# Single component model of the universe

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**Abstract:** This article proposes the quantum vacuum is a sea of Planck length and Planck time vacuum fluctuations; predominantly at Planck frequency. This hypothesis implies the quantum vacuum should have elasticity and impedance of $c\omega^2/G$ when wave amplitude has units of length or impedance or $c^3/G$ when amplitude is expressed as dimensionless strain. If the quantum vacuum has these properties, it would be the dominant component of the universe. Support for this is obtained from calculations which show that both gravitational waves and electromagnetic radiation also encounter this impedance of spacetime. The article then explores the possibility that this fluctuating quantum vacuum is the single universal field which generates everything observable in the universe. The next step is to see if it is possible to build a model of an electron from just this field. An electron model is proposed and successfully tested because the model exhibits an electron's approximate energy, inertia, de Broglie waves, special relativistic characteristics and apparent point particle characteristics. This is a field-based model of the universe where particles are quantifiable wave excitations. This new model generates several predictions about an electron's electrical and gravitational properties.

**Keywords:** impedance of spacetime; electron model; universal field; zero-point energy; gravitational waves

## 1 Introduction

Both experimental and theoretical physics research usually starts from the known and works towards understanding the next level of the unknown. This will be designated as the "top-down approach". There is another alternative that will be designated the "bottom-up approach". Examples of this include string theory, M theory and loop quantum gravity. These theories start with several basic starting assumptions and attempt to logically extend these assumptions to make bottom-up contact with the experimentally verified body of knowledge that constitutes established physics.

This introduction is given because this article is a new example of a bottom-up approach to understanding the universe. This bottom-up approach starts with the hypothesis that everything in the universe (all particles, forces and secondary fields) are derived from a single universal field. This universal field is essentially an expanded description of zero-point energy (ZPE) in the quantum vacuum. The approach then attempts to derive the laws of physics from this quantifiable universal field. This bottom-up approach still relies on experimentally determined facts. It just attempts to contact this established body of knowledge starting from the assumption that everything in the universe is derived from an expanded model of ZPE (the universal field).

Both fermions and bosons are currently described as possessing "wave-particle duality" [1]. The particle portion of this description is usually thought of as a physical corpuscle which possess quantized energy and has distinctly different properties from the wave portion of this duality. This article will propose a wave-based description of the universe which achieves particle-like properties from quantization of waves. A wave possessing $\hbar$ or $\hbar/2$ quantized angular momentum responds to a perturbation as a unit. This quantization is a fundamental property of the universal field (explained later). This wave-based model of the universe is useful because it generates a different perspective and different types of predictions compared to models of the universe incorporating corpuscular particles. Key to this approach is an elevation of ZPE in the quantum vacuum to the point that it has quantifiable properties capable of generating and sustaining very energetic high frequency waves.

As background, we will review the thoughts of some famous physicists which address the physical structure of the quantum vacuum. Charles Misner, Kip Thorne and John Archibald Wheeler are the authors of the authoritative textbook on general relativity titled *Gravitation* [2]. In the last chapter of this book, they specifically address the subject of the properties of ZPE in the quantum vacuum. Here are a few quotes from this chapter of the book. "No point is more central than this: empty space is not empty. It is the seat of the most violent physics…. The density of field fluctuation energy in the vacuum ~ $10^{94}$ g/cm$^3$, argues that elementary particles represent a percentage-wise almost completely negligible change in the locally violent conditions that characterize the vacuum…The vacuum has to be described properly before one has a foundational starting point for a proper perturbation-theoretical analysis." [2] This chapter also suggests the structure of this energy-like content of space. This book says, "The geometry of space is subject to quantum fluctuations in metric coefficients of the order of: $^{\text{Planck length}}/_{\text{length extension of the region under study}}$". These quotes from Misner, Thorne and Wheeler imply the described Planck length ($L_p$) vacuum fluctuations do not violate general relativity even though these QM effects have an implied density-like property with about $10^{94}$ gm/cm$^3$.

In the article, *Vacuum Quantum Fluctuations in Curved Space and the Theory of Gravitation*, [3] Andrei Sakharov proposes that field fluctuations have energy of $10^{28}$ eV (Planck energy) and exist on the scale of $L_p \approx 10^{-33}$ cm (Planck length). Sakharov extends this concept to form a connection between quantum fluctuations and the metric elasticity of space quantified by the gravitational constant.

Albert Einstein is generally credited with eliminating the need for the luminiferous ether. However, as documented in the book *Einstein and the Ether* [4], from about 1916 until his death in 1955, he believed the various fields represented ether-like physical content present in space. In these years, he used the terms "relativistic ether", "new ether" and "physical space" to convey this idea. For example, in 1934 he wrote, *"Physical space and the ether are different terms for the same thing; fields are physical states of space."* [5] In 1950 Einstein wrote "According to general relativity, the concept of space detached from any physical content does not exist." [6].

Therefore, these quoted physicists agree on the generalities that space has content and fields are physical states of space. Since we are attempting to determine the underlying structure of fields and space, the important statement implying structure is: "The geometry of space is subject to quantum fluctuations … of the order of: $^{\text{Planck length}}/_{\text{length extension of the region under study}}$". [2] Also, some of these physicists indicate that on the scale of Planck length, these quantum fluctuations have Planck energy ($10^{28}$ eV or $10^{94}$ g/cm$^3$) which implies Planck frequency oscillations.

This article will make a semantic distinction between observable energy and zero-point energy (ZPE). *Observable energy* will be defined as: *anything that generates gravity*. ZPE does not meet this definition even though it has energy-like properties including units of energy when expressed mathematically. Therefore, we need a new name to designate this vacuum activity that does not generate gravity. The vacuum fluctuations imply a state of flux. Therefore, the terms "the flux" and "flux energy" will be used to describe the energy-like vacuum fluctuations which have units of energy (kg·m$^2$/s$^2$) but do not generate gravity. The term "spacetime field" will also be used as a synonym for the quantum vacuum or universal field.

Planck units are used throughout this article. Here is a list of Planck units for reference.

| | |
|---|---|
| Planck length: | $L_p = (\hbar G/c^3)^{1/2} = 1.62 \times 10^{-35}$ m |
| Planck time: | $T_p = (\hbar G/c^5)^{1/2} = 5.39 \times 10^{-44}$ s |
| Planck frequency | $\omega_p = (c^5/\hbar G)^{1/2} = 1.86 \times 10^{43}$ rad/s |
| Planck force: | $F_p = c^4/G = 1.21 \times 10^{44}$ N |
| Planck density: | $\rho_p = c^5/\hbar G^2 = 5.16 \times 10^{96}$ kg/m$^3$ |
| Planck energy density: | $U_p = c^7/\hbar G^2 = 4.64 \times 10^{113}$ J/m$^3$ |
| Planck voltage: | $V_p = (c^4/4\pi\varepsilon_o G)^{1/2} = 1.04\times10^{27}$ V |
| Planck impedance | $Z_P = 1/4\pi\varepsilon_o c = 29.98\ \Omega$ |

## 2 Model of the quantum vacuum

In the book *The Quantum Vacuum* [7], Milonni states, "According to contemporary physics, the universe is made up of matter fields, whose quanta are fermions and force fields whose quanta are bosons. All these fields have zero-point energy" (ZPE). The objective here is to develop a model of a universal field (the "spacetime field") capable of generating everything in the universe. Therefore, this model cannot start by assuming the existence of fields. Instead, the model of the universal field must start at a more fundamental level which characterizes vacuum fluctuations of ZPE as quantifiable spatial and temporal oscillations of the vacuum. The proposed single component model of the universe is based on the following three points:

1) A volume of spacetime approximately Planck length in radius is undergoing a harmonic oscillation of its spatial and temporal properties. Within this volume, there are Planck length ($L_p$) and Planck time ($T_p$) fluctuations predominantly at Planck frequency ($\omega_p$).
2) The "spacetime field" is a sea of these harmonic oscillators which collectively propagate waves

at the speed of light and quantize angular momentum into ħ/2 units.

3) The basic building block of everything (fermions, bosons, electric charge and gravity) starts with a Planck length distortion of the spacetime field.

We will have introductory explanations of these three points, then proceed with a detailed justification and testing of these principles. We start with the first point which states that the spacetime field consists of harmonic oscillators which are undergoing rapid Planck length and Planck time fluctuations. Any model which implies the vacuum has a large energy density is usually rejected as unrealistic because the vacuum does not generate gravity. However, the proposed Planck length/time oscillation of space and time does not generate gravity. Here is the reasoning.

Imagine a hollow spherical mass with the density of a neutron star and an evacuated cavity at its center. The space in this cavity would not have gravitational acceleration but it would have a slower rate of time and larger proper distance between stationary points compared to the same space if the mass is removed. Now imagine this cavity volume if a hypothetical negative-gravity substance is substituted for the surrounding shell. The surrounding negative-gravity substance would produce the opposite gravitational effect on time and space. The cavity would have a faster rate of time and smaller proper distance between stationary points compared to empty space.

Next, imagine this cavity being about Planck length in radius. The space in this cavity is oscillating at Planck frequency between the spatial and temporal characteristics of gravity and negative-gravity. This is the proposed description of the fundamental ZPE vacuum fluctuations taking place in the quantum vacuum. This sinusoidal oscillation is *equal parts gravity and negative-gravity distortion of space and time.* This type of oscillation everywhere produces no gradient in the rate of time or spatial gradient. There is no gravitational collapse because there are no macroscopic spatial or temporal gradients.

The second of the three points states the spacetime field is a closely packed sea of many of these harmonic oscillators. A larger volume of vacuum with radius $r$ contains $k(r/L_p)^3$ of these oscillators where $k$ is near 1. This larger volume is proposed to also exhibit an overall spatial fluctuation of $L_p$. Therefore, the distance between two more widely separated stationary points fluctuates by about $L_p$. This larger volume also exhibits a temporal fluctuation such that two hypothetical perfect point clocks will differ by ± $T_p$. These spatial and temporal group fluctuations are at a lower frequency than $\omega_p$. This lower frequency is determined by time required for light to propagate across radial distance $r$.

This model of the quantum vacuum has support. It has been established [8 - 11] that distance between two points cannot be measured to an accuracy of Planck length and time cannot be measured to an accuracy of Planck time. The proposed properties of the quantum vacuum would explain this effect. Spatial and temporal fluctuations of this magnitude can be thought of as the background "noise" of the vacuum. This vacuum noise, combined with the quantized wave properties of particles, introduces probability to QM.

