Is the Higgs Field a Positive and Negative Mass Planckion Condensate, and Does the LHC Produce Extreme Dark Energy?

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ABSTRACT:

Assuming a two component, positive and negative mass, superfluid/supersolid for space (the Winterberg model), we model the Higgs field as a condensate made up of a positive and a negative mass, planckion pair. The connection is shown to be consistent (compatible) with the underlying field equations for each field, and the continuity equation is satisfied for both species of planckions, as well as for the Higgs field. An inherent length scale for space (the vacuum) emerges, which we estimate from previous work to be of the order of, $l_{+}(0) = l_{-}(0) = 5.032\ E - 19\ meters$*, for an undisturbed (unperturbed) vacuum. Thus we assume a lattice structure for space, made up of overlapping positive and negative mass wave functions,* ψ_{+} *, and,* ψ_{-} *, which together bind to form the Higgs field, giving it its rest mass of* $125.35\ Gev/c^2$ *with a coherence length equal to its Compton wavelength. If the vacuum experiences an extreme disturbance, such as in a LHC* $p\bar{p}$ *collision, it is conjectured that severe dark energy results, on a localized level, with a partial disintegration of the Higgs force field in the surrounding space. The Higgs boson as a quantum excitation in this field results when the vacuum reestablishes itself, within* $10^{-22} seconds$*, with positive and negative planckion mass number densities equalizing in the disturbed region. Using our fundamental equation relating the Higgs field,* φ*, to the planckion* ψ_{+}*and* ψ_{-}*wave functions, we calculate the overall vacuum pressure (equal to vacuum energy density), as well as typical* ψ_{+} *and* ψ_{-} *displacements from equilibrium within the vacuum.*

Keywords:

Winterberg Model, Quantum Vacuum, Higgs Condensate/Composite Model, Two-Component Superfluid/Supersolid Model for the Vacuum, Positive/Negative Planckion Mass, Q-Theory, Non-Linear Heisenberg Spinor Theory, LHC Energies, Dark Energy, Lattice Substructure for Space.

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I Introduction

The Higgs force field, and the Higgs boson, as a quantum excitation in that field, are probably the least understood, and most obscure feature, in the standard model of particle physics. In 2012, the LHC (Large Hadron Collider) $ATLAS$ and CMS collaborations [1-3] have found a particle compatible with the Higgs boson, having a rest mass of $125.35\ Gev/c^2$ (latest estimate). This interpretation is not definitive because even though the particle has all the characteristics of the Higgs boson (spin-less, charge-less, color-less), we are not really sure what a Higgs particle is. Could it ultimately be a composite particle, similar to a Cooper pair in the BCS theory found in condensed matter physics? If so, then the lattice would play an integral and crucial role in defining the Higgs field, as the condensate now reduces to something comparable to an electron-phonon-electron interaction.

Associated with this interpretation of the vacuum are far-reaching attempts to understand how gravity fits in. Work in this direction, nowadays is carried out, for example, by Sean Carroll and associates, as well as others [4-8]. In a series of papers they attempt to address the fundamental problem of how mass/energy, and the geometry of space, are interrelated via a quantum mechanical formulation of space, i.e., the vacuum. The hope is that through the specific phenomena of entanglement, a quantum mechanical description of space is possible, one that incorporates gravity, and clarifies how mass/energy within that space, and geometry are interconnected. Again the vacuum is assumed to be the key towards a proper understanding of the connection between gravity, quantum mechanics and geometry.

