J/m^3 = Planck energy density and $\rho_p = c^5/\hbar G^2 \approx 5\text{x}10^{96}$ kg/m^3 = Planck density.

$$I = k\,A_a^2\omega^2 z = k\,A_s^2\omega^2 Z_s$$

$$k(\Delta L)^2\omega^2(\rho_i c) = k\left(\frac{\Delta L\omega}{c}\right)^2 \omega^2 \left(\frac{c^3}{G}\right)$$

$$\rho_i = k\frac{\omega^2}{G} = k\frac{c^2}{\lambda\!\!\!^-{}^2 G} = k\left(\frac{\omega^2}{\omega_p^2}\right)\rho_p \tag{4}$$

$$U_i = k\frac{\omega^2 c^2}{G} = k\frac{F_p}{\lambda\!\!\!^-{}^2} = k\left(\frac{\omega^2}{\omega_p^2}\right)U_p \tag{5}$$

The energy density encountered by a gravitational wave propagating through the spacetime field experiences a ω^2 dependence. This frequency dependence is the reason for the designations "interactive energy density U_i of spacetime" and "interactive density ρ_i of spacetime". Equations (3 and 4) are a series of equalities that are different ways of expressing the interactive density ρ_i and interactive energy density U_i. Of particular interest here is $U_i = k\ (\omega^2/\omega_p^2)U_p$ where ω_p is Planck angular frequency (~$1.9\text{x}10^{43}$ s^{-1}) and Planck energy density ($U_p \approx 10^{113}$ J/m^3). The term ω^2/ω_p^2 is a coupling constant. Almost all the energy in the spacetime field is waves at Planck frequency. A hypothetical gravitational wave at Planck frequency ($\omega = \omega_p$) would experience a coupling constant equal to 1 and this wave would feel the full energy density of the spacetime field ($U_p = c^7/\hbar G^2$). However, frequencies less than Planck frequency experience a frequency mismatch and therefore a lower coupling constant. To help internalize the concept that gravitational wave equations support the quantum mechanical concept of vacuum energy, a numerical example will be given.

Suppose that there was a gravitational wave at an angular frequency of 1 s^{-1}. It would have a reduced wavelength of $\lambda\!\!\!^- \approx 3\text{x}10^8$ m and a frequency of about 0.16 Hz. If the gravitational wave had an intensity of 1 w/m^2, then substituting these values into Eq. 2 we would obtain a strain amplitude $A_s \approx 1.5\text{x}10^{-18}$ which is displacement of spacetime of $\Delta L = 4.7\text{x}10^{-10}$ m over a distance of $\lambda\!\!\!^- = 3\text{x}10^8$ m. This example is ignoring the numerical constant k. The gravitational wave is really encountering the interactive energy density in a volume of $ƛ^3$ in order to produce the displacement of ΔL = 4.7x10^{-10} m over distance 3x10^8 m. The assumed intensity was 1 w/m^2, but this is propagating at the speed of light, so the total energy of the gravitational wave over a volume of $ƛ^3$ = 2.7x10^{25} m^3 is 9x10^{16} J. Think about how 9x10^{16} J only produces a length change of ΔL = 4.7x10^{-10} m over a time period of $1/\omega$ = 1 second. Normally we just accept the fact that spacetime is a very stiff medium and not attempt to analyze the physical process that gives spacetime its stiffness. However, now we have an equation for the interactive density of spacetime $\rho_i = \omega^2/G$ (ignoring k). Setting ω = 1 s^{-1} we have ρ_i = 1.5x10^{10} kg/m^3. Over a volume of $ƛ^3$ this is equivalent to the gravitational wave needing to accelerating an interactive mass of $m_i = \rho_i ƛ^3 \approx 4\text{x}10^{35}$ kg. It is true that a gravitational wave is a transverse wave rather than a longitudinal wave, so it is not exactly accurate to make an analogy to accelerating a mass to a longitudinal velocity. However, the difference between the energy density of a longitudinal wave and a transverse wave in acoustics is only a numerical factor near 1. We can ignore this difference when attempting to make a point that will lead to explaining a factor of 10^{120} in the energy density of the universe. If we gave a mass of 4x10^{35} kg kinetic energy of 9x10^{16} J, it would have velocity of 4.7x10^{-10} m/s and move ΔL = 4.7x10^{-10} m over a time period of $1/\omega$ = 1 second (ignoring k). This matches the previously calculated displacement of spacetime that would be produced by a gravitational wave with: I = 1 w/m^2, ω = 1 s^{-1} and $ƛ$ = 3x10^8 m.

This is a successful test. We have shown a conceptually understandable model of why spacetime is so stiff. A gravitational wave with intensity of 1 w/m^2 at frequency of 1 s^{-1} only produced a distortion of spacetime of 4.7x10^{-10} m over a distance of 3x10^8 m because the energy being accelerated is equivalent to accelerating a mass of 4x10^{35} kg. This is a strain amplitude ($\Delta L/L$) of about 10^{-18}. The gravitational wave is interacting with a tremendously large energy density in the form of the dipole waves in spacetime. This is energy propagating at the speed of light which modulates the distance between points at $\pm L_p$ and modulates the rate of time by $\pm T_p$.