The spacetime field is proposed to exhibit superfluid properties and this relates to the quantization of angular momentum referenced in the second point. A Bose-Einstein condensate is a superfluid and will be used as an example. When angular momentum is introduced into a Bose-Einstein condensate, the bulk superfluid does not rotate. Instead, the superfluid quantizes angular momentum into discrete rotating vortices. Each vortex possesses ħ angular momentum [12 -14]. The analogy to a vortex with quantized angular momentum will later be extended to fermions and bosons exhibiting wave-particle properties and quantized angular momentum. Therefore, this quantized angular momentum ultimately gives particle-like properties to fermions and bosons.

The third point states that the universal field not only has Planck length vacuum fluctuations, but Planck length is also a universal wave amplitude for all fermions and bosons. For example, electrons will be shown to be a rotating wave with Planck length displacement amplitude. Also, Planck length is key to the derivation of both an electron's gravity and an electron's electrical charge. One last point about notation: This article will use the symbol $L_p$ to represent Planck length rather than the usual $l_p$. This symbol change adds clarity and seems appropriate for the elevated importance of Planck length.

## 3 Quantifying the quantum vacuum

The previous verbal description of the quantum vacuum from point #1 needs to be converted to equations which can then be tested. We will start with the well-known spectral energy density of ZPE which is: $\rho_o(\omega) = \hbar\omega^3 / 2\pi^2 c^3$ [7]. Equation (1) below integrates this spectral energy density to obtain the energy density between two frequencies; a lower frequency $\omega_1$ and a higher frequency $\omega_2$. Equation (1) carries this one step further (designated by arrow ⇒) and assumes we want all frequencies equal to or less than $\omega_2$. Therefore, $\omega_1 = 0$ and $\omega_2$ is merely designated ω. Also, the numerical constant $1/8\pi^2$ has been replaced with $k$ to broaden the usefulness of this equation as discussed later.

$$U_z = \int_{\omega_1}^{\omega_2} \frac{\hbar\omega^3}{2\pi^2 c^3} d\omega = \frac{1}{8\pi^2}\frac{\hbar}{c^3}\left(\omega_2^4 - \omega_1^4\right) \Rightarrow k\frac{\hbar\omega^4}{c^3} \quad (1)$$

Next, we want to test whether this sea of Planck length vacuum fluctuations can be treated as a quantum mechanical acoustic medium. A quantum mechanical wave with acoustic properties should slightly distort the sea of Planck frequency harmonic oscillators. Individual oscillators should slightly increase and decrease their frequency as a wave passes. This causes the flux to be able to absorb and return energy to the propagating wave. The ability to store and return energy to a wave means the spacetime field should exhibit elasticity and acoustic impedance. We want to understand and quantify these acoustic properties of the spacetime field (if they exist). We will test the hypothesis that the spectral energy density of Eq. (1) is caused by vacuum oscillations with amplitude of Planck length ($L_p$).

$$U = \frac{k}{c} A^2 \omega^2 \mathcal{Z} \ \ \text{J/m}^3 \quad (2)$$

$$\frac{k}{c}\left(\frac{\hbar G}{c^3}\right)\omega^2 Z_d = k\frac{\hbar\omega^4}{c^3} \quad (3)$$

$$Z_d \equiv \frac{c\omega^2}{G} \ \ \text{kg/m}^2\text{s} \quad (4)$$

$$Z_s \equiv \frac{c^3}{G} \approx 4.04\times 10^{35} \ \ \text{kg/s} \quad (5)$$

There is a universal equation for the intensity ($I$) of any type of wave propagation $I = kA^2\omega^2 Z$ where $A$ is amplitude, $k$ is a numerical constant and $Z$ is the impedance of the acoustic medium. This equation can be converted to energy density ($U$) by dividing intensity by the speed of propagation which for waves in spacetime is $c$ yielding: $U = I/c$. This results in Eq. (2).

We can solve for the impedance of spacetime created by Planck length vacuum fluctuations if we equate Eq. (1) to Eq. (2) and set amplitude $A$ equal to Planck length $A = L_p = (\hbar G/c^3)^{1/2}$. Then we solve for $Z$. This is done in Eq. (3) yielding Eq. (4) which is the "displacement impedance of spacetime" $Z_d \equiv c\omega^2/G$. This is an important step because we have just generated the impedance of a medium with both Planck length fluctuation amplitude and the spectral "energy" density of ZPE (flux energy density).

In equation (3) the substitution for the amplitude term was $A = L_p$. Amplitude can also be expressed as strain (maximum slope) which is amplitude expressed as a dimensionless number. The strain amplitude substitution into Eq. (3) would then be $A = L_p/\lambdabar = (L_p\omega/c)$ where reduced wavelength $\lambdabar = \lambda/2\pi = c/\omega$. This substitution into Eq. (3) (replacing $\hbar G/c^3$ with $(L_p\omega/c)^2$) yields another way of expressing the impedance of spacetime which is designated the "strain impedance of spacetime $Z_s \equiv c^3/G$". This same impedance will be derived in the next section using another approach.

# 4 Gravitational waves

## 4.1 Impedance calculation

The equations $Z_d \equiv c\omega^2/G$ and $Z_s \equiv c^3/G$ were obtained by assuming the spectral energy density of ZPE is caused by Planck length fluctuations of the vacuum. If the quantum vacuum is proposed to be an elastic medium with impedance, then is there any test which confirms this hypothesis? Surprising support comes from gravitational waves (GWs). In the 1991 book titled *Detection of gravitational waves* [15], the authors wrote "Starting from Einstein's field equation … the coupling constant $c^4/8\pi G$ can be considered a metrical stiffness (see Sakharov 1968 [3])… By analogy with acoustic waves, we can identify the quantity $c^3/G$ with the characteristic impedance of the medium. … The problem of detecting gravitational wave radiation can be understood as an impedance-matching problem." This same point is made in the more recent (2012) book on GW detectors [16]. Neither of these books show the derivation of impedance $c^3/G$ encountered by GWs. However, both books [15, 16] give the equation for the intensity of a GW in the limit of a weak plane wave. This equation is shown below as Eq. (6) in a slightly modified format.

$$I = \left(\frac{1}{16\pi}\right)\left(\frac{\Delta L}{L}\right)^2 \omega^2 \left(\frac{c^3}{G}\right) \ \ \text{kg/s}^3 \quad (6)$$

Equation (6) has arranged the terms in the GW intensity equation to permit easy comparison to the universal intensity equation $I = kA^2\omega^2 Z$. Making this comparison, it is obvious that $k = 1/16\pi$, amplitude $A = \Delta L/L$, and impedance ($Z$) is strain impedance

$Z_s \equiv c^3/G$ as shown in Eq. (5). Therefore, the idea of making an analogy between GWs and acoustic waves is not new. However, making the impedance connection to the quantum vacuum with ZPE and extending this to characterize a universal field is believed to be new.

In Eq. (6), $\Delta L/L$ is the GWs strain amplitude (maximum slope). When interferometers are used to detect GWs, $\Delta L$ is interpreted as the measured fringe shift in an interferometer and $L$ is the round-trip path length of the interferometer. If we assume the interferometer's round-trip path length, $L$, is less than about 10% of the GW wavelength, then the maximum strain (maximum slope of the sinusoidal GW) is approximated by $\hbar \approx \Delta L/L$ where $\hbar^2 = \hbar_+{}^2 + \hbar_\times{}^2$. The subscripts + and × represent GW polarizations. However, $\hbar \approx \Delta L/L$ is an approximation which becomes completely invalid as the round-trip distance ($L$) approaches the GW wavelength. The exact strain amplitude (maximum slope) is $\delta/\lambda\!\!\!^-$ where $\delta$ is the magnitude of the maximum displacement (with units of length) produced by the sinusoidal GW over an entire wavelength and lambda bar $\lambda\!\!\!^-$ is reduced wavelength $\lambda\!\!\!^- \equiv \lambda/2\pi$. When the strain amplitude approximation $\Delta L/L$ is replaced with the exact strain amplitude $\delta/\lambda\!\!\!^-$, then it is possible to restate Eq. (6) in a form where amplitude is $\delta$.

$$I = \left(\frac{1}{16\pi}\right)\delta^2\omega^2\left(\frac{c^3}{G\lambda\!\!\!^-{}^2}\right) \text{ kg/s}^3 \tag{7}$$

$$Z_d \equiv \frac{c^3}{G\lambda\!\!\!^-{}^2} = \frac{c\omega^2}{G} \text{ kg/m}^2\text{s} \tag{8}$$

Equation (7) expresses amplitude $A = \delta$ (displacement amplitude) with dimensions of length. This change transfers the reduced wavelength $\lambda\!\!\!^-$ to become part of impedance. Equation (8) defines "displacement impedance $Z_d$" obtained from Eq. (7). This is the same impedance as Eq. (4) which assumed ZPE had Planck length displacement amplitude. Therefore, GWs encounter the predicted impedance that should exist in spacetime if Planck length ($L_p$) vacuum fluctuations are present.

In acoustics, the wave amplitude is usually defined as the maximum particle displacement $\delta$ from the center position. A GW does not physically displace the center of mass of an isolated object such as an interferometer mirror suspended by wires. Instead, the space between the mirrors is affected such that the distance between mirrors as measured by a laser beam can change without physically displacing the center of mass of the mirrors. There is no concise wording in English to express this concept, so hereafter we will refer to "displacement amplitude" of a GW or other wave in spacetime and the reader must accommodate this imprecise simplification to imply a distortion of the properties of space.

### 4.2 Flux density from gravitational waves

Next, we will calculate the implied flux density of the quantum vacuum using GWs and the analogy of wave propagation in an acoustic medium. The following analysis will imply GWs encounter a property of spacetime which has units of density but does not meet the commonly accepted definition of density having rest mass or generating gravity. Therefore, the term "flux density" will be used to indicate this is a QM property of spacetime which has units of density. This density-like property (designated $\rho_\omega$) is only revealed to waves which distort the harmonic oscillators that are the QM structure of the spacetime field.