These attempts are not the newest attempts to understand the quantum mechanical vacuum, and the role it plays in determining particle interactions, as well as gravity. One older, and relatively novel, such approach, was proposed by F. Winterberg, who claimed in a series of papers [9-14], and in a book [15], that the vacuum is, in reality, made up of a vast assembly (sea) of positive and negative mass particles, held together by strong superfluid forces. Together, these particles, which he called planckions, form a two component superfluid/supersolid, which has zero net pressure, zero net mass density, and zero net entropy, due to their mass compensating effect, already at a scale of the Planck length, about, $10^{-35} meters$. Only when the vacuum is disturbed (perturbed) is there a net vacuum pressure, and energy density, which we showed, and identified with dark energy in later work [16-18]. However, this was at a vastly different length (and energy scale), approximately, $5\ E - 19\ meters\ (392.9\ GeV)$. Winterberg's theory is a very ambitious theory, where gravity and quantum mechanics are derived as two distinct, asymptotic limits, within a more encompassing, and very mechanistic, theory. The fundamental symmetry of nature, he claims, is not relativistic, $SO(1,3)$ Lorentz invariance, or extensions thereof, but rather the non-relativistic, $SO(3) \sim SU(2)$, which our three dimensional space reflects. Lorentz invariance in his model is a *dynamical* symmetry, which nature mimics. His theory was presented as an alternative to string theory.

Finally, if we go back even further, Heisenberg, in his non-linear spinor theory [19-27], attempted nothing less, starting already back in the 1930's, and continuing on into the 1950's and 1960's. He introduced a fundamental length scale for space itself, and even proposed, initially, a lattice like structure for the vacuum, which was estimated to lie somewhere beyond, $10^{-15} meters$. Below this distance scale, it was argued that there is a veritable "explosion" in the production of all types of "elementary particles", few of which are now regarded as "elementary". His work was largely ignored and sidelined. Only, recently, in string theory and quantum loop gravity, have some of his ideas been partially resurrected, albeit in a much different guise. Some excellent review articles are given in references [28,29].

In this work, we will attempt to make sense of, and connect all of these seemingly disparate ideas. Our contention is that Heisenberg, and Winterberg, are fundamentally correct in their interpretation of the vacuum having an intrinsic length scale, for the renormalizability of quantum field theories, to avoid singularities, and to prevent the divergences associated with the zero-point vacuum energy [15]. Interestingly, Winterberg studied under Heisenberg, and earned his PhD under his guidance. It is therefore perhaps no accident that they thought similarly in many respects. We believe that space has a lattice like structure, and moreover, that it is responsible for dark matter and dark energy [16-18], as well as ultimately, quantum mechanical entanglement (to be proven). Winterberg believes that the length scale for the vacuum is of the order of the Planck length, about, $10^{-35} meters$. Heisenberg, and others, believed it was much, much less, about, $10^{-15} meters$, or smaller. We conjecture, based on previous work [18], that it lies in the neighborhood of about, $5.032\ E-19\ meters$, and will make heavy use of this result in this paper.

The goal of the present work is to establish a connection between the planckions of Winterberg, and the Higgs field in the standard model of high energy physics, and show that the Higgs field really represents the vacuum made up of positive and negative mass planckion pairs. Our ansatz, or working assumption, is that one Higgs field is the equivalent of one positive and one negative mass, planckion pair, bound together through lattice like forces acting on the separate species individually. Because of these fluid forces, the positive mass planckions are forced to rub shoulders, spatially, with the negative mass planckions, and form a quasi, semi-bound state. Disrupting the vacuum means disturbing the Higgs fields. We also wish to make credible the idea that the LHC is really producing extreme dark energy, and disrupting some of these, $\psi_{\pm}$, bound states, temporarily, destroying the super-lattice structure for a small subset of the excited Higgs fields. When the vacuum re-establishes itself, $within\ 10^{-22}\ seconds$, the

Higgs boson is being produced. With the LHC, we may actually be probing and exploring the granular, lattice-like structure of space itself. This is our thought.

The outline of the paper is as follows. In section II we consider the Higgs sector. We believe it to be a phenomenological artifact of space, displaying $SO(1,3)$ invariance as a dynamical, but not as a fundamental, symmetry of nature. In section III we posit the fundamental relation relating the Higgs field, φ, to a $\psi_+$and ψ_- , planckion pair. We show that, with this particular identification or assignment, the equations of motion for both the positive mass planckion, ψ_+ , the negative mass planckion, ψ_- , and the Higgs field, φ , are satisfied. We also derive the continuity equations, connecting the two theories. In section IV, we use our, φ , and, $\psi_+ with$ ψ_- , connecting ansatz, to explain what transpires in a LHC, $\mathrm{p\bar{p}}$ collision from the viewpoint of the vacuum. This will be highly speculative interpretation, but numerical results are calculated, including increased vacuum pressure, and average, root mean square, planckion displacements from equilibrium within the vacuum. Finally, in section V, we summarize our results and present our conclusions.