While energy propagating at the speed of light has no rest mass, it can exhibit inertia. If light is confined to a box, the confined light exhibits inertia when the box is accelerated [13]. In fact, the inertia of confined light exactly equals the inertia of a mass with equal energy. A gravitational wave is also accelerating energetic waves moving at c. Therefore it is possible to define what will be called the "interactive mass m_i" and the interactive "energy e_i" being accelerated by a gravitational wave with reduced wavelength $ƛ$. Equations (6) and (7) give the definition and values of m_i and e_i.

$$m_i \equiv \rho_i ƛ^3 = k\, Z_s/\omega \qquad (6)$$

$$e_i \equiv U_i ƛ^3 = k\, F_p ƛ \qquad (7)$$

The simplicity of $m_i = Z_s/\omega$ and $e_i = F_p ƛ$ is surprising. For example, if ω = 1 s^{-1} then m_i = 4x10^{35} kg as previously calculated. There is a connection between m_i and the mass of a black hole. We will define the classical Schwarzschild radius as $R_s \equiv Gm_{bh}/c^2$ where m_{bh} is the mass of a black hole. If we set $m_i = m_{bh}$, then $R_s = ƛ$. This is no coincidence. A black hole forms when we reach the condition where the energy density of the energy associated with the fermions and bosons in a particular volume matches the interactive energy density of that volume of the spacetime field. Energy density (J/m^3) has the same units as pressure (N/m^2) when they are reduced to fundamental units (both are: kg/s^{2}m). In the spacetime-based model of the universe, both fundamental particles and black holes require pressure exerted by the spacetime field to contain the pressure generated by energy density generated by fermions and bosons possessing quantized angular momentum. The radius of a black hole is determined by this requirement to contain the internal pressure. The radius limit is set by the value of the interactive energy density possessed by the spacetime field.

3. CHARGE AND PHOTONS

Now we are ready to make a connection to photons and the aether. In references [2-4] a new constant of nature is proposed called the "charge conversion constant η". If everything in the universe is made out of the Planck length/time amplitude waves that fill spacetime, then using η it should be possible to reduce charge and electric field to a distortion of spacetime.

$$\eta \equiv \sqrt{\frac{G}{4\pi\varepsilon_o c^4}} = \frac{\sqrt{\alpha}L_p}{e} = \frac{L_p}{q_p} = 8.617 \times 10^{-18}\ \text{m/C} \qquad (8)$$

This constant has units of meter/coulomb. This conversion constant has been tested and in every case it gives reasonable results. It eliminates the unit of coulomb and replaces it with a strain of spacetime. For example, when the Coulomb force constant $1/4\pi\varepsilon_o$ is converted to a strain of spacetime, the result is that $1/4\pi\varepsilon_o\eta^2 = c^4/G$ = Planck force F_p. The most important finding is that the impedance of free space $Z_o = 1/\varepsilon_o c \approx 377\Omega$ encountered by photons converts to the impedance of spacetime times 4π. Here is the calculation:

$$\left(\frac{1}{\eta^2}\right) Z_o = \left(\frac{4\pi\varepsilon_o c^4}{G}\right)\left(\frac{1}{\varepsilon_o c}\right) = 4\pi\frac{c^3}{G} = 4\pi Z_s \qquad (9)$$

Photons experience the same impedance (c^3/G) as gravitational waves. Therefore, photons are quantized waves which propagate in the energetic spacetime field (the new aether).

Now that [2] has demystified electric field, charge and the impedance of free space ($Z_o \approx 377\ \Omega$) it is possible to calculate the distortion of the spacetime field produced by photons. References [2-4] show that multiple photons (n photons) confined in the smallest volume (~ ¼ λ in radius) produce a spatial distortion of spacetime of $\Delta L = \sqrt{n}\, L_p$. There is also a description of the distortion of spacetime that produces an electric field and the connection to the distortion of spacetime that produces a gravitational field. This will not be repeated here.

3. STRONG QUANTIZATION

It is often said that photons possess quantized energy of $E = \hbar\omega$. However, we will examine the limits of this quantization. Suppose that we make an analogy to the equivalence principle having a "strong" and a "weak" definition. Similarly, the proposal is made that there is a "strong" and "weak" definition of quantization. A strong definition of quantization would imply that only integer multiples of the fundamental unit are allowed. For example, if energy met the strong definition of quantization, then energy would only came in discrete units such as integer multiples of 1 eV. Photons would only come in discrete frequencies which would be integer multiples of the universal fundamental frequency associated with the universal unit of quantized energy. Obviously energy and frequency are not quantized according to the "strong" definition. Instead, a photon's energy is only weakly quantized. All of a photon's energy is transferred when it is absorbed, but a photon can possess any energy up to Planck energy. The same photon has different energy when viewed from different frames of reference.

Compare this to angular momentum which meets the definition of strong quantization. Angular momentum only comes in discrete units. All angular momentum in the universe only comes in integer multiples of ½ ħ. This is obvious with fermions and bosons, but a more revealing example can be made using a carbon monoxide molecule (CO) isolated in a vacuum. An isolated CO molecule can only possess integer multiples of $\hbar$ angular momentum. This translates into the CO molecule only being able to rotate at discrete frequencies which are integer multiples of its fundamental rotational frequency of 115 GHz. This meets the definition of strong quantization. For another example, take a photon that is part of the cosmic microwave background. Over the age of the universe this photon has lost most of its energy. However, the photon has kept 100% of its angular momentum. Angular momentum has strong quantization; energy has weak quantization.