The specific impedance of an acoustic medium is defined as $z \equiv \rho c_a$ kg/m$^2$s where $\rho$ is the density of the acoustic medium and $c_a$ is the acoustic speed of propagation. For GWs, $c_a = c$. Therefore, we can equate $z = Z_d$ (which is: $\rho_\omega c = c\omega^2/G$) and solve for the flux density $\rho_\omega$ of the medium. The answer is Eq. (9). GWs have the numerical constant $k = 1/16\pi$ but the symbol $k$ is used to broaden these equations because other waves in space have different numerical constants.

$$\rho_\omega = k\frac{\omega^2}{G} = k\left(\frac{\omega}{\omega_p}\right)^2 \rho_p = k\left(\frac{L_p}{\lambda\!\!\!^-}\right)^2 \rho_p \tag{9}$$

$$U_\omega = k\frac{c^2\omega^2}{G} = k\left(\frac{\omega}{\omega_p}\right)^2 U_p \tag{10}$$

$$U_{\text{zpe}} = k\frac{\hbar\omega^4}{c^3} = k\left(\frac{\omega}{\omega_p}\right)^4 U_p \tag{11}$$

Equation (9) gives the flux density encountered by GWs and Eq. (10) converts this to flux energy density $U_\omega$. If we set $\omega = \omega_p$, (Planck frequency), then the indicated flux energy density of the spacetime field is: $U_\omega = kU_p = k\ 4.6\text{x}10^{113}$ J/m$^3$. However, Eq. (10) says waves with lower frequency than Planck frequency encounter lower flux energy density because of the $(\omega/\omega_p)^2$ term. This is because lower frequency waves experience impedance mismatch and only partially couple to $U_p = c^7/\hbar G = 4.6\times10^{113}$ J/m$^3$.

However, one puzzle remains. Equation (1) calculated the ZPE density by integrating the ZPE spectral energy density and obtained $U_z = k\hbar\omega^4/c^3$ which is repeated in Eq. (11). Equations (10 and 11) are two different equations for flux energy density. The following example illustrates the difference. If $\omega = 1250$ rad/s (~200 Hz), then $U_\omega$ from Eq. (10) is about $10^{80}$ times larger than $U_z$ from Eq. (11). The question is: Why should the flux energy density of ZPE ($U_z$) shown in Eq. (11) be much smaller than $U_\omega$ shown in Eq. (10)?

The answer is that Eq. (11) calculated the flux energy density of ZPE frequencies equal to or less than ω while Eq. (10) calculated the flux energy density at all frequencies encountered by a wave in space with frequency ω. A wave in space such as a GW with frequency ω interacts with both higher and lower ZPE frequencies. Even though there is a frequency mismatch term, the frequencies higher than ω dominate because the spectral energy density increases with $\omega^3$. In the limit of Planck frequency, both Eq. (10 and 11) give the same answer which is: $U_\omega = U_z = kc^7/\hbar G^2$. This is because no frequency higher than Planck frequency is possible.

### 4.3 Numerical examples using GW150914 data

The implications of Eqs. (9) and (10) can be illustrated using the observed characteristics of the GW detected by LIGO in September 2015 designated: GW150914 [17, 18]. This GW was a chirp that went from about 30 Hz to 250 Hz. We will analyze the highest amplitude portion of this wave. This had: $\omega \approx 1250$ rad/s (about 200 Hz), $\lambda\!\!\!^{-} = 2.4 \times 10^5$ m, propagation speed $c$, strain amplitude $\hbar = 1.25 \times 10^{-21}$, and intensity of $I = 0.02$ w/m$^2$ calculated using Eq. (6). The maximum "displacement amplitude" (δ) is calculated from $\delta = \hbar\lambda\!\!\!^{-} \approx 3 \times 10^{-16}$ m. There are two ways of calculating the flux density $\rho_\omega$ of spacetime field encountered by this GW at 200 Hz. One way is to make the appropriate substitutions for $I$, ω and δ into the acoustic equation $\rho = I/\omega^2\delta^2 c$. The other way is to use Eq. (9) setting $k = 1/16\pi$ and $\omega = 1250$ rad/s. Both give the same answer which is $\rho_\omega = 4.7 \times 10^{14}$ kg/m$^3$ for a GW at 200 Hz. This is about 250,000 times the density of a white dwarf star. This flux density of the vacuum encountered by GWs converts to flux vacuum energy density of $U_{gw} = 4 \times 10^{31}$ J/m$^3$. This is the flux energy density that would be required to propagate a 200 Hz GW at the speed of light with intensity of 0.02 w/m$^2$ and strain amplitude of only $\Delta L/L \approx 1.25 \times 10^{-21}$.

Stated another way, the GW is causing an oscillating distortion of space. The ZPE harmonic oscillations of the vacuum are responding by elastically resisting this oscillating distortion by exhibiting impedance. The $\omega^2$ term in Eq. (8) means when $\omega = 0$, then the displacement impedance of the spacetime field ($Z_d = c\omega^2/G$) also equals zero ($Z_d = 0$). Therefore, only waves in spacetime with finite frequency encounter the enormous impedance of spacetime. Static spacetime exhibits impedance of zero.

So far, we have analyzed GW150914 from the data obtained at the earth's distance of about 1.3 billion light years. At this distance the GWs had intensity of about 0.02 w/m$^2$. It is informative to also look at a much closer distance of ½ wavelength ($7.5 \times 10^5$ m). from the merging black holes. The reported peak power of GW150914 was $3.6 \times 10^{49}$ w [17]. This power achieves intensity of about $I \approx 5 \times 10^{36}$ w/m$^2$ at this relatively close distance. The displacement amplitude required to achieve this intensity at 200 Hz is $\delta \approx 4.8$ km or about 2% of the reduced wavelength $\lambda\!\!\!^{-}$ of the GW. At speed of light propagation, this intensity converts to the GW having energy density of $U = I/c = 1.7 \times 10^{28}$ J/m$^3$. This GW at this distance had about 100 times the energy density of a white dwarf star! Even this tremendous energy density is easy for the proposed Planck length vacuum fluctuations of ZPE to propagate. At 200 Hz, the flux energy density of the propagation medium available to GWs is about $U_{gw} = 4 \times 10^{31}$ or $\rho_\omega = 4.7 \times 10^{14}$ kg/m$^3$. Therefore, at 200 Hz the propagation medium has about 2400 times higher flux energy density than the energy density of this GW and can easily propagate a GW with $I \approx 5 \times 10^{36}$ w/m$^2$.

## 5 Discussion

### 5.1 Single component model of the universe

We have derived both $Z_d = c\omega^2/G$ displacement impedance and $Z_s = c^3/G$ strain impedance from the assumption that ZPE is $L_p$ vacuum fluctuations and from the impedance encountered by GWs. These derivations not only use equations from two different branches of physics (general relativity and quantum field theory) but the derivation from GWs used macroscopic wave amplitudes and the ZPE derivation assumed Planck length displacement amplitude for the quantum vacuum.

If the quantum vacuum has the proposed properties of Planck length/time vacuum fluctuations and enormous impedance, then the quantum vacuum becomes the dominant component of the universe. It is proposed here that this is the only component of the universe. In other words, the Planck length/time fluctuating vacuum has the properties of a universal field which generates all particles and forces. The multiple fields designated in the standard model are modeled as multiple resonances within the single universal field.

The simplicity of such a model of the universe makes it possible to quantify and test. This article will demonstrate the plausibility of the proposed universal field forming particles and forces by showing it is possible to develop a wave-based model of an electron. This model will be tested to see if it approximately exhibits an electron's: 1) energy, 2) inertia, 3) de Broglie waves, and 4) point particle properties Then we will see if we can derive simplified forms of the laws of physics: 1) gravity, 2) electrical charge and 3) electrostatic force, These plausibility tests will use approximations.

### 5.2 de Broglie wave model from confined light

Fortunately, the design choice is helped because there is a remarkable similarity between the properties of light confined in a 100% reflecting optical resonator and the properties of a fundamental particle. We will start by explaining how confined light exhibits similar properties to a particle's de Broglie waves. This is the first step in generating the model of an electron model because simulating an electron's de Broglie wave characteristics requires a precise frequency and wave geometry.

Photons are usually visualized as freely propagating. However, photons exhibit different characteristics when they are confined by reflectors to a specific volume (specific frame of reference). This analysis will assume laser light reflecting between two 100% reflecting mirrors of a perfect optical resonator. This bidirectional electromagnetic (EM) wave propagation forms oscillating standing waves with uniform amplitude. This coherent confined light has a specific wavelength $\lambda_o$, frequency $\omega_o$ and energy $E_o$ in the stationary frame. Figure 1 shows a moving optical resonator.

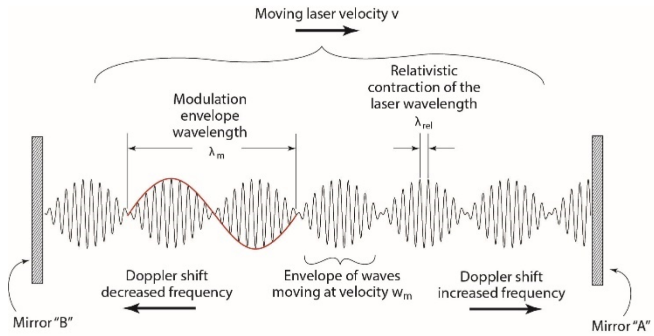



**Figure 1.** This figure shows the wave pattern present in a laser moving at 5% the speed of light. This pattern is the result of different Doppler shifts for light propagating in opposite directions.

The optical resonator in Figure 1 is moving from left to right with a constant velocity ($v$). Light propagating in the direction of motion is Doppler shifted up in frequency and light propagating the opposite direction is Doppler shifted down in frequency. This causes the depicted modulation envelope beats instead of the uniform amplitude standing waves that would be present in a stationary frame of reference. Fig. 1 is a snapshot of an instant in time that freezes these waves. The modulation envelope is an interference effect that propagates faster than the speed of light in the translation direction. Fig. 1 defines the "modulation envelope wavelength $\lambda_m$" as the wave in red formed by the modulation. Note that this red wave encompasses two of the modulation envelope maximums. It is not obvious from this figure, but there is also a 180-degree shift in the phase of the laser waves at each null. Therefore, the complete 360-degree cycle requires two envelope maximums.

