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On the Possible Existence of Superluminal P and S Waves within the Quantum Vacuum, and a Resolution to the Entanglement Problem

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Abstract

Within the framework of Winterberg's model for space where the vacuum consists of a very stiff two-component superfluid, made up of very massive, positive as well as negative mass, Planck particles, we offer an explanation for quantum entanglement. We make use of the hypothesis, that Planck charge, q_{Pl}, was created at the same time as Planck mass, m_{Pl}. Moreover, the repulsive force that Planck particles of a similar mass experience is, in reality, the electrostatic force of repulsion between like charges. There is also a gravitational force of attraction between two Planck particle of similar mass, but this will be shown to be related to the electrostatic force. We can prove that there is an electrostatic restoring force, $F_{+,x} = (m_{Pl})\ddot{x} = -\kappa x$, acting on a Planck particle within this, two-component, non-viscous fluid (sea), which forces the individual Planck particle back into its equilibrium positions when disturbed (displaced). Moreover, it can be derived from the electrostatic force between individual Planck particles, $G\frac{m_{Pl}^2}{r^2} = \hbar\frac{c}{r^2} = \frac{kq_{Pl}^2}{r^2}$. In fact, the spring constant, κ, can be shown to equal, $4\zeta(3)\hbar c n_+(0)$, where $\zeta(3)$ equals Apery's constant, 1.202…, an irrational number. The, $n_+(0) = n_-(0)$, is the relaxed, present day, number density for the positive, as well as for the negative mass Planck particle, making up the vacuum. In the present epoch, we estimate that, $n_+(0)$ equals, 7.848E54 m^{-3}. The relaxed distance of separation between nearest-neighbor positive, as well as negative, Planck particle pairs is, $l_+(0) = l_-(0) = 5.032\text{E}-19$ meters. We will argue that space is the arbitrator of quantum interactions, and not photons or gravitons, as is commonly thought. Space is inherently electrostatic (and gravistatic, at the same time) because these are the forces that hold it together. Moreover, space will allow for superluminal P and S waves to propagate, once the space is disturbed or otherwise disrupted (as in wave function collapse). We prove that the vacuum will thus allow for an almost instantaneous transmission of energy and information between two particles separated by a great distance using our two-component superfluid model. This may solve the quantum entanglement problem.

Keywords

Superluminal Waves, Quantum Vacuum, Electrostatic Force, Winterberg's Model, Space Interactions

1. Introduction

Quantum entanglement [1]-[3] is the phenomenon, where the acquisition of a quantum property, such as spin, for one particle at one location, can be deduced automatically and instantaneously, from the measurement of the same attribute for another particle some distance away. Normally it takes time for information to be passed along from one particle to the other. The two particles are seemingly correlated or entangled, once they have interacted at a previous time. According to the laws of quantum mechanics, a particle is a superposition of many states (outcomes) until measured, when one particular state (or outcome) is chosen. Once a quantum property is measured, such as spin, there is a so-called wave function collapse, as one particular result (attribute) has been chosen among many. The partner particle, some distance away, seems to know that result instantaneously. In other words, it seemingly takes no time for that information to pass and travel through space. Einstein famously referred to quantum entanglement as "spooky action at a distance".

Quantum entanglement has been verified experimentally in many different situations [4]-[9]. It also cannot be explained through so-called "hidden variables", as first suggested by Einstein. The Bell inequality [7] [10]-[15] seems to rule out that hidden variables are in play. A possible solution is space, itself. Some authors have suggested that wormholes, for example, may be the solution to this paradox [16] [17]. The resolution of the EPR paradox (quantum entanglement) could be ER (wormholes) [18]-[20]. But this solution is hypothetical at best, and the stability of a wormhole, in general, is questionable. Another mechanism may exist within the vacuum which leads to an almost instantaneous transmission of quantum information. This, of course, would have to be another unusual property of space itself, *i.e.*, the vacuum. In either instance, space cannot be empty.

Some time ago, Winterberg [21]-[27], introduced an alternative, and very interesting, model for space, *i.e.* the vacuum, where space is made up of very massive, positive and *negative* mass particles called Planck particles, or Planckions. These super massive particles are assumed to be real particles, versus virtual, and he assumed that they have positive and negative Planck mass. We also believe that the magnitude of these masses has the Planck mass, which is very large, but that the Planck mass may actually change in value with cosmological time (due to a time varying gravitational constant). Winterberg assumed that they are constant in value throughout time. They are certainly large enough at present so as to avoid detection in modern day accelerators.

According to Winterberg, these particles form a very rigid, two component, superfluid (we prefer super-solid), within which, certain waves, such as photons and gravitational waves, move at the speed of light. The positive and the negative mass Planck particles interact amongst themselves, and maintain a fixed distance of separation from other neighboring particles of the same species. Planck particles of opposite mass do not interact directly [27] [28], but rather, indirectly. Both positive and negative Planck particles occupy the same space; in fact, they make up and define space through their lattice-like super-solid structure. This sea, which consists of these supermassive positive and negative mass particles are held together by superfluid forces. We shall see in this paper that they are actually electrostatic forces. Because the two species take up the same space, they are invariably drawn next to one another. They are forced to rub shoulders with one another, so to speak, and strive to maintain a fixed distance of separation from one another. This forms a semi-rigid lattice of sorts, and it was Winterberg's contention that this constitutes the vacuum, *i.e.*, space, in its lowest energy state. As such, three-dimensional space can also be mechanically deformed and curved.

We also have to add thermal blackbody photon radiation, the cosmic background radiation, to the mix. Through collisions with these blackbody photons, the Planck particles will naturally oscillate, or vibrate, about their equilibrium positions. This produces quantum oscillators at an almost infinite number of points in space, which in turn lead to the Heisenberg uncertainty relationship [28] [29]. Material particles, like electrons, are like ships in an ocean and they get tossed about by the waves generated by these quantum oscillations, in a seemingly random and chaotic fashion. The thermal *CBR* blackbody photons, though their elastic collisions with the Planck particles, also remedy the cosmological constant problem. Now, we have two species of Planck particle, positive and negative, and they neutralize one another in their energy, already at the subnuclear level [28]-[30]. Both phenomena would otherwise be difficult to explain if it weren't for the positive and negative mass Planck particles.

Winterberg developed an extensive and elaborate theory around this idea, and we will use it here, to establish an intimate connection between electrostatics, and gravistatics, at the quantum level. We believe that this two-component superfluid is the key towards understanding the connection between gravitation and electrostatics, at least at the quantum scale.

In the Winterberg model, fluid forces are responsible for keeping the Planck particles a fixed distance apart. When Planck particles are displaced from their equilibrium positions, increased Planck pressure forces them back into position. We can think of them as restoring forces, and we have modeled them as such [28].