It is proposed that all quantization in the universe is ultimately traceable to angular momentum being strongly quantized. When a photon is absorbed by an atom, it transfers 100% of its angular momentum to the atom. All the photon's energy is also transferred to the atom, but that is just a byproduct of transferring its $\hbar$ unit of quantized angular momentum. The amount of energy transferred from the photon to the atom depends on the frame of reference of the atom. However, the angular momentum transferred is independent of the frame of reference.

Why is angular momentum quantized? This was explained in [2-4] but the EM paper [3] will be quoted here. "We are imagining spacetime as a sea of Planck length/time waves at all frequencies up to Planck frequency. These waves possess no angular momentum and can be thought of as being the most perfect superfluid possible. We can get an insight into this superfluid by looking at a Bose-Einstein condensate which is also a superfluid. It is an experimentally observed fact that a Bose-Einstein condensate cannot possess angular momentum. If angular momentum is introduced, the angular momentum is isolated into quantized units which are a function of $\hbar$. The isolated angular momentum vortices in a Bose-Einstein condensate have been experimentally observed [14-16]. It is proposed that fermions are a rotating Planck length/time wave possessing ħ/2 angular momentum. These are analogous to the rotating vortices that exist in the superfluid Bose-Einstein condensate. Photons are propagating waves possessing $\hbar$ of angular momentum. They propagate in the spacetime field which is a sea of superfluid Planck length/time waves that lack angular momentum. When a photon (a wave possessing angular momentum) propagates through the spacetime field that lacks angular momentum, the photon introduces angular momentum that produces a phase change to a very small portion of the spacetime field (limited frequency, volume and energy) The spacetime field quarantines angular momentum. This results in photons having quantized angular momentum and a particle-like property."

It was previously stated that wave-particle duality is contradictory. A photon must be either predominantly a particle which acts like a wave or predominantly a wave which sometimes acts like a particle. The model of a photon being proposed is that it is always a wave that propagates in the superfluid spacetime field. The superfluid properties quarantine the photon's angular momentum into quantized $\hbar$ units. To support this statement several important questions must be explained. These are: 1) How does the distributed wave energy collapse to a point? 2) If the spacetime field is the new aether, does it have an implied frame of reference? 3) Is there a reasonable explanation for the photoelectric effect and Compton scattering?

Some of these questions can be answered briefly and others require a longer explanation. First, how does a wave-dominated photon model transfer all its distributed angular momentum and energy to a single atom? We know that two entangled photons possess the property of responding to a perturbation faster than the speed of light. The two entangled photons form a single quantized angular momentum system. Measuring the polarization of one of the photons immediately results in the other entangled photon having the orthogonal polarization. The proposed method by which quantized waves accomplish this is discussed in the EM paper [3]. But the point is that the total quantized angular momentum of two entangled photons is preserved by super-luminal communication speed. By analogy, a single photon possessing distributed quantized angular momentum must also possess super-luminal communication within itself. To preserve its quantized angular momentum, a single photon must be able to transfer all its angular momentum by collapsing its wave structure faster than the speed of light. By extension, the distributed energy of a photon can collapse faster than the speed of light into an absorbing atom. This gives a photon its particle-like properties. The photo-electric effect is explained by the quantized wave model of a photon because the transfer of $\hbar$ of angular momentum also transfers all of a photon's energy to a single atom or a single electron. If a single electron receives all the photon's energy, the electron can be ejected from a surface. Also the quantized wave model has no problem explaining how a photon explores all possible paths between two events as required by the path integral.

4. SPACETIME FIELD REFERENCE FRAME

One of the major objections to the luminiferous aether concept of the late 19 century was that the properties attributed to the aether implied that it should be possible to detect motion relative to the aether. However, the medium of the spacetime field is different than the luminiferous aether. Gravitational waves propagate in the medium of spacetime and yet gravitational waves always propagate at the speed of light. If it was possible to do a Michelson-Morley experiment using gravitational waves, no motion relative to spacetime would be detected. This can be understood using two insights. First, the spacetime field is a sea of strongly interacting dipole waves in spacetime. They are moving at the speed of light, so no motion can be detected relative to this medium. Second, all particles, fields and forces are ultimately made out of the same dipole waves in spacetime that forms the spacetime field [2, 4]. Fermions, bosons and forces including gravity scale with the local frame of reference relative to the spacetime field. This concept ultimately explains the physics behind Lorentz invariance. The universe is only energetic spacetime so all our references are just different manifestations of the spacetime field. Therefore, the speed of light is constant even when we use a physical ruler to define distance and a mechanical watch to define the rate of time.