This effect has been mathematically analyzed in [19]. Only a key step and the conclusions are presented here. In the stationary frame, the standing waves have angular frequency $\omega_o$ and wavelength $\lambda_o$. The frame of reference of Fig. 1, is moving to the right with velocity $v$. Therefore, the left ($L$) and right ($R$) counter propagating waves have different Doppler shifted frequencies designated $\omega_L = \gamma(1 - \beta)\omega_o$ and $\omega_R = \gamma(1 + \beta)\omega_o$ where $\beta = v/c$ and $\gamma = (1 - \beta^2)^{-1/2}$. A key intermediate wave equation from [19] is Eq. (12) where $k_R = \omega_R/c$ and $k_L = \omega_L/c$.

$$\psi = e^{i(k_R x - \omega_R t)} + e^{i(k_L x - \omega_L t)} \tag{12}$$

$$\lambda_m = \frac{2\pi c}{\gamma\beta\omega_o} = \frac{\lambda_o}{\gamma\beta} \tag{13}$$

$$\lambda_{rel} = \frac{2\pi c}{\gamma\omega_o} = \frac{\lambda_o}{\gamma} \qquad (14)$$

$$v_{phase} = \frac{c}{\beta} = \frac{c^2}{v} \qquad (15)$$

$$v_{group} = \beta c = v \qquad (16)$$

After several more steps, reference [19] identifies the modulation envelope wavelength as Eq. (13) and the relativistic contracted wavelength $\lambda_{rel}$ as Eq. (14). The modulation envelope waves are an interference effect that moves faster moving faster than the speed of light with velocity $v_{phase}$ given in Eq. (15). The standing waves with relativistic contraction move at group velocity ($v_{group} = v$) as indicated in Eq. (16). This is the same velocity as the moving frame of reference. Equations (15, 16) also apply to de Broglie waves.

$$\lambda_m = \frac{\lambda_c}{\gamma\beta} = \frac{h}{mc}\frac{c}{\gamma v} = \frac{h}{\gamma m v} = \frac{h}{p} = \lambda_d \qquad (17)$$

Equation (13) is $\lambda_m = \lambda_o/\gamma\beta$ where $\lambda_o$ is the laser wavelength of confined light in a stationary frame. If we set $\lambda_o$ equal to a particle's Compton wavelength (set: $\lambda_o = \lambda_c = h/mc$), then Eq. (17) shows that $\lambda_m = h/p = \lambda_d$. In words, when $\lambda_o = \lambda_c$, the modulation wavelength $\lambda_m$ of confined light equals a particle's de Broglie wavelength ($\lambda_d$) when both are moving at the same velocity. This is an important first step in defining our electron model because it says that the model should be based on waves in the spacetime field with a wavelength equal to an electron's Compton wavelength. Therefore, the frequency of these waves should be equal to an electron's Compton angular frequency $\omega_c = 2\pi c/\lambda_c = mc^2/\hbar = 7.76\times10^{20}$ rad/s.

Equation (14) describes an effect which is best described by looking at Fig. 1. This figure has the label: "relativistic contraction of the laser wavelength $\lambda_{rel}$". The bidirectional waves viewed in a moving frame of reference do not have exactly the same standing wavelength as the stationary standing waves $\lambda_o$. Bidirectional waves exhibit the special relativity property relativistic wavelength contraction quantified as $\lambda_{rel} = \lambda_o/\gamma$. This contraction is of the exact size required to match the relativistic contraction of the distance between the mirrors. This keeps the number of standing waves between the mirrors constant.

In Fig. 1, no support is shown for the two mirrors. But imagine these mirrors are attached to a "rigid" metal bar which maintains a constant proper distance. Why do the fundamental components of this bar appear to undergo relativistic contraction when viewed in a moving frame of reference? If everything in the metal bar (including forces) is ultimately formed by waves with properties similar to the confined bidirectional waves in Fig. (1), this would produce the relativistic contraction of special relativity. Reference [19] also shows that the energy of the confined light exhibits a relativistic energy increase of $E = \gamma mc^2$ and the inertia increase is $p = \gamma m v$. Relativistic time dilation is not shown, but this also can be derived from the assumption of confined waves propagating at the speed of light. All of special relativity can be derived from the assumption that everything physical in the universe is based on waves propagating at the speed of light but confined to a specific volume. The example has used EM waves, but this will change later to waves in the spacetime field.

Returning to the de Broglie waves, Fig. 1 shows the light propagating along an optical axis which is parallel to the velocity vector. The mathematical analysis also makes this simplifying assumption. What happens if the propagation direction is not parallel to the optical axis? The easiest way to analyze all possible orientations is to assume monopole emission of light emanating from a point at the center of a spherical reflector. The reflected light would return to the center, forming spherical standing waves.

Figure 2A shows a cross section of just outgoing waves if they are viewed in a frame of reference moving to the right at about 20% the speed of light. The effect of the Doppler shift on the outgoing waves is obvious. Figure 2B shows the Doppler effect on the incoming (reflected) waves. Figure 3 shows a spherical reflector and the result of combining Figs. 2A and 2B.

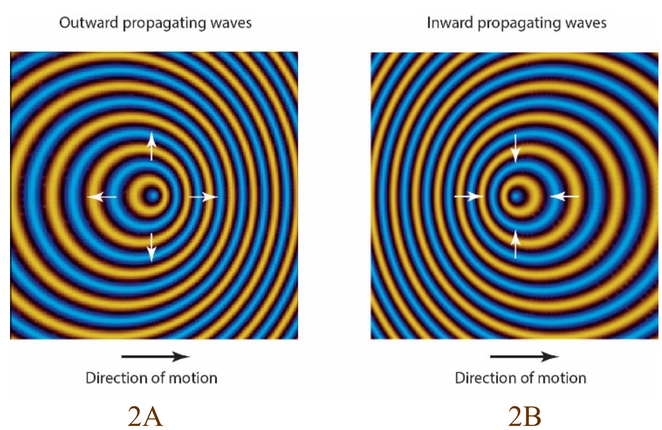



**Figure** 2A Doppler shift on outward propagating waves
**Figure** 2B Doppler shift on inward propagating waves

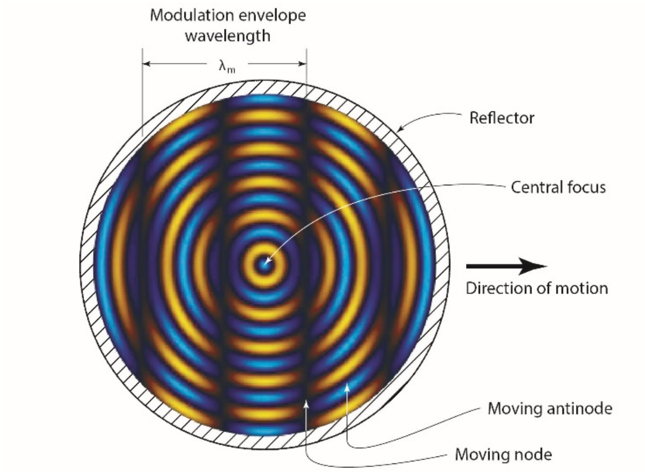



**Figure 3** Interference pattern produced when the Doppler shifted wave patterns from Fig. 2A and 2B are added together.

The modulation pattern in Fig. 3 moves in the direction of translation with velocity faster than the speed of light. The modulation envelope has wavelength designated $\lambda_m$ in Figs. (1, 3). These waves with stationary wavelength $\lambda_o$, form wave modulation envelopes with the characteristics described in Eq. (13 – 16). This corresponds to a particle's de Broglie wave characteristics if the EM frequency equals to a particle's Compton frequency and the velocity is the same. This pattern will also exhibit relativistic length contraction and relativistic increase in energy.

### 5.3 Inertia and gravitational weight simulation

The Higgs boson interacts with W and Z bosons and gives them inertia (rest mass). However, only a small percentage of the inertia of protons and neutrons is currently explained as being derived from an interaction with the Higgs field. This is mentioned because there is no mystery about the source of inertia of confined light. When light is confined in an optical resonator, there is equal photon pressure (equal opposing forces) on both reflectors. However, if the optical resonator is accelerated, the opposing forces on the mirrors are unequal. In the time it takes for light to travel the distance between reflectors, there is a change in velocity due to the acceleration. The light striking the rear reflector is Doppler shifted up in frequency and the light striking the front reflector has been Doppler shifted down in frequency. There is unequal pressure on the reflectors generating a net force which resists acceleration. This net force exactly equals the inertial "force" expected from a mass of equal energy. Suppose there is an electron and a positron in a reflecting box. There must be no difference in inertia if these particles annihilate and the energy converts to an equal energy of confined photons. Any difference would be a violation of the conservation of momentum.

The inertial force and weight of confined light has been examined in more detail [20, 21]. The equivalence principle implies the gravitational force of confined light must equal the inertial force produced by equal acceleration. This is mentioned because a wave-based particle model automatically generates the inertia of confined light with equal energy. Even chaotic propagation of confined light exhibits the inertial force or gravitational force of a particle with equal energy.

The point is that this wave-based model of particles explains the inertia of these particles without requiring an interaction with the Higgs field. The inertia of an electron with energy of 511,000 eV must exactly match the inertia of confined photons with total energy of 511,000 eV. This inertia match also applies to all hadrons and even Higgs bosons. The proposed particle model has no problem achieving this match.

### 5.4 Proposed wave-based electron model

While the previous analysis assumed a specific wavelength of coherent light, most of these effects could have used incoherent light confined in any container. For example, to generate an electron's inertia, gravitational weight, relativistic length contraction, relativistic energy and relativistic time dilation, the only requirement is that the confined EM radiation must equal an electron's energy. The simulation of the electron's de Broglie waves is different. To achieve an electron's de Broglie wave properties, the underlying frequency must equal the electron's Compton frequency. Also, the waves must be bidirectional radial standing waves. Some mechanism for reflecting these waves is required to confine these waves. This will be discussed later.

We also previously decided that the electron model must incorporate $\hbar/2$ quantized angular momentum when measured on a specific axis. Since the spacetime field quarantines angular momentum, this is the key property that allows a wave in the spacetime field to be confined to a specific volume and acquire particle-like properties. Therefore, the model must be modified from the monopole emitter shown in Figs. (1, 2) to a wave with $\hbar/2$ quantized angular momentum rotating at angular frequency $\omega_c$. Furthermore, this must be a dipole wave in spacetime which is limited to displacement amplitude of $L_p$ and $T_p$. This is the type of wave that is formed when $\hbar/2$ quantized angular momentum is introduced into the spacetime field. With these design requirements, the following wave-based model of an electron will be proposed, then subjected to numerous tests.

The central core of an electron is a dipole wave in the spacetime field with Planck length/time displacement amplitude. This is a rotating wave possessing $\hbar/2$ quantized angular momentum when measured on a single axis. This wave forms a closed loop that is approximately one Compton wavelength in circumference and rotates at an electron's Compton angular frequency ($\omega_c = \hbar/mc = c/\lambda\!\!\!^{-}_c$). This is a diffuse wave without a sharp boundary, but with a mathematical radius of $\lambda\!\!\!^{-}_c = \hbar/mc = c/\omega_c \approx 3.86\times10^{-13}$ m.

This rotating wave is attempting to dissipate, but its angular momentum is quantized, and its frequency forms a resonance within the spacetime field. The resonance establishes density variations within the spacetime field that form a spherical Bragg reflector for wavelength $\lambda\!\!\!^{-}_c$. Rotating standing waves form external to the mathematical radius which return energy and exert the required pressure on the core. These standing waves not only stabilize the rotating core, but they also generate the electron's electric and gravitational fields.