Winterberg assumed that two similar Planck particles, whether they have positive or negative mass, repel each other much like charges in electrostatics. The question naturally arises as to whether the Planck particle force is ultimately an electrostatic force? We believe that this could very well be the case [29], and assume so in this work.

Moreover, if like mass Planck particles are anchored in position, and keep a finite distance apart from one another, then there must be two forces acting on the individual Planck particle, one attractive and one repulsive, along any given direction in space. The repulsive force is electrostatic, and the attractive force is also electrostatic [29]. An electrostatic attractive force might, however, simulate gravity, if viewed at from the opposite direction. What if Planck charge and Planck mass were both created at the same time, as two components of the same particle? Wouldn't they attract and repel simultaneously?

Also, their creation need not be at the Planck temperature, ~E32 Kelvin. If Newton's constant, G, is varying with respect to cosmological time, then, G is a function of time, or *CBR* temperature, and, $G^{-1} = G^{-1}(t) = G^{-1}(T_{CBR})$. These Planck particles could have formed and created the vacuum, *i.e.* three-dimensional space, at a very high, but reduced temperature, of the order, ~E21 - E22 Kelvin. The, $G^{-1}(t)$, would now take on (or assume) the role of an order parameter, associated with the vacuum itself [30]-[33]. Irrespective of the temperature of formation, we would have a vacuum, which is not only electrically, but also massively, neutral in its very earliest stages.

It is well known that all particles in the standard model, such as quarks and leptons, started to freeze out later, at much reduced temperatures, well below, ~ E16 Kelvin, or 1 TeV [34]-[37]. According to the proposed model, the universe, *i.e.*, three-dimensional space, is born electrically and massively neutral because there are equal numbers of positive and negative masses, as well as their corresponding positive and negative charges. In the Winterberg model, fermions and bosons, are quasiparticles, *i.e.*, collective vortex excitations, which can form, and propagate, within the two-component superfluid. See reference, [27], for specific details.

The outline of this paper is as follows. In Section 2, we present a different view of the vacuum. This will be in contrast to the conventional view, where the vacuum is made up of virtual particle-antiparticle pairs, such as, e^+e^-, $\mu^+\mu^-$, $\cdots$, $\nu\bar{\nu}$, $\cdots$, $q\bar{q}$, and photons, which pop in and out of existence, in a seemingly random, and chaotic fashion. These virtual particles, together with the bosons, which include photons and gravitons, form the vacuum. Our view is non-traditional, and we call it the Winterberg model. The vacuum consists of a semi-rigid super-solid made up of a sea of positive and negative Planck particles held together by very strong fluid forces. The positive Planck particle has positive Planck mass and positive Planck charge, *i.e.*, $m_{Pl} = |m_{Pl}|$ and $q_{Pl} = |q_{Pl}|$, respectively. The negative Planck particle has the negative of these values. Particles, such as fermions, are quasi-particle excitations within the vacuum. They are not the ground state of the vacuum. Photons are emitted whenever charged quasiparticle excitations are accelerating. Gravitational waves are also possible, as these have been detected observationally [38]-[41]. Gravitational waves are created whenever massive objects are accelerating. These photons, and gravitational waves, can travel within the lattice, and they do propagate at the speed of light, carrying energy and momentum.

In our model, the photons and gravitational waves are one class of wave. There are other types of waves, such as longitudinal compressional waves (P waves) and transverse shear waves (S waves) in a solid. These waves can also be created, and move through the medium, which, in our instance, is the vacuum. Their cause, or source, however, is very different. A rupture, or disturbance within the vacuum will create them, and not accelerating charges or masses. As will be seen in this work, when traveling through our vacuum, they can travel at superluminal speeds, and transmit energy and information (such as a wave function collapse for an entangled particle), much faster than the speed of light. This we will prove. The vacuum will now mediate the force between entangled or correlated particles.

The fundamental symmetry of the vacuum will now be $SO(3)$ invariance, and not Lorentz $SO(1,3)$. This was first recognized, and appreciated, by Winterberg. According to his thesis, $SO(1,3)$ is a dynamic symmetry, which space can simulate under certain conditions. For all practical purposes, space knows no time, and, because of this, the vacuum is, independent of time. Space can be deformed and curved almost instantaneously at the quantum level due to these P- and S-waves, and the information they carry. This is our model.

In Section 2, we review the Winterberg two-component superfluid model, and the individual forces acting on the positive and negative Planck particles. We model these as restoring forces, which will always force the particles back into their equilibrium positions, if and when displaced, due to an outside influence. The proposed ground state of the vacuum is one where the Planck particles are anchored, and oscillating about their equilibrium positions. Remember that forces acting on each Planck particle species are independent of the other.

In Section 3, the electrostatic force between two similar Planck particles, inversely proportional to their distance of separation squared, will be shown to lead to precisely Hooke's law, $F = -\kappa x$, where x is the Planck particle displacement from equilibrium, and κ is the vacuum spring constant, a new fundamental constant of nature. This amazing result was derived in previous work [29], and we repeat it here to emphasize the fact that this force is vacuum specific, does not involve time, and that the vacuum, per se, may be treated as a super-solid. We actually derive a numerical value for the vacuum spring constant, κ. The very large calculated value for the vacuum spring constant will show that space is indeed very, very rigid. Even though the vacuum is very stiff, and rigid, it can be deformed, and curved. We emphasize that this is literally a *mechanical* deformation of the lattice at the subnuclear level, and that space has a graininess associated with it, which we estimate is of the order of, 5E−19 meters. At this scale, we should be able to see features of the lattice.

In Section 4, we introduce vastly new material. For those readers who are very familiar with previous work by this author, this section can be jumped to, immediately. Here we calculate the bulk, and shear modulus, for our vacuum. It will come as no surprise that these values will depend crucially on the numerical value of our vacuum spring constant. Both expressions for shear and bulk modulus are remarkably simple, and could almost have been deduced, through dimensional analysis, in hindsight. Then we go on to derive the longitudinal, and transverse speeds, for our P- and S-waves, respectively. Both types of waves will exceed the speed of light, by many, many orders of magnitude. Hence, we will postulate that quantum information can be transmitted almost instantaneously between entangled or correlated particles through these types of waves. Because of a previous interaction, the entangled particles have a history with one another, and one particle is receptive to the information flow from the other partner particle, at incredible speeds. Space, and its' deformation, will be shown to be practically independent of time.

Finally, in Section 5, we present our summary and conclusions. We will discuss some of the implications of our model. Perhaps the most striking is the abandonment of the Stueckelberg-Feynman diagrams, as the ground state representation of the vacuum. These, within our model, are thought to be higher order corrections to the vacuum, and while they may be useful in perturbation calculations leading to higher order radiative corrections, we believe that *they do not represent the ground state of space*. Elementary particles are already excitations within the vacuum according to Winterberg, and as such, a vacuum filled with such particles, whether they are virtual or real, cannot represent the lowest energy, or ground state, of the vacuum.