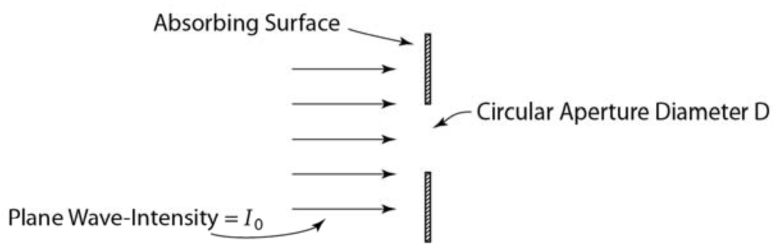

FIGURE 1A

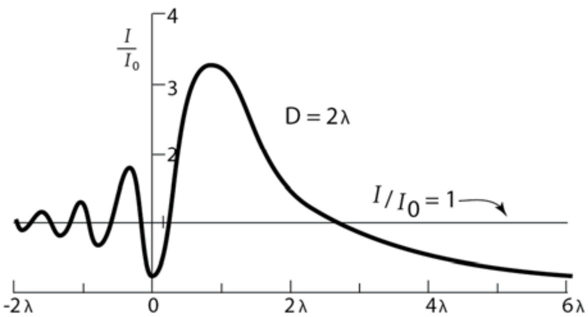

FIGURE 1B

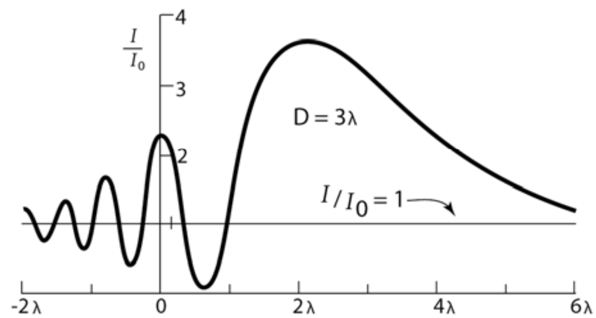

FIGURE 1C

5. BACKWARDS PROPAGATION OF WAVES

One of the best examples which illustrate the dominance of the photon's wave properties is illustrated in Figures (1A, B & C). This figure is an adaption of figures from the book Optics of the Electromagnetic Spectrum [17]. Figure 1A shows the cross-section of a circular aperture with an absorbing surface and aperture diameter D. A plane wave with wavelength λ approaches the circular aperture from the left and the portion of the beam that passes through the aperture proceeds to the right. We normally expect to see the far field diffraction pattern of a circular aperture with its central Airy disk and its concentric diffraction patterns. However, figure (1) is different. It shows the diffraction of EM radiation that actually takes place close to a circular aperture. More specifically, the figures 1B and 1C plot the intensity along the axis that passes through the center of the circular aperture. This can be calculated using the Huygens-Fresnel-Kirchhoff principle, but it can also be experimentally measured using microwaves interacting with an absorbing circular aperture. Figure 1B shows the intensity produced by an absorbing circular aperture that is 2 wavelengths in diameter ($D = 2\lambda$) and figure 1C is 3 wavelengths in diameter ($D = 3\lambda$). If there was no aperture, the intensity would be $I_o = 1$. With the absorbing aperture in place, the intensity along the central axis is "I" and the Y axis represents the intensity ratio I/I_o. Notice that there is a line designating the incident intensity $I/I_o = 1$ for reference. The X axis designates the number of wavelengths (+ or –) from the center of the circular aperture.

The first thing to notice by looking at the intensity plots is that they are counterintuitive. An absorbing aperture would not be expected to have any effect on the approaching electromagnetic radiation. Yet both figures 1B and 1C show interference effects to the left of the aperture. This is the region before the EM radiation even reaches the aperture. If a photon is visualized as being dominated by an energetic particle, how is it possible that the probability of finding the energetic particle should produce interference effects before the energetic particle actually reaches the absorbing aperture? Furthermore, figure 1B (with D = 2λ) shows that the intensity at the center of the aperture is only about 25% of the plane wave intensity. Figure 1C (with D = 3λ) has intensity at the center of the circular aperture about 2.25 times the plane wave intensity.