This concept is difficult to illustrate in figures because it is a 3-dimensional chaotic rotation that has an expectation rotational axis, but all rotational directions are present with reduced amplitude. However, Figs. 4 is an attempt to illustrate the waves of a stationary electron viewed with the rotational axis pointing towards the viewer. This figure freezes an instant in time for a distortion of spacetime that is chaotically rotating at about $10^{20}$ Hz.

In Fig. 4, the central core is the spherical volume containing the central bright yellow and blue volumes. (hereafter called "lobes"). This is a dipole wave in spacetime with Planck length amplitude that forms a closed loop, one Compton wavelength in circumference. These lobes distort space such that a semi-circular (180-degree) arc with radius $\lambda\!\!\!^{-}_c$ through the yellow lobe is longer than expected from geometry by approximately $L_p$. A similar 180-degree arc through the blue lobe is shorter than expected by approximately $L_p$. As this rotates, there is not only a modulation of distance, but there is also a modulation of the rate of time such that a perfect clock inside the core of an electron would speed up and slow down as the blue and yellow lobes passed over the clock. A second perfect clock, not encountering the electron's time modulation, would show the electron is producing a ± Planck time modulation at the electron's Compton frequency.

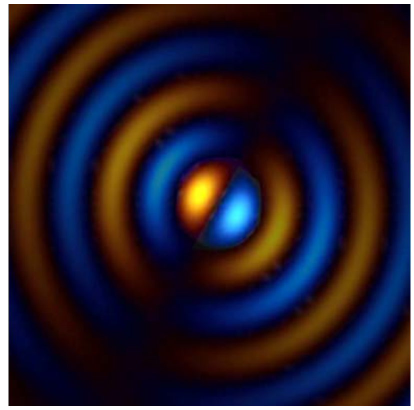
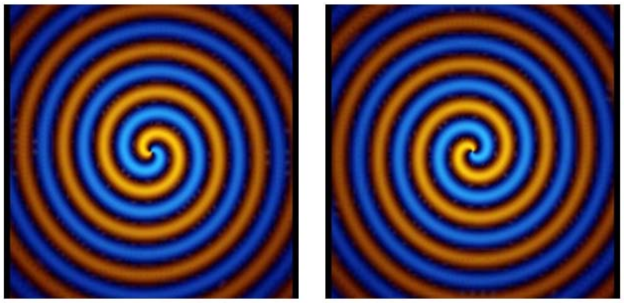


**Figure 4:** The rotating wave pattern which generates the proposed electron model. The two central lobes form the rotating core. Bidirectional "standing waves" (also rotating) form external to this core. These external waves produce not only the electro's de Broglie waves but also the electron's electric and gravitational fields.

Within the core volume with radius $\lambda\!\!\!^{-}_c$, all the ZPE vacuum fluctuations at approximately Planck frequency are still present. The additional modulation at frequency $\omega_c$ represents an additional energy density. We can only measure differences in energy. Therefore, we ignore the vast flux energy density of the vacuum fluctuations and are only able to detect the additional concentration of energy from the rotating dipole wave which we recognize as an electron.

The core boundary (the mathematical radius) is approximately the first black circular null surrounding the two central lobes in Fig. 4. It is intuitive to think of the two core lobes as generating the bidirectional waves external to the core. However, Fig 5A and 5B are the sinusoidal Archimedean spirals which generated Fig. 4 when they were added together. The equation for a single line Archimedean spiral is $r = a + b\theta$. This equation uses polar coordinates ($r$, $\theta$). The parameter "$a$" turns the spiral and "$b$" specifies the progression distance between successive turns. Figs. 5A and 5B show a sine wave turned into an Archimedean spiral. For example, a circle drawn with its center corresponding to the origin of the spirals encounters both yellow and blue waves in 360 degrees. With yellow being positive and blue being negative, the amplitude forms a sine wave.



5A 5B

**Figure 5A and 5B**: These figures show the outgoing (5A) and incoming (5B) waves that form Fig. 4. These Archimedean spirals are rotating counterclockwise at the electron's Compton frequency ($\omega_c \approx 7.8\times10^{20}$ rad/s).

Figure 5A was created by assuming a sinusoidal Archimedean spiral rotating counterclockwise. Figure 5B is created assuming the Archimedean spiral in Fig 5A reflects off a circular reflector (not shown). The spiral in Fig. 5B appears to be a spiral with the opposite rotation direction compared to Fig. 5A. However, Fig. 5B represents the reflected waves propagating inward. The two spirals are both rotating counterclockwise at the electron's Compton frequency. The combination forms the interference pattern shown in Fig. 4. Even the bright central lobes in Fig. 4 are the result of adding together the bidirectional waves of figures 5A and 5B.

The same way that the interference between bidirectional waves create modulation envelopes that propagate faster than the speed of light in Fig. 1, these interference patterns in Fig. 4 also are rotating around the electron's core with a tangential velocity faster than the speed of light. The entire wave pattern depicted in Fig 4 is rotating as a unit at the electron's Compton frequency.

Rather than a single reflector assumed in the computer model, the reflection in the model of an electron is assumed to be the result of a nonlinear effect which generates periodic flux density variations in the surrounding spacetime field. This periodicity is the equivalent of a multilayer dielectric reflector that reflects waves in spacetime with an electron's Compton wavelength back towards the core. This has some similarity to laser light being reflected by acoustic waves in a transparent material (Bragg reflection). Stimulated Brillouin scattering is a related effect where the laser light itself creates acoustic waves in a transparent medium which then reflect the light in the reverse direction. The stimulated Brillouin scattering creates a frequency shift which is not present for this proposed resonance effect in the spacetime field.

For counter propagating waves traveling at the speed of light, energy density $U$ and pressure $P$ are equivalent with the relationship of $U = P$. However, for random propagation such as blackbody radiation in a closed cavity, the relationship is $U = 3P$. The units of energy density and pressure are: $\mathrm{J/m^3} = \mathrm{N/m^2} = \mathrm{kg/s^2m}$. This is mentioned because the energy density of the electron model is about $U \approx 10^{24}\ \mathrm{J/m^3}$. Therefore, the electron's internal pressure is approximately $10^{24}\ \mathrm{N/m^2}$. The counter propagating waves external to the core and the surrounding spacetime field must be able to supply this much opposing pressure to stabilize the electron model. At frequency $\omega_c = 7.8\times10^{20}$ rad/s, the flux has energy density of $U_\omega = kc^2\omega^2/G \approx 10^{68}\ \mathrm{J/m^3}$. This converts to the spacetime field being able to generate a maximum pressure of $\sim10^{68}\ \mathrm{N/m^2}$. Therefore, the flux can easily exert enough pressure to stabilize the electron model. Point particle models cannot be stabilized by any known mechanism.

## 6. Analysis of the electron model

### 6.1 Electron Energy Calculation

It is possible to calculate the approximate energy in this model of an electron because we know the displacement amplitude, $A = A_d = L_p = (\hbar G/c^3)^{1/2}$, frequency, $\omega = \omega_c = m_e c^2/\hbar = c/\lambda\!\!\!^{-}_c$, displacement impedance $Z = Z_d = c\omega_c^2/G$ and the approximate volume $V = k\lambda\!\!\!^{-}_c{}^3 = k(c/\omega_c)^3$. Equation (2) gives energy density $U$, so the energy equation is merely energy density times volume: $E = UV$.

$$E = UV = kA^2\omega^2 ZV/c = kL_p{}^2\omega_c{}^2 Z_d V/c$$
$$= k\,(\hbar G/c^3)\omega_c{}^2(c\omega_c{}^2/G)(c/\omega_c)^3(1/c) = k\hbar\omega_c \qquad (18)$$

Making these substitutions, Eq. (18) generates $E = k\hbar\omega_c = k\ 8.19\mathrm{x}10^{-14}$ J which is an electron's internal energy times a numerical constant near 1. We do not know the value of $k$, but this is an approximation which would be exact if $k = 1$. This same answer is obtained from $E = kA^2\omega^2 ZV/c$ if we convert to using strain impedance $Z = Z_s = c^3/G$ and strain amplitude $A = A_s = L_p/\lambda\!\!\!^{-}_c \approx 4.18\times10^{-23}$.

This is a successful first test. It is true that $E = k\hbar\omega_c = k\ 8.19\mathrm{x}10^{-14}$ J is an approximation, but the currently accepted models of electrons (point particles or one-dimensional vibrating strings) have no structure that can be quantified. Therefore, this model of an electron is unique because it generates an electron's approximate energy from the bottom up starting with first principles.

To help appreciate the implications of this energy calculation, it will be restated in words. We previously found that a 200 Hz GW ($\omega \approx 1250$ rad/s) encountered an impedance of spacetime of about $10^{25}$ kg/m$^2$s. However, inserting an electron's Compton angular frequency ($\sim 10^{21}$ rad/s) into $Z_d = c\omega_c^2/G$ generates impedance greater than $10^{60}$ kg/m$^2$s. This enormous impedance permits a wave that only displaces the spacetime field by Planck length to produce an electron's energy in a volume of the flux with radius approximately equal to an electron's reduced Compton wavelength $\lambda\!\!\!^{-}_c$.

A rotating dipole wave in spacetime is a confined wave propagating at the speed of light. This calculation shows this model has approximately the electron's energy. Therefore, this combination means this model also approximately achieves an electron's properties of inertia, gravitational weight, relativistic energy, and relativistic length contraction.

## 6.2 Angular momentum Calculation

We also know that the source of these waves must plausibly possess $\hbar/2$ angular momentum when measured along the Z axis. A quantized wave propagating at the speed of light has momentum $p = E/c$. If this wave is propagating in a circle with radius $r = \lambda\!\!\!^{-}_c = \hbar c/E$, and treated with the moment of inertia of a rotating hoop, then the angular momentum would be $\mathcal{L} = pr = (E/c)(\hbar c/E) = \hbar$. However, a wave is distributed over a volume, so the wave also fills the entire volume with radius $\lambda\!\!\!^{-}_c$. This decreases the moment of inertia. The rotation is also chaotic which further reduces the net angular momentum. If the distributed moment of inertia similar to a rotating disk is assumed rather than a rotating hoop, then the angular momentum would be $\hbar/2$. Even this approximation is much better than the approximation of $\mathcal{L} = 0$ obtained from a point particle model of an electron. The point particle model attempts to hide its inadequacy by claiming an electron possesses undefined "intrinsic angular momentum". This test is another successful plausibility approximation.

## 6.3 Point particle properties of electron model

Next, we will examine whether this model of an electron as a rotating wave with $L_p$ spatial displacement would appear to be a particle with no discernable radius (a point particle). This is not a classical particle with a hard surface. It is a rotating wave which only displaces space by undetectable Planck length and Planck time. The fact that this undetectable $L_p$ spatial amplitude is distributed over a much larger volume ($r = \lambda\!\!\!^{-}_c$) does not make it observable. It only makes the properties of an electron more confusing (mysterious). Its rotational frequency interacting with the impedance of spacetime gives it an electron's energy, but this energy is elusive.