We also discuss the role of photons, and gravitons. Gravitational waves exist, as they have been detected [38]-[41], for cataclysmic events in space, such as black hole mergers. But gravitons, per se, are still questionable and hypothetical particles, as they have not been observed directly. Photons, *as mediating force particles*, may have to be revised, at the most fundamental level. They certainly appear whenever charged particles are being accelerated, for example, when there are energy jump transitions within atoms, in nuclear reactions, or in particle-antiparticle annihilation. But in all these instances, we have charged particles which are accelerating. Gravitational waves also rely on accelerating objects, in this case, accelerating masses for their formation.

2. The Vacuum According to Pilot/Winterberg

The Planck mass, m_{Pl}, is related to Planck charge, q_{Pl}, by the following relation.

$$m_{Pl}^2 G = \hbar c = q_{Pl}^2 k \tag{2-1}$$

This is easily proven by using the respective definitions for both, m_{Pl}, and, q_{Pl}. In the above equation, k, is related to the electric permittivity of free space,

ε_0^{elstat}, by the Equation, $k = 1/\left(4\pi\varepsilon_0^{elstat}\right) = 8.988\text{E}9$ (MKS). All units not expressly written out are MKS units. Using Equation (2-1), both, m_{Pl}, and, q_{Pl}, could be created at the same time, and not necessarily at Planck temperature of, ~ E32 Kelvin. If G varies with cosmological time, then Equation (2-1), tells us that, m_{Pl}, must also vary with cosmological time such that the product, $m_{Pl}^2 G = \hbar c$, stays constant. In the current epoch, $G = G_0 = 6.674\text{E}-11$ (MKS). This fixes the Planck mass in the present epoch to equal, $m_{Pl} = m_{Pl,0} = 2.176\text{E}-8\ \text{kg}$. The Planck charge has the value, $q_{Pl} = 1.876\text{E}-18$ Coulombs. This quantity is assumed not to vary with time.

We next multiply Equation (2-1), by $1/r^2$. The, r, will stand for the distance of separation between two similar Planck mass particles, which is the same distance as between the two Planck charge particles. Because they are one and the same particle by our hypothesis, we have two separate forces coming into being at the same time, as two separate force magnitudes are formed.

$$Gm_{Pl}^2/r^2 = \hbar c/r^2 = kq_{Pl}^2/r^2 \tag{2-2}$$

Along a line connecting the two particles, one of the forces, Gm_{Pl}^2/r^2, will be attractive, and the other, kq_{Pl}^2/r^2, repulsive, when acting on an individual Planck particle. From Equation (2-2), it follows namely that,

$$\left(-G\frac{m_{Pl}^2}{r^2} + kq_{Pl}^2/r^2\right)\hat{i} = 0 \tag{2-3}$$

The unit vector, $\hat{i}$, points from one mass to the other, along a particular direction in space. In Equation (2-3), we see that Newton's law, and, at the same time, Coulomb's law, hold for two positive Planck particles, as well as for two negative Planck particles. A Planck particle is now categorized by the same value for, (m_{Pl}, q_{Pl}).

What about a positive Planck particle separated from a negative one? This would introduce a minus sign for the two terms on the left-hand side of Equation (2-3), but their sum would still add up to zero. Positive and negative Planck particles do not interact directly, but indirectly [27] [28], through their individual fluid forces. These fluid forces are caused by particles within their own species. The fluid forces are such as to make the positive and negative mass particles spread out evenly. However, as argued previously, because the two species occupy the same space, the positive and negative particles are invariably drawn next to each other through their respective fluid forces. They are forced to rub shoulders with one another, so to speak, without necessarily interacting. Nevertheless, Equation (2-3), still works as an effective force law between unlike charges/masses.

Equations (2-2), or, (2-3), are the effective forces acting on *an individual* Planck particle due to another specific Planck particles in the vicinity. The simplest way to write the magnitude of this force law is simply,

$$F = \hbar c/r^2 = F_{grav} = F_{elstat} \tag{2-4}$$

These Planck particles need not be nearest neighbors. This is both simultaneously an attractive and a repulsive force by virtue of Equation (2-2), or, (2-3). When attractive, we can call it gravity. When repulsive, we call it electrostatic. Positive and negative mass Planck particles want to maintain a fixed distance of separation from other positive and negative mass Planck particles, respectively.

It was stated that positive and negative mass Planck particles want to maintain a fixed distance of separation from one another. When displaced from equilibrium, the Planck particles will experience a restoring force wanting to bring them back to their original configuration. This equilibrium state is the ground state, or lowest energy state, for the vacuum. For the positive and the negative Planck particle, those restoring forces are [28], respectively,

$$F_{+,x} = \left(m_{Pl}\right)\ddot{x} = -\kappa x \tag{2-5}$$

$$F_{-,x} = \left(-m_{Pl}\right)\ddot{x} = +\kappa x \tag{2-6}$$

The, κ, is the vacuum spring constant, which is assumed to be the same for both the positive and the negative Planck particle.

We have, $+\kappa$, on the right-hand side of Equation (2-6), which is needed for a bounded solution. Choosing a negative value for the spring constant on the right-hand side would give us a hyperbolic sinusoidal solution, which is unbounded. The, x, in both equations, refers to the displacement from equilibrium, either positive or negative, along a particular direction in space. If the Planck particles get too close to other particles of the same species, then there will be repulsion. If they stray too far from each other, then there will be attraction. In this way equilibrium is maintained within the fluid, where the individual Planck particles are, more or less, anchored in position. We shall see very shortly, that κ has a very high value indicating a very stiff or rigid fluid. We prefer super-solid, which makes the vacuum semi-rigid. It can, however, still be deformed and curved, given its semi-rigid structure.

As was demonstrated by Winterberg, the *collective fluid force* acting on a positive mass Planck particle is,

$$\overrightarrow{F_+} = -n_+^{-1}\vec{\nabla}p_+ = -n_+^{-1}\left(\vec{\nabla}n_+\right)m_{Pl}c^2 \tag{2-7}$$

This is due to the other positive Planck particles within the fluid. In Equation (2-7), $n_+\left(\vec{x}\right)$ represents the positive Planck particle number density, and $\vec{\nabla}p_+$ is the gradient of the Planck vacuum pressure, $p_+\left(\vec{x}\right)$. The positive Planck vacuum pressure is due to the other positive Planck particles in the vicinity, and it equals, $p_+ \equiv n_+ m_{Pl}c^2$, where c is the speed of light and, m_{Pl}, is the Planck mass.