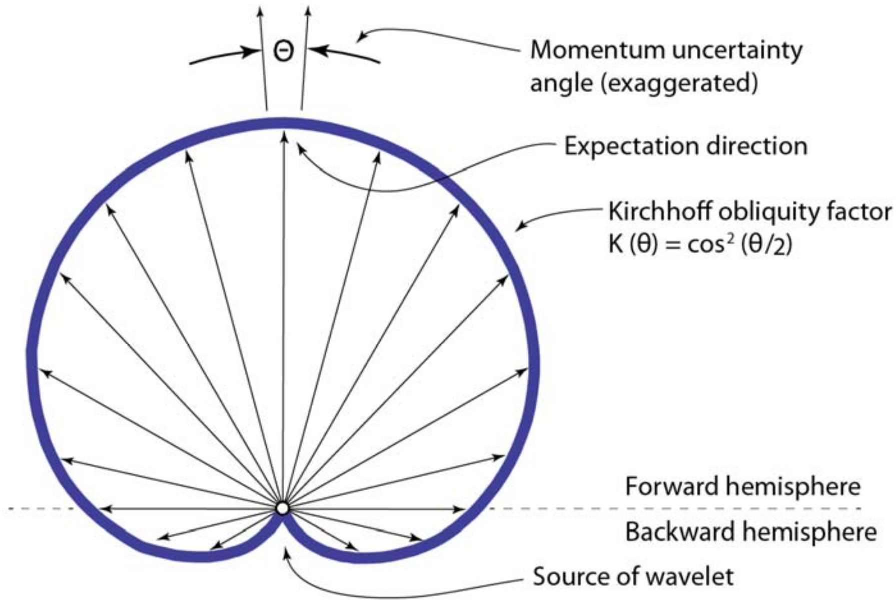

FIGURE 2 Wavelet amplitude distribution
Kirchhoff obliquity factor

6. HUYGENS PRINCIPLE

The counter intuitive plots in figures 1B and 1C are explained by the Huygens-Fresnel-Kirchhoff principle and experimentally verified by microwave experiments. When Huygens first proposed his principle, he postulated that every point on a wavefront became the source of a new hemispherical wave that are called "wavelets". He proposed that these wavelets only propagated into the forward hemispherical direction. Fresnel improved on Huygens principle by introducing phase to the wavelets and proposing that the intensity was amplitude squared. Finally Kirchhoff replaced the concept of a hemispherical wavelet with a distribution illustrated in figure 2.The amplitude distribution formulated by Kirchhoff is called the obliquity factor $K(\theta)$. When expressed in spherical coordinates this factor is: $K(\theta) = cos^2(\theta/2)$. This distribution is plotted in figure 2.

The small circle labeled "source of wavelet" is the emission point of each new wavelet. The maximum amplitude direction, designated "expectation direction" in figure (2), is the perpendicular to the wavefront. However, the wavelet emits waves in all directions with different amplitudes (different arrow lengths) except that the opposite direction to the expectation direction has zero amplitude. Note that figure (2) designates the dividing line between the portion of the waves that propagate into the forward hemisphere and the backwards hemisphere. There is a small portion of the wavelet amplitude distribution which have backwards vector components (radiating into the backwards hemisphere). It is these wavelet components with a backwards propagation component which are interacting with the waves which have not reached their apertures in figures 1B and 1C. The combination of these two components produce the interference effects on the left side of the circular apertures in figures 1B and 1C. All of this is conceptually understandable if the proposed wave-based photon model is assumed. It is very hard to imagine how a particle dominated photon model achieves the interference pattern in figures (1B and 1C).

The spacetime-based model of a propagating photon is more complete and quantifiable than any competing model based on the vague concept of wave-particle duality. As shown in references [2, 3], there are equations which define the distortion of the spacetime field produced by a photon. There is even a prediction derived from these equations that there should be a volume dependent maximum possible intensity of EM radiation which the spacetime field can transmit. This surprising prediction is analyzed and shown to be correct because this maximum distortion condition corresponds to the energy density which makes a black hole. Also the photon model is part of a much larger model of the entire universe constructed out of the Planck length/time waves in spacetime. This complete model makes correct predictions about previously unknown relationships that exist between the gravitational force and the electrostatic force. Until this model was developed, no connection was previously found between gravity and any other force.

Figure (2) can also be used to illustrate one other feature of the proposed wave-based photon model. Suppose that an isolated atom in an excited state emits a photon into the surrounding vacuum. Most physicists would probably assume that the photon was emitted into a narrow emission angle. However, the spacetime-based model of a photon has the distribution of waves initially emitted into a spherical shell of waves with intensity distribution the same as the obliquity factor $K(\theta) = cos^2(\theta/2)$ shown in figure (2). Therefore there is maximum amplitude at $\theta = 0°$ and zero amplitude in the opposite direction ($\theta = 180°$). All other directions have some intermediate amplitude as given by $K(\theta)$. The photon's zero amplitude direction is the direction of momentum transferred to the emitting atom. As previously discussed in references [3, 4], it is hypothetically possible to tell the direction of the emitted photon to within the momentum uncertainty angle (figure 2) if it is possible to detect the atom's recoil direction. Therefore, this would seem to restrict the amplitude of the photon's emitted waves. However, it is possible to do a thought experiment which proves that waves must exist beyond the momentum uncertainty angle must exist. Actually, the emitting atom must also be undisturbed as it recoils after emitting the photon. Suppose that before emission, an atom in the excited state is located at one focus of an elliptical reflector. When the atom emits the spherical shell of waves with $K(\theta)$ distribution, all these waves would be captured by the elliptical reflector and focused at the second focus point of the elliptical reflector. The waves would come to a spherical focus with a radius of about ¼ wavelength. To achieve this small a focus, it is necessary to capture all the waves emitted by the atom, not just the waves emitted into the momentum uncertainty angle. If a single atom is to absorb the emitted photon without any reflector, then it is true that the atom must lie within the momentum uncertainty angle designated in figure (2). However, that limitation is set because there must be conservation of momentum. An absorption outside of this momentum uncertainty angle would impart too large a transverse momentum to the absorbing atom and violate the conservation of momentum.

The idea that an atom emits waves into the wide angle emission pattern shown in figure (2) seems to be counter to our experience with collimated beams such as laser beams. However, each atom in a laser can emit waves into a wide emission pattern yet form a narrow bean. Stimulated emission causes each atom to emit its waves in phase with the other waves. Since the final intensity is equal to amplitude squared, the properly phased emission achieves a well formed laser beam.