While most physicists believe an electron is smaller than about $10^{-18}$ m, this size is incompatible with an electron's electrical charge. For example, a particle with charge $e$ and radius of about $10^{-18}$ m would have about 1,000 times too much energy to be an electron. If the particle size is Planck length, then the energy in the charge $e$ electric field would exceed an electron's energy by a factor of $10^{20}$.

Mac Gregor [24] states that some experiments imply an electron has a radius comparable to its Compton radius $\lambda\!\!\!^{-}_c$. Here is a quote: "An electron's manifestations in atomic bond states is not point-like. The Lamb shift reveals that the electric charge is smeared out over a region of space which is comparable to the electron Compton radius". Mac Gregor [24] also states that the point particle radius "leaves us with no calculation explanation for either the magnetic moment, or the spin value of the electron."

Physical interpretations of experiments are influenced by the possible explanations being considered. If the model of a rotating wave with $L_p$ amplitude is considered, then 50 GeV collision experiments would be discounted. Instead, Lamb shift and magnetic moment experiments would be considered non invasive and more likely to give correct results.

Another related consideration will be introduced here. It is difficult to appreciate how small the electron's displacement amplitude ($L_p$) is compared to the electron's mathematical radius. Suppose we imagine enlarging the electron's mathematical radius by about $10^{19}$ times to equal the radius of the earth. Enlarging the electron's wave amplitude ($L_p$) by the same $10^{19}$ times means the electron's displacement amplitude would still be smaller than a proton ($L_p \times 10^{19} \approx 10^{-16}$ m).

Next, imagine an electron and a positron "colliding". Except we will imagine them as earth size rotating waves, each with displacement amplitudes of $\sim 10^{-16}$ m. If they were classical waves, they should merely pass through each other without noticing. However, they both possess quantized angular momentum. This quantized angular momentum makes these weak and diffuse rotating waves have a probability of interacting at a point as a quantized unit.

An electron and proton are just weak waves which can sometimes pass through each other without colliding. The electron's quantized $\hbar/2$ unit of angular momentum interacts all or nothing. If the electron collides, this all or nothing quantization choice demands the interaction is at a point within a single quark. Therefore, both the electron and the quark appear to be point particles.

### 6.4 Virtual particle formation and annihilation

It is easy to extrapolate from this model of an electron to a model of virtual electron-positron pairs. The quantum vacuum is Planck length/time fluctuations predominantly at Planck frequency. While the fundamental harmonic oscillations are about Planck length in radius, this means that many Planck length/time vacuum fluctuations can collectively exhibit Planck length/time fluctuations over larger volumes. These larger volume fluctuations last for a time characteristic of the volume size.

The electron's Compton frequency is proposed to correspond to a resonance in the flux. Therefore, even the random vacuum fluctuations have a tendency to momentarily achieve a Planck length distortion in a volume corresponding to an electron's mathematical radius. Such a distortion can briefly have the properties of an electron-positron pair. This fluctuation lacks the $\hbar/2$ quantized angular momentum to be stabilized. Therefore, the deception is discovered in a time of $1/\omega_c$ and this effect redistributes itself back into the flux. A more detailed description of the virtual particles can also generate the correct energy and lifetime from a calculation similar to the calculation which generated the energy of the electron model. The ease with which this model of the universe explains virtual particles gives additional support to the model.

## 7 Model of an electron's electric and gravitational properties

The previous sections dealt with the properties of an electron's rotating core. The analysis of the core gave insights into an electron's energy, angular momentum, inertia and point particle properties. We are now going to switch and discuss the effects the electron's rotating core has on the surrounding spacetime field. This has already been partly covered in the modeling of an electron's de Broglie waves and Figs. (2 - 4). A more detailed description of an electron's electric and gravitational fields is given in [25]. However, even that description is preliminary. This section will support this partial model by showing that equations for gravitational curvature, gravitational force, electrical potential and electrostatic force can be derived from equations for the standing waves external to an electron's core.

If the spacetime field was infinite and perfectly homogeneous, it would have no resonances, no boundaries and no nonlinearities. However, the very description of the spacetime field implies that Planck frequency is the maximum allowed frequency and Planck length is the boundary for the minimum allowed length. Only hypothetical Planck frequency waves would encounter Planck energy density with a coupling constant of 1. Lower frequency waves experience the smaller coupling constant described in Eq. (9 and 10) as $(\omega/\omega_p)^2$.

These boundary conditions imply the spacetime field must exhibit nonlinearities even for frequencies (wavelengths) far from these limits. The standing waves surrounding the rotating core should have a linear (first order) component which is a sine wave at the electron's Compton frequency. There should also be a distortion of this sine wave which is the nonlinear (second order) components generated by the boundary conditions. The first order effects generate an electron's electric field and the second order effects generate an electron's gravitational field.

The simplified model has the rotating core transitioning to rotating standing waves beyond the mathematical radius $ƛ_c = 3.86\times10^{-13}$ m. At this radius, the strain amplitude is $A_s \equiv L_p/ƛ_c = 4.18\times10^{-23}$ and this amplitude should decrease with $1/r$ at greater radial distance. The electron's natural length standard is its mathematical radius $ƛ_c$. Therefore, equations are simplified when distance from the center of the core is stated as the number ($N$) of reduced Compton wavelengths. The definition of $N$ is: $N \equiv r/ƛ_c = rmc/\hbar$. Measuring distance in meters is a human construct, but $N$ is an electron's natural standard. When $r = ƛ_c$ then $N = 1$. At distance $r > ƛ_c$, the dimensionless strain amplitude is $A_s/N$. This will be shown to be related to an electron's electrical charge and electrostatic force. However, we will start with an explanation of how the electron model produces gravitational curvature of spacetime and a gravitational force.

The spacetime field has finite flux energy density $U_\omega$. This is a boundary condition which should introduce nonlinearities. Therefore, waves in the spacetime field should exhibit a linear sinusoidal component and a nonlinear (second order) component which scales with higher orders of strain amplitude $A_s$. For an electron, the only important nonlinear term is $A_s^2$ (demonstrated later). As explained in [25], the first order bidirectional standing waves depicted in Fig. 4 generate second order, very weak, nonlinear effects not depicted in Fig. 4. The most important of these nonlinear effects is a non-oscillating distortion of the flux which has dimensionless slope of $A_s^2/N$.

$$\frac{dt}{d\tau} \approx 1 + \frac{Gm}{c^2 r} = 1 + \frac{A_s^2}{N} \tag{19}$$

$$\mathbb{F}_G = \frac{Gm^2}{r^2 F_p} = \left(\frac{A_s^2}{N}\right)^2 \tag{20}$$

The non-oscillating distortion of the spacetime field is proposed to be the electron's gravitational field. The electron's strain amplitude $A_s$ and distance expressed as $N$ radius units will be shown to generate both the electron's gravitational and electrostatic equations. Equation (19) shows the temporal gravitational curvature ($dt/d\tau$) caused by an electron's mass/energy on the space beyond distance $r > ƛ_c$.

The ratio $dt/d\tau$ is well known in general relativity as the ratio of the rate of time in zero gravity ($dt$) to the rate of time in gravity ($d\tau$). The equation ($dt/d\tau \approx 1 + Gm/c^2r$) is a weak gravity approximation. However, for an electron's mass ($m_e$) at distance greater than $ƛ_c$, this equation is virtually exact because the electron's gravity is extremely weak. The difference between the weak gravity approximation shown in Eq. (19) and the exact solution $dt/d\tau = [1 - (2Gm/c^2r)]^{-1/2}$ is less than 1 part in $10^{88}$. When $m = 0$, then there is no gravity and $dt/d\tau$ =1. Therefore, the important relationship generating curvature is $Gm_e/c^2r = A_s^2/N$ One of the mysteries of physics has always been: How does mass cause the curvature of spacetime? This model provides the following answers:

1) Zero-point energy is a nonlinear medium for waves in spacetime.
2) A fermion such as an electron is a Compton frequency rotating wave possessing $\hbar/2$ quantized angular momentum.
3) This rotating wave generates a nonlinear effect in the surrounding spacetime field which has both oscillating and non-oscillating terms [25]. A non-oscillating distortion is the electron's gravitational field described by Eq. (19)

Equation (20) express dimensionless force between two of the same mass particles (2 electrons) using the open symbol $\mathbb{F}_G$. This is the Newtonian gravitational equation divided by Planck force ($F_p = c^4/G$) to achieve Planck units of force. Equation (20) shows that this dimensionless force can also be expressed as $(A_s^2/N)^2$. Reference [25] shows a simplified derivation of this force. Next, we will compare these gravitational equations to the comparable equations related to electrical potential and electrostatic force.

$$\mathbb{V}_E = \frac{q_p}{4\pi\varepsilon_o r V_p} = \frac{A_s}{N} \tag{21}$$

$$\mathbb{V}_e = \frac{e}{4\pi\varepsilon_o r V_p} = \sqrt{\alpha}\,\frac{A_s}{N} \tag{22}$$

$$\mathbb{F}_E = \frac{q_p^2}{4\pi\varepsilon_o r^2 F_p} = \left(\frac{A_s}{N}\right)^2 \tag{23}$$

$$\mathbb{F}_e = \frac{e^2}{4\pi\varepsilon_o r^2 F_p} = \left(\sqrt{\alpha}\,\frac{A_s}{N}\right)^2 \tag{24}$$

Equations (21, 22) use the symbol $\mathbb{V}$ to represent electrical potential expressed as a dimensionless number. This is accomplished by dividing electrical potential (with units $kg{\cdot}m^2/s^2C$) by Planck voltage $V_p = (c^4/4\pi\varepsilon_o G)^{1/2} \approx 10^{27}$ Volts. Equation (21) gives $\mathbb{V}_E$, the dimensionless electrical potential for Planck charge ($q_p = (4\pi\varepsilon_o\hbar c)^{1/2}$) and Eq. (22) gives $\mathbb{V}_e$, the dimensionless electrical potential for charge $e$. The relationship between $q_p$ and $e$ is: $q_p = e/\alpha^{1/2} \approx 11.7e$. The fine structure constant is: $\alpha = e^2/4\pi\varepsilon_o\hbar c \approx {}^1/_{137}$.

The important point is that the proposed particle model is indicating that there should be a first order distortion of the spacetime field with dimensionless magnitude $\mathbb{V}_E = A_s/N = L_p/r$. This is the dimensionless magnitude of the electrical potential produced by Planck charge.