Like all fluids, particles within the fluid will want to move from higher pressure regions to lower pressure regions. For an increase in pressure, in moving the particle from, x, to, $x+dx$, there is a restoring force acting in the opposite direction, wanting to bring the particle back. In one dimension, Equation (2-7), namely reads,

$$F_{+,x} = -n_+^{-1}\, dn_+/dx\, m_{Pl}c^2$$

$$-\kappa x = -n_+^{-1}\, dn_+/dx\, m_{Pl}c^2 \tag{2-8}$$

We have set the left-hand side of Equation (2-8), equal to, $-\kappa x$, because this is our restoring force. Think of the left-hand side as a response to the right-hand side, where we assume some sort of external influence, which causes the displacement, dx. For a positive dx, the force is acting in the opposite direction. Hence the minus sign.

Equation (2-8), is easily solved by bringing the, dx, over to the left-hand side and integrating. The solution is,

$$n_+(x) = n_+(0)\mathrm{e}^{\kappa x^2/\left(2m_{Pl}c^2\right)} \tag{2-9}$$

Increasing x in either the positive or negative sense, increases the positive Planck number density, n_+. Furthermore, the positive Planck vacuum mass density, defined as, $\rho_+ \equiv m_{Pl}n_+(x)$, and the positive Planck vacuum pressure, defined as, $p_+ \equiv m_{Pl}n_+(x)c^2$, will also both increase in value. This produces a force, acting in the opposite direction, as indicated by Equation (2-8). Equation (2-9), indicates a "hole", or trough, centered about, $x = 0$, for the positive mass planckion to "rest" in. The minimum positive Planck vacuum pressure is achieved when, $x = 0$. Finally, we now also have a corresponding positive charge vacuum density at point x, $\sigma_+ \equiv q_{Pl}n_+(x)$. Displacing x from its equilibrium position, $x = 0$, will also increase the vacuum charge density.

For a negative Planck particle, the counterpart to Equation (2-7), is found by replacing all positive signs by negative signs, and making the substitution,
$m_{Pl} \to -m_{Pl}$. Thus, the fluid force acting on the negative Planck particle, equals,

$$\overrightarrow{F_-} = +n_-^{-1}\vec{\nabla}p_- = +n_-^{-1}\left(\vec{\nabla}n_-\right)\left(-m_{Pl}\right)c^2 \tag{2-10}$$

This force, $\overrightarrow{F_-}$, is due to the other negative Planck particles populating the vacuum in the vicinity, in this sea of negative charge and mass. Here, $n_-(\vec{x})$ stands for the negative Planck particle number density, and, $p_-(\vec{x})$ is the corresponding negative Planck pressure, defined by, $p_- \equiv n_-(\vec{x})\left(-m_{Pl}\right)c^2$. We notice that p_- is inherently negative. The mass density is defined as, $\rho_- \equiv n_-(\vec{x})\left(-m_{Pl}\right)$, and charge density as, $\sigma_- \equiv n_-(\vec{x})\left(-q_{Pl}\right)$, Both are also inherently negative. Note that in Equation (2-10), the negative mass particle is taking the path of *steepest ascent*, because, here, we are taking the positive gradient. Think of a negative mass particle in the earth's gravitational field… it would accelerate upwards when released. This is in contrast to Equation (2-7), where we are looking at the path of steepest descent, or negative the gradient, for a positive mass particle.

In one dimension, Equation (2-10), reduces to

$$F_{-,x} = +n_-^{-1}\, dn_-/dx\left(-m_{Pl}\right)c^2$$

$$+\kappa x = -n_-^{-1}\, dn_-/dx\, m_{Pl}c^2 \tag{2-11}$$

See Equation (2-6). We have set the left-hand side equal to, $+\kappa x$, because this is a restoring force for the negative mass Planck particle. The solution to Equation (2-11), is found by integration. The result reads,

$$n_-(x) = n_-(0)\,\mathrm{e}^{-\kappa x^2/(2m_{Pl}c^2)} \tag{2-12}$$

This Gaussian looking function indicates a peak at, $x = 0$, versus a trough, as in Equation (2-9). A trough for a negative mass particle is equivalent to a hole for a positive mass particle. In other words, a negative mass Planck will move in such a way, as to want to *increase* its Planck vacuum pressure. Again, think of a negative mass particle in the earth's gravitational field. When released it would accelerate upwards at 9.81 m/s^2, thereby increasing its gravitational pressure. At, $x = 0$, in Equation (2-12), we have maximum pressure for a negative mass Planck particle. Any positive or negative displacement from this equilibrium position, will lead to restoring forces tending to bring the negative mass particle back to, $x = 0$.

The total Planck vacuum pressure, p, due to both positive and negative Planck particles, in a region of space, $\vec{x}$, is

$$\begin{aligned} p(\vec{x}) &= p_+ + p_- \\ &= m_{Pl}c^2(n_+ - n_-) \\ &= 0 \quad (\text{undisturbed fluid}) \\ &\neq 0 \quad (\text{disturbed fluid}) \end{aligned} \tag{2-13}$$

The undisturbed fluid is the ground state of the vacuum. Here, the positive and negative mass number densities exactly balance, *i.e.*, $n_+(\vec{x}) = n_-(\vec{x})$, and the net mass and net charge densities vanish. The Planck vacuum pressure is related to the net Planck particle mass density, ρ, by the equation of state, $p = \rho c^2$. Therefore, by Equation (2-13), we may also write,

$$\begin{aligned} \rho(\vec{x}) &= \rho_+ + \rho_- \\ &= m_{Pl}(n_+ - n_-) \\ &= 0 \quad (\text{undisturbed fluid}) \\ &\neq 0 \quad (\text{disturbed fluid}) \end{aligned} \tag{2-14}$$

The same holds for the total charge density, $\sigma(\vec{x})$. The total charge density, $\sigma(\vec{x}) = \sigma_+ + \sigma_-$. If, $n_+(\vec{x}) > n_-(\vec{x})$, or, $n_+(\vec{x}) < n_-(\vec{x})$, the two-component superfluid will no longer be undisturbed. Then we will have a net Planck vacuum pressure, a net Planck vacuum mass density, and a net Planck vacuum charge density. A net Planck vacuum mass/charge density and pressure for the vacuum, positive or negative, is a prediction of Winterberg's theory.

There is a second kind of disturbed vacuum Planck fluid possible, one for which, $n_+(\vec{x}) = n_-(\vec{x})$. We can vortex rotation within a region of space. Here, the positive and negative Planck number densities match. Winterberg believes that these quasiparticle excitations due to rotating positive and negative Planck particles, either with, or counter to one another, can produce elementary particles, and the characteristics associated with them, such as spin, mass, charge, and magnetic moment. The mass, specifically, would be a consequence of their rotational kinetic energy. Their charge would also result from their rotational KE. There has to be a localized pressure difference, which is responsible for such vortex rotations. We can think of elementary particles as mini eddy currents arising within such a superfluid, which can decay, or remain stable with time. Both are possible in a superfluid. This is an intriguing notion, but further discussion would take us too far afield.