7. COMPTON SCATTERING

Perhaps the Compton scattering experiment in 1923 had the biggest influence in changing scientific opinion about the nature of photons. In the late 19^{th} century and early 20^{th} century there was nearly universal acceptance that light was a wave that propagated in the luminiferous aether. Maxwell's equations and Young's double slit experiment seemed to confirm that light was a wave. The Michelson-Morley experiment and the photo-electric effect shook this view, but what appeared to be conclusive proof was the Compton scattering experiment. There seemed to be no way to salvage the purely wave nature of light. The paradox of light having both wave and particle properties was born. To prove that a photon can be a quantized wave, it is necessary to be able to explain how waves can produce Compton scattering. The following explanation is long but it is necessary to counter the experiment which seems to demand that a photon is a particle.

Arthur Compton observed the scattering of x-ray photons by electrons. The x-rays struck a carbon block and were scattered by the carbon atom's electrons. The scattered x-rays exhibit a decrease in frequency that is a function of scattering angle. The connection between scatter angle and the energy of the x-rays implied that individual electrons were recoiling and removing energy from the x-rays. The decrease in the frequency of the scattered x-rays supported the model that energy had been removed from particle-like photons and this energy was given to the recoiling electrons. **A simple Doppler shift of waves reflecting off the moving electron does not correspond to the correct frequency shift.** The classical wave theory of light was disproven. The interaction is nicely described by Compton's equations which treated photons as particles. He received the 1927 Nobel Prize in physics for this work.

7.1: Schrodinger's Article on the Compton Effect: The particle-based explanation of Compton scattering is well known. It is usually assumed that there is no viable wave-based explanation. However, much less well known is that in 1927 Erwin Schrodinger showed that there was also a wave-based explanation of Compton scattering which assumed that electrons and photons had non classical wave properties. Schrodinger's explanation will be briefly given, then his explanation will be expanded to encompass the proposed photon model and the associated particle model also based on Planck length/time waves in spacetime. It will be shown that the quantized wave model actually is superior to the particle-based explanation.

In 1927, Erwin Schrodinger authored a paper titled "The Compton Effect" [18]. 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. He did not present a model of how an electron in a moving frame of reference generates de Broglie waves. He merely assumed their existence. Also Schrodinger did not specifically address the question of how wave-based photons achieved the non-classical property of being quantized. Schrodinger looked at the collisions of photons and de Broglie waves as if they were a continuous process. In this case four waves are presumed to exist and interact continuously. These four waves are 1) the electron's de Broglie waves before the interaction 2) the scattered electron's de Broglie waves after the interaction 3) the light wave before the interaction and 4) the scattered light wave after the interaction. Schrodinger found that the electron's two superimposed de Broglie waves combined to make a new wave that he called a "wave of electrical density". This combined wave had the perfect periodicity to reflect the incident light waves 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 perfectly matches the interference pattern produced by the electron's two superimposed de Broglie waves. The waves that were used to represent both the scattered electron and the scattered photon (after the interaction) had the correct frequency shift and scatter angle. However, he lacked an explanation of how an electron produced de Broglie waves and lacked a quantized wave model of a photon which could interact with these de Broglie waves. Because of these deficiencies, Schrodinger's explanation was largely ignored and Compton scattering was considered proof that a propagating photon must possess a physical particle property. The spacetime-based model of both an electron and a photon now can build on Schrodinger's partial explanation and give a conceptually understandable explanation of Compton scattering.

Schrodinger made an analogy between Compton scattering and Brillouin scattering. 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. His translated words are: "*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.*" In Brillouin scattering, light waves and sound waves interact. The maximum reflection is obtained if the following equation is satisfied: $\lambda \approx 2\Lambda \sin\theta$ where: λ = light wavelength, Λ = acoustic wavelength and θ = the angle between the light propagation direction and a plane parallel to the acoustic waves. This equation would be exact if the acoustic wave was stationary. Since the acoustic wave has a speed much less than the speed of light, the condition of a stationary acoustic wave is approximately met. 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.

7.2 Vector Diagrams: Schrodinger's point will be explained using figures (3 and 4 next page). Figure 3 shows a stationary electron labeled "electron's momentum = 0 before scattering". An incident x-ray photon interacts with the electron causing the electron to scatter with the momentum vector shown and the lower frequency photon to scatter in the direction shown. All of these are commonly included in Compton scattering diagrams, but figure 3 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 (electron's momentum after scattering) but the depicted half momentum has been displaced slightly for clarity.

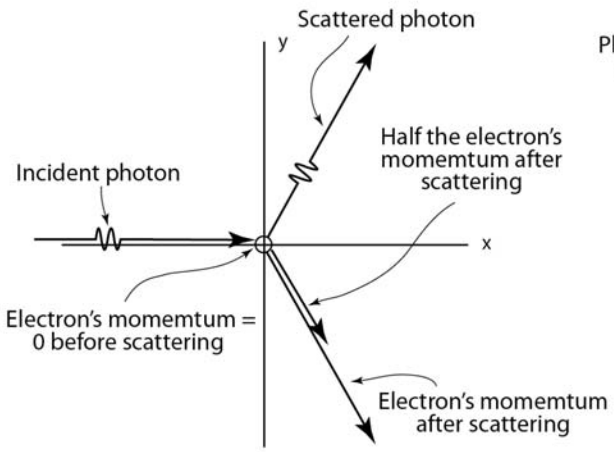

FIGURE 3 Compton scattering vector diagram (stationary electron before scattering)