The obvious problem is that an electron has charge $e$, not Planck charge $q_p$. However, rather than $q_p$ being a flaw, this is perhaps revealing the electron is attempting to have Planck charge, but an additional nonlinearity in the spacetime field ($\sqrt{\alpha}$) degrades this to charge $e$. Planck charge is the fundamental unit of electrical charge derived from $\varepsilon_o$, $\hbar$ and $c$. For example, Planck charge has a coupling constant of 1 to a photon but charge $e$ has $\alpha$ coupling constant. Perhaps vacuum polarization is responsible for this reduction. In any case $\mathbb{V}_e = \sqrt{\alpha}{\cdot}A_s/N$.

Equation (23) gives the dimensionless electrostatic force between two Planck charges and Eq. (24) gives the dimensionless force between two charge $e$ particles. Both equations are Coulomb's law divided by Planck force $F_p$. The next section will compare the electrostatic Eqs. (22 - 24) to the gravitational Eqs. (19, 20).

## 8 Predictions

What qualifies as a prediction? In 1861 James Maxwell developed the equation, $c = \sqrt{1/\varepsilon_o \mu_o}$ . This was an early result of his work which eventually led to the famous Maxwell's equations. This relationship between $c$, $\varepsilon_o$ and $\mu_o$ was previously unknown and will be designated as a "prediction" which could be proven correct without an experiment. The work on the single component model of the universe has also generated equations which show previously unrecognized relationships. These are proposed to qualify as predictions even though they can be proven correct without an experiment.

Equations (19 – 24) show that combinations of $A_s$, $N$ and α (combinations of $L_p$, $ƛ_c$ and α) can generate an electron's gravitational curvature, gravitational force, electrical potential and electrostatic force. This is being used to support the proposed single component model of the universe. However, this model is also generating useful new insights (predictions) into the relationship between forces. For example, comparing $\mathbb{F}_G = (A_s^2/N)^2$ to $\mathbb{F}_E = (A_s/N)^2$, the only difference is between $A_s^2$ compared to $A_s$. This wave-based analysis reveals connections between the gravitational force and the electrostatic force that were not previously recognized.

The magnitude of the electrostatic force between two electrons is about $4.2\times10^{42}$ times larger that the gravitational force between two electrons. This is a constant ratio, independent of separation distance. However, since an electron's gravity scales with $A_s^2$ and an electron's electrostatic force scales with $A_s$, this analysis predicts that there should also be a fundamental square relationship between these force magnitudes.

$$F_G = \xi N^2 F_e^2 \tag{25}$$

$$\mathbb{F}_G = N^2 \mathbb{F}_E^2 \tag{26}$$

Equation (25) is one of several ways of expressing the square relationship between the magnitude of the electron's gravitational force $F_G$ and the square of the magnitude of the electron's electrostatic force ($F_e^2$). The term ξ in Eq. (25) is an electrostatic force constant $\xi \equiv G/\alpha^2c^4 \approx 137^2/F_p \approx 1.55 \times 10^{-40}$ $\mathrm{N}^{-1}$ where $\mathrm{N}^{-1}$ is inverse newton. Recall that $N$ italicized is the number of reduced Compton wavelengths. If we use previously defined $\mathbb{F}_G$ and $\mathbb{F}_E$ from Eq. (20, 22), then the fundamental square relationship between these forces can be stated without ξ as shown in Eq. (26).

If gravitons are unrelated to virtual photons and if both forces are assumed to be transfer by these messenger particles, then there should be no square relationship between these forces. However, it is very reasonable that two forces related through a nonlinearity should have a square relationship. This is a clear case where the wave-based model of the universe makes a correct prediction which challenges the commonly accepted model of forces.

$$\frac{F_G}{F_e N\alpha^{-1}} = \frac{F_e N\alpha^{-1}}{F_p} \tag{27}$$

$$\frac{r_g}{L_p} = \frac{L_p}{ƛ_c} \tag{28}$$

$$\frac{F_G}{F_e\alpha^{-1}} = \frac{r_g}{ƛ_c} \tag{29}$$

Equations (27 – 29) are three more examples of previously unknown relationships which emerge from Eq. (19 – 26). Equation (27) is derived from Eq. (25) and reveals another prediction which is that there is a symmetry between the gravitational force, the electrostatic force and Planck force. To explain this, we will assume two electrons separated by distance $r = Nƛ_c$. On a logarithmic scale of force magnitude, the electron's electrostatic force product $F_eN\alpha^{-1}$ is exactly midway between the extremes of Planck force $F_p$ and the gravitational force ($F_G$) between these 2 electrons. If we assume two hypothetical particles with Planck charge $q_p$ and any mass less than $m_p$ and separated by their mathematical radius $ƛ_c$ (therefore: $N = 1$), then the electrostatic force magnitude $F_E$ is exactly midway between the weakest force $F_G$ and the strongest force $F_p$.

Equation (28) is derived from Eq. (19). Equation (28) says there is another symmetry between $ƛ_c$, $L_p$ and $r_g$ where $r_g$ is defined as an electron's or muon's gravitational radius $r_g \equiv Gm/c^2$. The physical significance of $r_g$ is shown by substituting $r_g$ into Eq. (19) to produce $dt/d\tau = 1 + r_g/r$. A particle's gravitational radius ($r_g$) is half its Schwarzschild radius. The gravitational distortion (curvature) of the spacetime field scales with a particle's gravitational radius ($r_g/r$).

On a logarithmic scale of length, Planck length falls exactly midway between $r_g$ and $ƛ_c$. For example, Planck length is exactly midway between an electron's mathematical radius $ƛ_{ce} \equiv 3.86 \times 10^{-13}$ m and its gravitational radius $r_{ge} \equiv 6.76 \times 10^{-58}$ m. More massive particles have a smaller $ƛ_c$ and a larger $r_g$. These values merge at the limit of Planck mass $m_p = (\hbar c/G)^{1/2}$ where $r_g = L_p = ƛ_c$.

Equation (28) also says a fundamental particle's gravitational radius $r_g$ is the inverse of its mathematical radius $ƛ_c$, when both radii are expressed in dimensionless Planck units ($r_g/L_p$ and $ƛ_c/L_p$). For example, an electron's dimensionless radii are inversely related: $4.18 \times 10^{-23} = 1/2.39 \times 10^{22}$. Equation (29) says the force magnitude ratio ($F_G/F_e\alpha^{-1}$) between two electrons equals the electron's radii ratio ($r_g/ƛ_c$). This also fits with the wave-based particle model, but the derivation involves several equations from Table 1.

## 9 Why is electrical charge independent of a particle's energy?

One of the most fundamental mysteries of physics is: What is electrical charge? The mystery of electrostatic force being independent of particle energy is currently "explained" by merely declaring different energy particles such as electrons and muons have a property called "electrical charge" which is independent of particle energy. However, this disconnect between electrostatic force and particle energy makes "electrical charge" appear to be a fundamental property of nature without a conceptually understandable physical explanation.

We think of gravity as a great mystery, but at least we can see that gravitational effects scale with mass (energy). With electrical charge, we do not even have that level of understanding. Therefore, a severe test of the proposed single component model of the universe is to see if the model can explain how an electron and a muon can have very different energy but generate the same electrostatic force.

The answer to this mystery is hidden in the equation $\mathbb{V}_e = \sqrt{\alpha}\, A_s/N$ which is Eq. (23). How does this equation give the correct electrical potential for both an electron and a muon? A muon's strain amplitude $A_s = L_p/ƛ_c$ is about 207 times larger than an electron's strain amplitude because a muon's $ƛ_c$ is 207 times smaller. Therefore, how can an electron and a muon both have the same electrical potential (same charge)? There are two keys to this mystery: 1) Eq. (23) is only valid for $r \geq ƛ_c$. Therefore, values of $r$ less than $3.86 \times 10^{-13}$ m are valid for muons, but not valid for electrons. 2) For values of $r$ greater than $3.86 \times 10^{-13}$ m, muons and electrons have the same electrical potential of $\mathbb{V}_e = \sqrt{\alpha}\ L_p/r$. Since experimental measurements are made beyond this distance, they both generate the same electrostatic force and we say they have the same "charge".

This wave-based model predicts that electrons and muons do not have the same electrical properties at distances less than $3.86 \times 10^{-13}$ m. For example, the electrical potential at an electron's mathematical radius is $V_{max} \approx 3{,}700$ Volts. A smaller muon has 207 times larger maximum electrical potential ($V_{max} \approx 770{,}000$ Volts) and 207 times more energy in its electric field. external to its mathematical radius. All this additional energy is in the small spherical shell volume between radii $3.86 \times 10^{-13}$ m and $1.86 \times 10^{-15}$ m.

This model has a muon and an electron both have the same percentage of their total energy in their respective electric fields. Only a model which has a muon 207 times smaller than an electron can have this symmetry where both particles have the same percentage of total energy in their respective electric fields.

Collision experiments have been used to determine the size of an electron. However, collisions never give the correct answer for the size of a wave-based electron. The problem is that a relativistic collision reduces the size of an electron's mathematical radius at the instant when the experiment is determining size. These are not two hard balls colliding. They are soft quantized waves which contract when energy is added. At the moment of closest approach, all the kinetic energy of the collision is converted to increase the electron's internal energy (frequency). This reduces the size of the mathematical radius at this instant. For example, if two electrons collide with energy of 50 GeV, this momentarily increases the electron's internal energy and decreases its radius by a factor of about 100,000. This is a case of an experiment greatly distorting the property it is attempting to measure.

## 10 Charge conversion constant

If everything in the universe is derived from the single component spacetime field, then it should be possible to explain electrical charge and an electric field as a conceptually understandable distortion of this universal field. Equation (23) quantifies the dimensionless electrical potential generated by a hypothetical particle with Planck charge as: $\mathbb{V}_E = A_s/N = L_p/r$. One physical interpretation of $\mathbb{V}_E = L_p/r$ is that

Planck charge ($\pm q_p$) produces a $\pm$ Planck length ($\pm L_p$) non-oscillating distortion of the spacetime field. The dimensionless ratio $L_p/r$ is the slope of the distortion produced by Planck charge at distance $r \geq ƛ_c$. The connection between Planck charge and Planck length is also supported by the equation for the dimensionless electric field produced by Planck charge which is: $\mathbb{E}_E = q_p/4\pi\varepsilon_o r^2 V_p = L_p^2/r^2$. Therefore, electrical potential converts to slope $L_p/r$ and electric field converts to the rate of change of the slope $L_p^2/r^2$. The hypothesis is that a positive or negative Planck charge produces a positive or negative Planck length distortion of the spacetime field. This hypothesis can be tested by formulating a "charge conversion constant" which converts the unit coulomb into a unit of "polarized length".

$$\frac{q_p}{L_p} = \sqrt{\frac{4\pi\varepsilon_o c^4}{G}} = 1.16\times10^{17}\ \text{C/m} \qquad (30)$$

Equation (30) shows the proposed "charge conversion constant" $q_p/L_p$ with units of coulombs per meter (C/m). This proposed constant replaces the unit of "coulomb" in equations with a polarized distortion of the spacetime field with units of length. An electron, and other charge $e$ particles produce a proportionally smaller, non-oscillating distortion of $L_p\sqrt{\alpha} \approx 1.4\text{x}10^{-36}$ m. In previous articles [25, 26] this charge conversion constant is designated η, but $q_p/L_p$ is more intuitive.