We next will focus our attention on finding a relation between the Planck vacuum spring constant, κ, and, $n_+(0)$, the Planck number density for an undisturbed Planck fluid.

3. Determination of the Planck Vacuum Spring Constant

We next want to establish a connection between the vacuum spring constant, κ, which holds for both species of Planck particle, and, $n_+(0) = n_-(0)$, which is the undisturbed positive and negative mass Planck particle number density. For ease of writing, we now set, $n_+(0) = n_+$, and, $n_-(0) = n_-$. As shown previously in Section 2, a positive mass Planck particle will simultaneously attract and repel another positive mass Planck particle through electrostatic forces. The same can be said for negative mass Planck particles. In short, the Planck particles strive to maintain a fixed distance of separation from one another.

Let us consider a string of *positively charged* Planck particles, all in a row, along the x-axis, and label them, #1, #2, #3, etc. Due to the symmetry, and the vector nature of forces, the forces in the, y, and, z, direction will cancel each other out, *i.e.* not contribute, due to the ensemble of the other Planck particles within the vacuum, and we need only concern ourselves with forces in the x-direction. We focus on particle, #3, and sum up the individual forces acting on this particle, when that 3rd particle is displaced a distance, x, to the right. We claimed previously, that displacing this Planck particle will cause a restoring force in the amount, $F_{+,x} = (m_{Pl})x = -\kappa x$, and so we set,

$$\begin{aligned} -\kappa x &= F_{43x} + F_{23x} + F_{53x} + F_{13x} + \cdots \\ &= -kq_{Pl}^2\left[1/(l_+ - x)^2 - 1/(l_+ + x)^2 + 1/(2l_+ - x)^2 - 1/(2l_+ + x)^2 + \cdots\right] \\ &= -\hbar c/l_+^2\left[1/(1 - x/l_+)^2 - 1/(1 + x/l_+)^2 + 1/(2 - x/l_+)^2 - 1/(2 + x/l_+)^2 + \cdots\right] \end{aligned} \quad (3\text{-}1)$$

In the last line, Equation (2-1), was employed. The force that particle, #4, exerts on particle, #3, which is, F_{43x}, is pointing to the left, and hence the negative sign in Equation (3-1). The force that particle, #2, exerts on particle, #3, which is, F_{23x}, is pointing to the right, and hence the positive sign associated with this force in Equation (3-1). The positive and negative signs for all subsequent forces are found in this fashion. In, Equation (3-1), l_+, is the unperturbed nearest-neighbor distance of separation between two positive Planck particles.

The, l_+, is related to the positive mass Planck particle number density, n_+, through the equation,

$$n_+ = l_+^{-3} \quad (3\text{-}2)$$

It is assumed that our three-dimensional space is tessellated in such a fashion, such that there are no gaps or overlapping regions. A similar expression holds for the negative Planck particles, $n_- = l_-^{-3}$.

Let us now define the dimensionless coefficient, $\beta \equiv x/l_+$. We recognize that, Equation (3-1), contains terms of the form,

$$1/(m-\beta)^2 - 1/(m+\beta)^2$$

within the parenthesis on the right-hand side. The quantity, m, can take on integer values, $m = 1, 2, 3, \cdots$. There is a mathematical identity, which states that,

$$1/(m-\beta)^2 - 1/(m+\beta)^2 = 4m\beta/(m^2-\beta^2) \quad (3\text{-}3)$$

Upon making use of this identity, we can therefore write, Equation (3-1), as follows,

$$-\kappa\beta l_+ = \left(-\hbar c/l_+^2\right)\left[4\beta/(1-\beta^2)^2 + 8\beta/(4-\beta^2)^2 + 12\beta/(9-\beta^2)^2 + \cdots\right] \quad (3\text{-}4)$$

Next, in Equation (3-4), we can factor out the, $-\beta$, term on both left- and right-hand sides. Then, we bring the, l_+, term from the left-hand side over to the right-hand side, and make use of Equation (3-2), to simplify. The result, after factoring out the numerical value of 4, is,

$$\kappa = \left[4\hbar c n_+(0)\right] * \left[1/(1-\beta^2)^2 + 2/(4-\beta^2)^2 + 3/(9-\beta^2)^2 + \cdots\right] \quad (3\text{-}5)$$

Equation (3-5), holds for any value of β, including $\beta = 0$, or, what is equivalent, $x = 0$.

We specialize to, $\beta = 0$. Then we have,

$$\kappa = \left[4\hbar c n_+(0)\right]\left[1 + 1/8 + 1/27 + 1/64 + \cdots\right] \quad (3\text{-}6)$$

Equation (3-6), equals an infinite series, which converges [42] [43]. The series has the value,

$$\sum_{n=1}^{\infty}\left(1/n^3\right) = \zeta(3) = 1.202\cdots \quad (3\text{-}7)$$

here, ζ is the Riemann Zeta function, and $\zeta(3)$ equals Apery's constant, an irrational number. Numerically, $\zeta(3) = 1.202\cdots$. We make use of this series to obtain an expression for, κ, the vacuum spring constant. It reads,

$$\begin{aligned}\kappa &= 4\hbar c n_+(0)\zeta(3) \\ &= (4.808\cdots)(\hbar c)n_+(0)\end{aligned} \quad (3\text{-}8)$$

This expression for, κ, was derived under the assumption that, $\beta = x/l_+ = 0$. But it must also hold for any and all values of x, which would include, $x \neq 0$. In other words, the infinite series for the specialized case, $x = 0$, will carry over to the more generalized case, where we have, $x \neq 0$.

The arguments, which were presented above were for a positive mass/charge Planck particle must also hold for a negative mass/charge Planck particle. Some of the signs change, but the outcome is the same. The negative Planck particles are also held in check by what are, essentially, electrostatic forces. They can be given a massive interpretation by virtue of Equation (2-3). We simply replace, kq_{Pl}^2, by,

Gm_{Pl}^2, or, $\hbar c$, in Equation (3-1). The products are all equal.