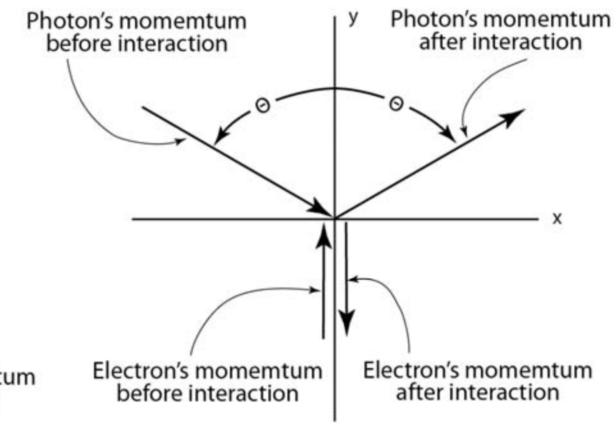

FIGURE 4 Compton scattering vector diagram in the frame of reference that gives zero energy transfer (moving electron before scattering)

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 4. In figure 4, 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 4. 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". In other words, the two opposite propagation directions produce a composite de Broglie wave which does not move. The de Broglie waves become standing waves in the frame of reference represented by figure (4). 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 quantized wave photon and the electron, but there is no energy transferred. In this zero energy transfer frame of reference, the electron momentum moving towards the X axis (before scattering the photon) is the same magnitude but opposite direction as the electron momentum moving away from the X axis (after scattering the photon). The reversal in direction along the Y axis is the momentum transferred to the quantized wave photon along the Y axis. The superposition of the two sets of the electron's de Broglie waves produces a stationary standing wave pattern (density wave) with periodicity of $\Lambda_d = \hbar/mv$ where "v" is the magnitude of the electron's velocity before and after the scatter interaction. 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 3. The frequency shift and angle change is simply analogous to reflecting off a moving multi-layer dielectric mirror.

7.3: Model of de Broglie Waves: So far, the explanation given is similar to Schrodinger's explanation. However, now we will switch to using the spacetime-based particle model presented in references [2, 4]. This is complete enough that it generates several important characteristics

FIGURE 5A FIGURE 5B FIGURE 5C

Figures 5A, 5B and 5C – These patterns represent waves in the spacetime field created by an electron moving from left to right. The core of the electron is not shown, but it is creating standing waves at its Compton frequency. Figure 5A is the Doppler shifted outgoing waves and 5B is Doppler shifted incoming waves. Figure 5C is the superposition of 5A and 5B. The vertical bands are the de Broglie waves created by this model. The black and white printed version does not show the digital alternate blue and yellow waves.

of an electron including 1) the electron's gravitational curvature of spacetime, 2) the correct gravitational force between two electrons, 3) the correct electrostatic force between two electrons provided that the fine structure constant is manually installed and 4) the electron's de Broglie waves if the electron is in a moving frame of reference. The point of interest for Compton scattering is the way that the spacetime electron model generates de Broglie waves.

The spacetime-based model of an electron has a dipole wave in spacetime with quantized angular momentum of ½$\hbar$ rotating at the electron's Compton frequency. [2, 4] This produces waves at the electron's Compton frequency in the surrounding spacetime field. The electron is stable because a resonance achieves a condition where the spacetime field exerts opposing pressure by forming standing waves. These standing waves have equal amount of energy propagating both away from the rotating core (outgoing waves) and towards the rotating core (incoming waves). If these standing waves could be observed in a stationary frame of reference, they would appear to be concentric waves at the electron's reduced Compton wavelength $\lambda\!\!\!^-_c = \hbar/mc$. oscillating at the electron's Compton angular frequency $\omega_c = mc^2/\hbar$. However, to obtain de Broglie waves the standing waves have to be observed from a moving frame of reference.

Figure (5A) shows the Doppler shifted outgoing waves if the electron is moving from left to right. The Doppler effect pictured assumes that the electron is moving at about 30% of the speed of light. Figure (5B) represents the Doppler shifted incoming waves assuming the same speed and direction of motion. When the waves depicted in Figures (5A and 5B) are combined, de Broglie waves appear as shown in panel (5C). This panel depicts a frozen moment in time. In a video, the de Broglie waves (dark vertical bands) would move from left to right at faster than the speed of light. This simulation achieves the correct de Broglie wave characteristics including phase velocity ($w_d = c^2/v$), group velocity ($u_d = v$) and wavelength ($\lambda_d = h/mv$) as explained in reference [4]. If the electron is moving at 0.3c, then $w_d \approx 3.3c$

To achieve the standing waves previously described in reference to figure (4), a second set of waves moving in the opposite direction have to be added to the moving waves depicted in figure (5C). This second set of waves are the same as figure 5C except that the de Broglie wave motion is the opposite direction (right to left). Recall that the Compton scattering previously described requires that two sets of de Broglie waves (before and after scattering) which are superimposed to create a stationary standing wave. A computer simulation of the combined de Broglie waves has been achieved. The result looks exactly like figure (5C) when a single moment is frozen in time. These standing waves have the characteristics of a multi-layer dielectric mirror which perfectly interacts with the photon's waves propagating in the spacetime field.