We can test this charge conversion constant without exactly understanding all the details. For example, an electron is a rotating wave which would attempt to migrate in such a polarized distortion. We would perceive this migration as an "electrostatic force" acting on the electron. With this introduction, it is possible to perform some tests to see if this conversion to polarized length gives reasonable answers.

To convert a term with units of coulomb to a distortion of the spacetime field, multiply the term by any variation of $q_p/L_p$ which cancels the units of coulomb. Below are 3 examples which are chosen because the conversions also make surprising predictions about fundamental physics.

$$\left(\frac{q_p}{L_p}\right)^2\left(\frac{1}{4\pi\varepsilon_o}\right) = \left(\frac{4\pi\varepsilon_o c^4}{G}\right)\left(\frac{1}{4\pi\varepsilon_o}\right) = \frac{c^4}{G} = F_p \qquad (31)$$

$$\left(\frac{q_p}{L_p}\right)^2\left(\frac{\mu_o}{4\pi}\right) = \left(\frac{4\pi\varepsilon_o c^4}{G}\right)\left(\frac{1}{4\pi\varepsilon_o c^2}\right) = \frac{c^2}{G} \qquad (32)$$

$$\left(\frac{q_p}{L_p}\right)^2 Z_o = \left(\frac{4\pi\varepsilon_o c^4}{G}\right)\left(\frac{1}{\varepsilon_o c}\right) = 4\pi\frac{c^3}{G} = 4\pi Z_s \qquad (33)$$

Equation (31) shows the Coulomb force constant $1/4\pi\varepsilon_o$ with units (kg·m$^3$/C$^2$s$^2$) converts to Planck force ($F_p = c^4/G$) with units (kg·m/s$^2$). This is both surprising and reasonable because Planck force is the maximum force in natural units. Therefore, this conversion predicts that the Coulomb force constant $1/4\pi\varepsilon_o$ is merely another way of stating this universal maximum force. This concept expands our physical interpretation of equations incorporating $1/4\pi\varepsilon_o$. Equation (32) converts the permeability constant $\mu_o/4\pi$ to $c^2/G$ with units of kg/m. This is the conversion of mass to a linear dimension. For example, an electron's mass is $m_e = (c^2/G)r_{ge}$ where $r_{ge} = 6.8\text{x}10^{-58}$ m is an electron's gravitational radius.

However, most revealing is Eq. (33) which eliminates units of coulomb (C) from the impedance of free space $Z_o = 1/\varepsilon_o c \approx 377$ m$^2$kg/C$^2$s = 377 Ω. This is the impedance encountered by EM radiation. This conversion says the impedance encountered by EM waves ($Z_o$) is virtually the same as the impedance encountered by GWs: $Z_o \Rightarrow 4\pi Z_s$ with units of kg/s.

If EM radiation and GWs both encounter the same impedance ($c^3/G$), this implies photons are quantized waves propagating in the same stiff elastic medium (the same spacetime field) as GWs. Therefore, the spacetime field is proposed to be the propagation medium for EM radiation. There are similarities to the classical ether, but this is a universal field that also forms fermions, bosons and forces. Therefore, everything scales with this single field. It achieves Lorentz invariance and meets Einstein's idea of a "relativistic ether".

Einstein also apparently anticipated that matter is derived from the "physical states of space". In 1930 he said, "Now it appears that space will have to be regarded as the primary thing and that matter is derived from it, as a secondary result." [27].

## 11 Photons and Compton scattering

References [25, 26] go into more detail about the photon model. These references determine that individual photons all have the same displacement amplitude, which is Planck length ($L_p$). This explains why the equation for photon energy $E = \hbar\omega$ does not require an amplitude term. Normally the energy of a wave depends on wave amplitude, but photons (and even fermions) all have the same displacement amplitude ($L_p$). Therefore, it is possible to write an equation for the energy of a photon (a quantized wave) without an amplitude variable.

Also [26] analyzes Compton scattering which is often cited as conclusive proof that photons are fundamentally particles. However, [25] reexamines this and shows that a quantized wave explanation of Compton scattering is not only plausible, but it is proposed to be *better* than the particle-based explanation. The reason is because the wave-based electron transitions between its initial velocity before scattering to its final velocity after scattering without accelerating through forbidden intermediate velocities.

## 12 Future Analysis

All mathematical analysis of physics requires the adoption of a set of starting assumptions. These starting assumptions are usually not enumerated, but they are implied by relying on work which previously adopted these assumptions. If one of the starting assumptions is wrong, the mathematical analysis will generate incorrect answers which do not correspond to physical reality. However, suppose the analysis is using correct assumptions but is missing an essential starting assumption. Then the mathematical analysis will give correct answers, but the missing assumption leaves gaps. These gaps cause the physical interpretation of the calculated answers to contain conceptual mysteries.

This is exactly what we have today. Physics has numerous mysteries which are not just unknowns at the limit of our current knowledge. Well established principles of quantum mechanics and relativity contain mysteries which defy logical understanding. The reason for these types of mystery is proposed to be a missing essential starting assumption. The universal field and the associated structure of particles and forces is proposed to be the essential missing assumption.

For example, it is not conceptually understandable how the proper speed of light can be constant in all frames of reference. However, if light propagates as quantized waves in a universal field, and if this universal field also generates wave-based particles and forces, then there is coordination between everything in the universe. The relativistic length contraction and other transformations of special relativity become conceptually understandable and the constant speed of light is no longer a mystery.

It is a mystery how matter causes curvature of empty space. But this becomes conceptually understandable if matter is quantized waves which generate standing waves beyond the observable surface of the matter. These weak standing waves extend into the surrounding universal field and cause distortion (curvature) of this physical medium.

Gravitational curvature is currently considered to be a geometric distortion of empty space. Electrical potential is currently considered to be a field unrelated to gravity. However, a connection between gravitational curvature and electrical potential is revealed when both are modeled as the result of waves in the nonlinear universal field.

The real benefit of this bottom-up approach is that it should make numerous falsifiable predictions about all aspects of physics. One of the criticisms of string theory, M theory and loop quantum gravity is that these theories have not produced any falsifiable predictions. The proposed single component model of the universe should be the opposite extreme. This hypothesis includes a dominant new assumption which affects all of physics. Therefore, its predictions should extend to subjects as diverse as cosmology, quantum chromodynamics, the strong force and gravity. Only further development will determine the value of these predictions. But a hypothesis that promises numerous falsifiable predictions is worthy of further research.

## 13 Summary and Conclusion

This article proposes that zero-point energy (ZPE) of the quantum vacuum is the dominant, single component source of everything in the universe. The objective is to develop a model of a single universal field which plausibly can generate everything in the universe – all particles, forces, secondary fields and even the laws of physics. Lorentz invariance requires a coordination between the laws of physics. This coordination is understandable if it can be shown that everything scales with a single universal field.

The quantum vacuum is proposed to be a sea of Planck length and Planck time vacuum fluctuations, predominantly at Planck frequency. Individual vacuum fluctuations are on the scale of Planck volume. This "noise" of the vacuum extends to larger volumes and proportionately lower frequencies. The distance between even widely separated points fluctuates by Planck length without violating any laws. These vacuum fluctuations have some of the properties of energy, but they do not meet the proposed definition of being "observable energy". For example, the proposed model of the spatial and temporal oscillating distortions cancels gravitational effects.

Therefore, this model of the quantum vacuum has no observable energy density, but it also has a fluctuating structure which corresponds to Planck energy density when expressed mathematically. This description of the universal field was quantified. Waves in the spacetime field encounter impedance. There are two mathematical forms of this single impedance – either $Z_s = c^3/G$ or $Z_d = c\omega^2/G$. For example, it was shown that ZPE, GWs and even EM radiation encounter this impedance. Also, this impedance is key to generating and quantifying wave-based models of both particles and forces.

An introduction to wave-based particles is given by showing that light confined to a specific volume by reflectors exhibits 6 properties we normally associate with particles. For example, standing light waves confined in an optical resonator exhibit the equivalent of relativistic length contraction, relativistic increase in energy, inertia and weight in a gravitational field. However, the similarity between the modulation envelope of confined light and de Broglie waves indicates the frequency and wave structure required by the electron model.

In this model, waves propagating in the spacetime field are confined to a specific volume by a quantization of angular momentum. Using the impedance of spacetime, Planck length displacement amplitude, and a wave model rotating at an electron's Compton frequency, the proposed model approximately generates an electron's energy and quantized angular momentum.

Even though this model of the universe is in its infancy, it has already generated numerous predictions. Some of these predictions can easily be proven correct without an experiment because they predict previously unknown relationships. Examples of predictions which are easy to prove correct are:

• The gravitational force magnitude between two electrons scales with the square of the electrostatic force magnitude Eq. (25)

• On the scale of two electrons, there is a symmetry between the gravitational force, the electrostatic force and Planck force. Eq. (27).

• An electron's wave-based mathematical radius is the inverse of its gravitational radius when both radii are expressed in dimensionless Planck units. Eq. (28)

There are other predictions which are reasonable but have not been conclusively proven correct. Here are several in this category which relate to electrical charge, electric fields and EM radiation.

• Planck charge produces a Planck length polarized distortion of the universal field. This insight can be reduced to a proposed charge conversion constant ($q_p/L_p$) which converts the unit of coulomb to a unit of polarized length. Eq. (30)

• Using the charge conversion constant, the Coulomb force constant $1/4\pi\varepsilon_o$ converts to Planck force $c^4/G$. Eq. (31)

• Gravitational waves and EM radiation encounter the same impedance. Using the charge conversion constant, the impedance of free space ($Z_o \approx 377\ \Omega$) encountered by EM radiation converts to the impedance of spacetime encountered by gravitational waves (ignore the $4\pi$ factor). Eq. (33) All of this leads to the following conclusion:

This article has shown it is plausible for the quantum vacuum to be a sea of Planck length and Planck time vacuum fluctuations, predominantly at Planck frequency. This proposed model of space has quantifiable elasticity, impedance and the characteristics of a universal field.

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