We still have to determine the relaxed Planck particle number density, $n_+ = n_-$ in order to calculate a numerical value for κ, by Equation (3-8). This has been done in previous work [29], and we will not repeat the derivation here. We refer the reader to that publication to obtain the proof. We used the fact that our Planck particles are, more or less, spatially anchored, or locked, in position. Hence, they are confined to a region of space where box quantization must apply. They are also continuously vibrating (oscillating), and thus accelerating, which produces gravitational, or, what is equivalent, electromagnetic, radiation. This vibration is due to their collisions with thermal blackbody photons, from the cosmic background radiation (*CBR*), mentioned earlier. Because they are "boxed in", and radiating, the energy of the radiation emitted must be related to the quantum energy level jumps, or transitions, permissible within that box. We looked at the most probable energy transition and equated that to the peak energy being emitted by these quantum radiators. Much like the Bohr atom for Hydrogen, energy level transitions account for the radiation frequency emitted. The situation here is totally analogous. We found the dimensions of this cubic box, in this fashion.

The result is,

$$L \equiv l_+ = l_- = 5.032\text{E}-19 \text{ meters} \tag{3-9}$$

The dimensions of the cubic box are, L^3. L also gives us the distance of separation between nearest-neighbor positive, and nearest-neighbor negative, Planck particles. The length of the box centered around the positive or negative Planck particle is also the distance of separation between nearest-neighbor Planck particles.

We point out that our nearest-neighbor separation distance, for a specific species of Planck particles, is very close to the limits what modern day accelerators are able to probe. The diameter of a quark is about, 8.60E−19 meters. Equation (3-9), is just a hair below that. The *LHC* at *CERN* produces 7 TeV protons whose Compton wavelength is 1.78E−19 meters. All these distances are comparable to the nearest-neighbor Planck particle separation distance. Could it be that we are on the cusp of observing an inherent "graininess" to the vacuum? This would represent quite an achievement, and an obvious validation of this model. If space is indeed structured and pixelated, that would indeed represent a revolutionary discovery.

Having determined the nearest-neighbor separation distance between individual Planck particles in the present epoch ($T_{CBR} = 2.725$ degrees Kelvin), we proceed to find the average number density for both our positive and the negative mass Planck particle. We will employ, Equations (3-2) and (3-9). Substituting, Equation (3-16), into, Equation (3-2), we find that,

$$n_+ = l_+^{-3} = 7.848\text{E}54 \text{ m}^{-3} \tag{3-10a}$$

$$n_- = l_-^{-3} = 7.848\text{E}54 \text{ m}^{-3} \tag{3-10b}$$

These number densities for our Planck particles are, needless to say, very large in value. But remember that we are attempting to find a "graininess" to space, which most believe is inherently smooth and continuous. If one has this many particles in a box of size, 1 m^3, then space would indeed appear smooth and continuous.

Let us now come back to our defining equation for the vacuum spring constant, Equation (3-8). Utilizing, Equations (3-8), and, (3-10a), we can now evaluate its value. We obtain for this calculation,

$$\kappa = 1.194\text{E}30 \text{ Newtons/meter} \tag{3-11}$$

This is a current cosmological epoch value because the vacuum spring constant will scale upon expansion of the universe, as shown in reference [30], where we assume that Newton's constant varies with time. This very large value for the vacuum spring constant justifies our assumption that we are dealing with a very stiff super-solid when considering the vacuum. Planck particle restoring forces are indeed very, very large, even for the smallest displacements within our three-dimensional space. These positive and negative Planck particles can thus provide for giving space its structure, and they also allow for its deformation and curvature.

We have shown that the Planck vacuum spring constant can be defined strictly in terms of quantum electrostatic forces. Or, equivalently, quantum gravistatic forces. See Equation (3-1), where a quantum electrostatic force can also be given a gravistatic representation. In the previous section, κ, was associated with the restoring force *if either the electrostatic force, or, equivalently, the gravistatic force, got the upper hand*. They are one and the same force as indicated by, Equation (2-2). For equilibrium, the electrostatic force of repulsion was counteracted by the gravitational force of attraction between two Planck particles of similar mass/charge.

We can also look more carefully at the sum given in, Equation (3-1). All the negative sign contributions pull the #3 particle to the left. All the positive sign contributions pull planckion particle #3 to the right. If, $x = 0$, then there is no displacement and particle #3 is in equilibrium. In other words, both the individual forces pulling to the left and the individual forces pushing to the right add up to zero. We can identify the gravitational force with the sum of either one of these net forces, pushing or pulling. The electrostatic force would then be identified with the counteracting force, and acting in the opposite direction.

When Planck particles first came into existence, two force magnitudes were simultaneously created. But they counteracted each other, as shown in Equation (2-3). We believe that the gravitational force has evolved with cosmological time through a cosmologically varying G value, whereas the electrostatic force has not. As such, gravity became weaker with time, whereas the electrostatic force essentially remained the same. In this way gravity became weaker with time, whereas electrostatics has not. This may be the real reason why gravity is so much weaker than electrostatics in the current epoch.

4. P-Waves and S-Waves within the Quantum Vacuum

In this section we will introduce a possible mechanism for the transmission of quantum information. We will argue that it is not photons, or gravitons which will transmit that information. Rather, the vacuum or space itself, will be able to carry that information. Space, being a super-solid, will allow for two types of waves to propagate within it. We can have longitudinal, compressional P-waves. And there are also transverse shear waves, or S-waves. P-waves are compressional pressure waves and they move by compressing, and expanding the material in the direction of motion. S-waves are shear waves which vibrate the material *perpendicular* to the direction of motion. P-waves are faster than S-waves because they can exploit both shear and compressional rigidity. The S-waves, by contrast, only exploit shear rigidity to transmit the waves' energy.

The expressions for the respective wave speeds [44] [45] in a solid are as follows,

$$v_{\text{P-Waves}} = \sqrt{\left(B + \frac{4}{3}S\right)\Big/\rho} \tag{4-1}$$

$$v_{\text{S-Waves}} = \sqrt{S/\rho} \tag{4–2}$$

where, B is the bulk modulus, which represents the resistance of the material to compress. The variable, S, is the Shear modulus, which expresses the resistance of the material to shear. And, ρ, is the mass density of the material. The units for B and S are Newtons/m^2, the same as those for pressure.

We start with shear waves. To find an expression for S, we refer to the figure below, **Figure 1**.

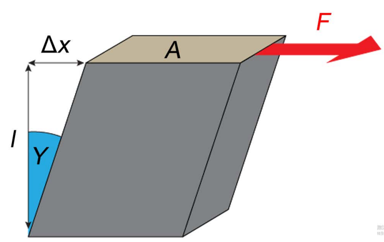

Figure 1. Shear modulus illustration. See text.

In this figure, F, is the applied force and Δx is the amount of shear. The shear modulus is given by [44] [45],

$$S = (F/A)/(\Delta x/l) \tag{4-3}$$

here, $F/\Delta x = \kappa$, and $l/A = L/L^2$, where L is the length of the cube. The length of our elemental cube may be taken as, Equation (3-16), and the κ value will be obtained from, Equation (3-18). Substituting these values renders,

$$S = \kappa/L = 2.373\text{E}48 \tag{4-4}$$

This is a remarkably clean and simple expression. The larger the value for the vacuum spring constant, the larger the value for the shear modulus, which makes perfect sense. Shear waves can only be defined for solids, which is the case here. It cannot be defined for conventional liquids or gases, or radiation.