The other part missing from Schrodinger's explanation is any mention that the wave-based photon still must achieve the non-classical property of being quantized. If photons were classical waves, then Schrodinger's explanation would not have been sufficient. However, each electron is receiving a specific amount of energy and momentum. This requires quantized photons to carry away the offsetting amount of energy and momentum. The spacetime-based photon model of a photon achieves quantized angular momentum by the interaction with the spacetime field with superfluid properties as previously explained. The photon-electron interaction would transfer ħ of angular momentum between the electron and the photon. This results in the momentary collapse of the distributed waves previously discussed. The spin of both the electron and scattered photon is reversed. The non-classical particle-like properties of the quantized wave photon would be exhibited.

This spacetime wave explanation of Compton scattering is proposed to actually be ***better*** than the particle based explanation. A photon possesses both linear momentum $p = E/c$ and $\hbar$ angular momentum. The photon must transfer both a vector component of the linear momentum and a reversal of the angular momentum to the scattered electron. Therefore, it is not possible for the scattered electron to receive intermediate linear momentum transfers which accelerate the electron through intermediate velocities before it reaches the final scattered velocity. Similarly, it is not possible to transfer the angular momentum in intermediate steps. The scattered electron must transition from the velocity and angular momentum before scattering to the velocity and angular momentum after scattering without possessing intermediate velocity and angular momentum states. This required transition fits perfectly with the wave-based explanation because both the electron's wave pattern and the photon's wave pattern fade from the condition before scattering to the condition after scattering. No intermediate wave patterns are present. Models which incorporate point particles cannot explain this type of transition. They must merely claim that this discontinuous momentum transfer is another mystery of QM.

The wave-based explanation of particles and photons also gives a ***better*** explanation of the emission of a photon when an electron transitions between two orbitals in an atom. There is a very good paper titled "How a Photon is Created or Absorbed" [19] that is also available online. This paper contains numerous references to experiments which show that a time period equal to the inverse bandwidth is required for an atom to make the transition between energy levels to emit a photon. For example, the D_2 transition of a rubidium atom takes about 26 ns to emit a photon (quantized wave train) at a wavelength of 870 nm. This emission has a bandwidth of 38 MHz which is the inverse of 26 ns. The wave-based model of the emission of a photon has the wave properties of the two orbitals existing simultaneously during this transition period. This results in a beat frequency equal to the photon's emission frequency which lasts for a time period equal to the inverse of photon's bandwidth. A wave-based model of both electrons and photons can explain an orbital transition taking finite time period with no intermediate states. A particle-based model must merely postulate that the transition is a discontinuous jump and ignore the experimental evidence that it takes time.

Quantized angular momentum is central to the proposed photon model. Yet linearly polarized photons do not appear to have a specific angular momentum. The proposed photon model implies that linearly polarized photons possess a specific type of angular momentum that is hard to detect. Experiments to prove or disprove this point are possible. For more information, contact the author.

8. CONCLUSION

The case has been made that spacetime is an energetic medium consisting of small amplitude waves which produce a modulation of space such that the distance between points varies by $\pm$ Planck length and perfect clocks in flat spacetime will vary by $\pm$ Planck time. These waves are primarily at Planck frequency which implies Planck energy density (10^{113} J/m^3) but lower frequencies are also present. Resonances create some favored lower frequencies which appear to be virtual particles forming and annihilating in the vacuum. This energetic spacetime field is proposed to be the new aether which is the propagation medium for the quantized waves that are photons. The spacetime field possessing superfluid properties which forces angular momentum to be quantized into units of ½ ħ and ħ. These quantized waves appear to possess particle properties because the preservation of quantized angular momentum causes all the energy of distributed waves to collapse into an absorbing particle at faster than the speed of light. This model is also supported by the following: 1) The energy density of the spacetime field was supported by a calculation using gravitational wave equations from GR. 2) The electromagnetic impedance of free space (Z_o) has been shown to be the same as the impedance of spacetime $Z_s = c^3/G$ experienced by gravitational waves. Therefore photons are waves which encounter the same impedance as gravitational waves. 3) The spacetime field has been shown to be a Lorentz invariant medium with no definable frame of reference. 4) The photoelectric effect can be explained by the waves possessing quantized angular momentum. 5) Compton scattering was shown to have a wave-based explanation that actually does a better job of explaining how the electron transitions from initial to final velocity without accelerating trough intermediate speeds. 6) The wave-based model of particles and photons gives the best explanation of the emission of a photon over a finite time period by an atom. 7) The multiple discrete fields of the standard model are replaced by the single spacetime field with multiple resonances. 8) The vacuum constants of G, c, $\hbar$ and ε_0 are evidence that the vacuum is not an empty void. Each of these constants corresponds to a property of the spacetime field.

The model of the universe which incorporates energetic spacetime answers many of the mysteries of both QM and GR. If spacetime is an empty void, there should be no universal speed limit for fermions and bosons. Mass should not be able to curve spacetime. There should not be the multiple fields of the standard model. We know that fields exist, but we have never been able to describe them in terms of something more fundamental. Now a structure has been suggested which corresponds to the QM properties of the vacuum. The uncertainty principle not only allows Planck length/time waves to exist, but the existence of these waves **causes** the uncertainty principle. This building block also becomes the new aether and the mechanism for transferring all action at a distance

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