For the bulk modulus, B, the formula is [44] [45],

$$B = -(F/A)/(\Delta V/V_0) \tag{4-5}$$

In this equation, F is the applied force, ΔV, is the amount of volume compression, and, V_0, is the original volume. The negative sign tells us that a compressional force will lead to a volume *decrease*. The numerator in Equation (4-5) is the bulk stress, and the denominator is the bulk strain. Referring to Figure 2, if we allow, or specialize for compression in only one direction, the x direction, we see that $\Delta V = L^2 \Delta x$, and, $V_0 = L^3$. We also know that, $F/\Delta x = -\kappa$. Substituting all this into Equation (4-5) allows us prove that,

$$B = -(F/\Delta x)(1/L) = \kappa/L \tag{4-6}$$

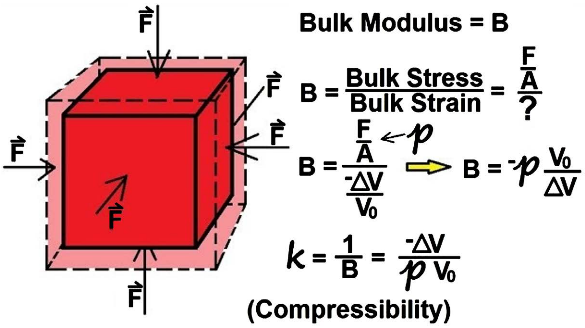

Figure 2. Bulk modulus definition. See text.

We notice that both S, and B, have the same value, namely, κ/L, which is perhaps not surprising upon some reflection. As mentioned, dimensional analysis could possibly lead to such results. Therefore, utilizing Equations (4-1), and (4-2),

$$v_{\text{P-Wave}} = \sqrt{2.33}\sqrt{\kappa/(L\rho)} \tag{4-7}$$

$$v_{\text{S-Wave}} = \sqrt{\kappa/(L\rho)} \tag{4-8}$$

Moreover, for a homogeneous isotropic solid (the case here), there is a relationship between S, and B, which states that,

$$S = B/(3(1-2\nu)) \tag{4-9}$$

In this expression, ν is Poisson's ratio defined as,

$$\nu \equiv d\varepsilon_{trans.}/d\varepsilon_{axial} \tag{4-10}$$

And, $\varepsilon_{trans.}$, is the transverse strain, whereas, ε_{axial}, is the axial strain. Here, we have, $S = B$, for our vacuum, and thus, $\nu = 1/3$.

We next turn to ρ, which is the mass density. If we set $\rho = 0$, then both the P- and S-wave speeds would be infinitely fast. See, Equations (4-7), and (4-8). For a vacuum in the ground state with absolutely no disturbances, we would have precisely these speeds for transmission, as can be seen by, Equation (2-15). But space, in general, is not empty. There is always stuff in it, like ordinary solids, liquids and gases. We can also have plasmas, radiation, elementary particles, and other "contaminants", if you will, in that box. Thus, we will resort to the concept of a "dirty box". This is now a box filled with stuff. This box has to be sufficiently large such that it can accommodate the solid, the liquid, the gas, the plasma, etc. An elemental box of size, L^3, where L is specified by, Equation (3-16), will definitely not suffice to contain the "material". We are now thinking of a box, of typically macroscopic size, 1 m^3, or 1 km^3, as examples.

In box, the S, given by, Equation (4-4), will have to be modified. We have to replace the vacuum shear modulus, S, by,

$$S_{Total} = S + S_{Stuff} \tag{4-11}$$

where, S, is the shear modulus of the Winterberg vacuum (what was calculated previously), and, S_{Stuff} is the shear modulus of the other stuff in the box. However, if we look at the numerical value of S, as specified by, Equation (4-4), we see that every other conceivable value for S_{Stuff} will pale in comparison to the S value just calculated. And thus, the second term on the right-hand side of Equation (4-11), can safely be ignored when compared to the first. Actually, because we have two species of Planck particle, the positive and the negative, the first term should, more correctly, be multiplied by a factor of two.

Furthermore, the vacuum mass density, $\rho = 0$, also has to be replaced. We replace, $\rho = 0$, by,

$$\rho_{Total} = \rho + \rho_{Stuff} \tag{4-12}$$

But because $\rho = 0$, for an undisturbed vacuum, by, Equation (2-14), it is only the second term, which contributes. Hence, for a macroscopic box filled with stuff, Equation (4-2) reduces to,

$$v_{\text{S-Waves}} = \sqrt{2S/\rho_{Stuff}} \tag{4-13}$$

The factor of two under the radical is due to the two species of Planck particle, positive and *negative*, *which both contribute to the shear modulus*.

Some real-life numerical examples of Equation (4-13) have been worked out, and are shown below.

$$v_{\text{S-Wave}}\left(\rho_{\text{Air}} = 1\ \text{kg/m}^3\right) = 2.18\text{E}24\ \text{m/s} \tag{4-14a}$$

$$v_{\text{S-Wave}}\left(\rho_{\text{Water}} = 1000\ \text{kg/m}^3\right) = 6.89\text{E}22\ \text{m/s} \tag{4-14b}$$

$$v_{\text{S-Wave}}\left(\rho_{\text{Metal}} = 10000\ \text{kg/m}^3\right) = 2.18\text{E}22\ \text{m/s} \tag{4-14c}$$

$$v_{\text{S-Wave}}\left(\rho_{\text{Universe}} = 8.67\text{E}-27\ \text{kg/m}^3\right) = 2.33\text{E}37\ \text{m/s} \tag{4-14d}$$

$$v_{\text{S-Wave}}\left(\rho_{\text{10 Sun Mass Black Hole}} = 1.84\text{E}17\ \text{kg/m}^3\right) = 5.08\text{E}15\ \text{m/s} \tag{4-14e}$$

Normally, a shear wave cannot be defined for a liquid or a gas because we need shear rigidity. And, Equations (4-14a), and (4-14b), are specifically for a gas, and a liquid, respectively. However, the final expression, $v_{\text{S-Waves}} = \sqrt{2S/\rho_{Stuff}}$, does not explicitly involve the shear modulus associated with a liquid or gas, since we have used the vacuum value for the shear modulus. Thus, the quantities, calculated above, are all valid.

What about the P-wave? First, the bulk modulus can be defined for any solid, liquid, or gas. Irrespective of what the box is filled with, $B_{Total} = B + B_{Stuff}$. However, because of the extremely large value for $B = S$, specified by, Equation (4-4), the quantity, B, will always be much, much greater than any conceivable value for, B_{Stuff}. Hence, $B_{Total} = B$. Also, more correctly, $B_{Total} = 2B = 2S$, because we have two species of Planck particle, positive and negative, and both contribute to the vacuum bulk modulus.

As before, the total mass density is, $\rho_{Total} = \rho + \rho_{Stuff}$. However, by, Equation (2-15), $\rho = 0$, for an undisturbed vacuum. And so, $\rho_{Total} = \rho_{Stuff}$. Therefore, we can prove that,

$$v_{\text{P-Wave}} = \sqrt{2.33}\, v_{\text{S-Wave}} \tag{4-15}$$

See, Equations (4-7) and (4-8). We can, therefore, take the values calculated in Expressions, (4-14a-e), and simply multiply them by $\sqrt{2.33}$, to find the corresponding speeds for, $v_{\text{P-Wave}}$. We notice that our P- and S-waves travel the quickest in the universe at large, as indicated by, Equation (4-14d), as this comes closest to empty space.

These P- and S-waves can carry information through the vacuum much like Earth quake waves do when they pass though the Earth. And just like Earth quake waves, they are caused by stresses and strains within the solid, such as a rupture, or a disturbance, or, an "event" within the solid. A wave function collapse within the vacuum could be such an "event". As can be deduced from the derivation above, the extreme superluminal speeds are due to the extreme values for vacuum shear modulus, S, and, vacuum bulk modulus, B. We believe that because of these superluminal speeds, many orders of magnitude greater than the speed of light, information travels almost instantaneously fast, when traveling within the quantum vacuum. It would take close to no time at all to transmit information over very large distances. They may help explain entanglement.

But there is another aspect worth considering. Earth quake waves also serve to dissipate or disperse energy, and bring the Earth back to equilibrium conditions. Within the vacuum we can imagine a similar scenario, and function. The P- and S-waves will cause the vacuum to revert back to the ground state by dissipating the energy created by the disturbance, or event, as quickly as possible. In this way, they might serve to hold the vacuum together in the lowest energy state configuration possible. If our thinking is correct, it is *NOT* the photons or gravitons which hold the vacuum together, but rather, the electrostatic Planck particle binding force, as well as the P- and S-waves. The latter allow for the dissipation of energy due to disturbances or events within space. And taking a measurement might just qualify as a disturbance, or event.

We close this section with a hypothetical thought experiment. Imagine that our Sun, all of a sudden, were to lose its mass, for whatever reason. According to our theory, the curvature caused by the Sun's mass would almost instantaneously be lifted. That information would be carried by our P- and S-waves. So, a split second later, the curvature would be lost, and the orbiting bodies, such as the Earth would start to fly off at a tangent. Heat and light would still be emitted from the Sun's surface through photons, and reach us much later, 8 minutes, 20 seconds later, and then some, because photons travel at the speed of light. The little bit later is due to the slightly increased distance of separation due to the Earth flying off at a tangent. The spatial manifold is held intact by quantum electrostatic forces, and that information travels through the vacuum through the P- and S-waves. They propagate much, much faster than light, almost infinitely fast. The flatness of space is thereby reestablished almost instantaneously.

5. Summary and Conclusions

We introduced a model for space where Planck mass and Planck charge were frozen out of the vacuum simultaneously. We treated mass and charge as two components of a more fundamental particle, the Planck particle. Based on previous and extensive work by Winterberg, the vacuum is a vast assembly (sea) of positive and negative mass Planck particles, which form a two-component superfluid, which fills all of space. This ether is initially massless, electrically neutral, and has zero net gravitational pressure, in its initial, undisturbed state.

Within the Winterberg model, we introduced the notion that Planck mass and Planck charge were created simultaneously, which lead to the creation of two force laws simultaneously, one electrostatic, and one seemingly gravitational in nature. Both however can be viewed as electrostatic. The electrostatic force keeps two Planck particles of the same species, whether they have positive or negative mass, apart. The gravistatic force law can be thought of as bringing them together. Equilibrium is achieved, because individual Planck particles want to maintain a fixed distance of separation from one another within their species. Gravity is connected to electrostatics, on a quantum level, by Equations (2-2) and (2-3).

Planck particles are anchored, or locked, in position spatially via electrostatic fluid forces. Equation (2-7) holds for the positive mass Plank particles, and Equation (2-10), is valid for the negative mass Planck particles. Both lead to number density functions, which will tend to bring the Planck particle back to equilibrium, if displaced. See Equations (2-9) and (2-12). The total vacuum pressure is zero, and so is the net energy density, if Planck particles are undisturbed. Refer to, Equations (2-13) and (2-14).

In Section 3, we looked at the restoring force acting on individual Planck particles more carefully and discovered that it is entirely electrostatic in origin. See Equation (3-1). The Planck vacuum spring constant could thus be evaluated, and the result is Equation (3-8). Moreover, by appealing to box quantization, and Planck's radiator formula, we could determine the nearest neighbor inter-spatial distance of separation between Planck particles of the same species. Those values are given by Equations (3-9a, b). We then calculated the average number density for the positive mass and negative mass, Planck particle. This is for an undisturbed vacuum. Equations (3-10a, b), are the result. (These values for positive and negative Planck particle number density holds only in the present cosmological epoch if we leave open the possibility that Newton's gravitational constant, G, can vary with cosmological time.) Given the Planck particle number density, the vacuum spring constant, κ, due to these Planck particles, could be evaluated. Numerically we obtain, $\kappa = 1.194\text{E}30\ \text{N/m}$, as indicated by Equation (3-11). The vacuum is very, very stiff, as can be seen by this extreme large value for, κ. Moreover, this spring constant will also be epoch dependent, if Newton's gravitational constant varies with time.

In Section 4, we introduced the concept of P- and S-waves for our super-solid vacuum. A bulk and shear modulus could be defined for each type of wave, and as it turns out, when calculated, the bulk modulus equals the shear modulus, for the quantum vacuum. Both are proportional to the vacuum spring constant, κ, calculated previously. The P-wave, and S-wave speeds were then calculated for various substances. For a perfectly undisturbed vacuum where the mass density equals zero, their speeds were both infinite, *i.e.*, it takes no time to transmit information through the quantum vacuum. For the more realistic situation where the vacuum is filled with matter, in the form of either a solid, a liquid or a gas, the P and S-wave speeds have finite values, which can be calculated. A few examples were worked out, and are given by Equations (4-15a, b, c, d, e). We see that these speeds are typically many, many orders of magnitude greater than that of light. An event within the vacuum such as a rupture or a disturbance, can thus transmit information and energy through the vacuum almost instantaneously. Photons and gravitational waves, are interpreted not as mediating particles (carriers of force) within our framework, but as waves due to accelerating objects, within the vacuum.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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