II The Higgs Sector

We start with the nonlinear, relativistic Higgs field equation,

$$\varphi + \mu^2\varphi - 4\lambda \; |\varphi \;|^2\varphi = 0 \qquad (2-1)$$

In this equation, the Higgs self-coupling strength, $\lambda > 0$, and μ is defined as, $\mu \equiv m_\varphi c/\hbar$, with m_φ equal to the mass of the Higgs boson. To make a connection to the standard model in particle physics, φ, is, in reality, a $SU(2)$ complex, doublet of the form,

$$\varphi = \begin{pmatrix} \varphi^1 + & i\,\varphi^2 \\ \varphi^0 + & i\,\varphi^3 \end{pmatrix} \qquad (2-2)$$

Upon symmetry breaking (electro-weak→ electromagnetism + weak interaction), this reduces to,

$$\varphi = 1/\sqrt{2} \;\begin{pmatrix} 0 \\ v \end{pmatrix} \qquad (2-3)$$

We will ignore the complexities associated with the complex, doublet structure as this will not be relevant for our discussion. Nor will we consider the specifics of spontaneous symmetry breaking, per se.

Experimentally, the self-coupling strength has been determined to equal, $\lambda = .260$, and the mass of the Higgs is found to equal, $m_\varphi = 125.35\ GeV/c^2 = 2.231 * 10^{-25} kg$. Upon spontaneous symmetry breaking, the Higgs field reduces to,

$$<\varphi^0> = 1/\sqrt{2}\ v = \mu/\sqrt{(2\lambda)} = 1/\sqrt{2}\ (246\ GeV) = 174\ GeV \qquad (2-4)$$

, in units of energy, where selectively, $\hbar = c = 1$. The vacuum expectation value, $174\ GeV$, is known as the electro-weak symmetry breaking scale. In actual, non-reduced units, $<\varphi^0> = 8.804\ E17\ m^{-1}$.

The, μ, in equation, $(2-1)$, can be evaluated; its value is

$$\mu \equiv m_\varphi c/\hbar = 6.344\ E17\ m^{-1} \qquad (2-5)$$

The coherence length, ξ, for the Higgs field is its Compton wavelength, and represents the scattering size of the Higgs boson, given a Yukawa like potential. It is equal to, μ^{-1}, and numerically,

$$\xi = \mu^{-1} = 1.576\ E-18\ meters \qquad (2-6)$$

The numerical values are given to establish a connection with the standard model of particle physics.

The Winterberg model assumes that, φ, is, in reality, exactly nonrelativistic. Making the transition to the non-relativistic limit, we must set [15],

$$(1/c^2)\ \partial^2\varphi/\partial t^2 \rightarrow (2im_\varphi/\hbar)\ \partial\varphi/\partial t + \mu^2\varphi \qquad (2-7)$$

Then equation, $(2-1)$, reduces to,

$$i\hbar\ {}^{\partial\varphi}/_{\partial t} = -\hbar^2/(2m_\varphi)\ \nabla^2\varphi - m_\varphi c^2\varphi + (2\lambda\hbar^2/m_\varphi)\ |\varphi|^2\varphi \qquad (2-8)$$

Interestingly, as in the Higgs model, the non-relativistic equation, $(2-8)$, has the *same static, global solution* as in the relativistic case, namely,

$$\varphi_0^2 = \mu^2/(2\lambda) = 7.751\ E35\ m^{-2} \qquad (2-9)$$

A non-trivial, $\varphi_0 \neq 0$, is needed for spontaneous symmetry breaking. We emphasize that equation, $(2-8)$, can be derived from a Lagrangian, which is exclusively non-relativistic, and displays $SU(2)$ invariance.

Winterberg next assumes that, $\varphi_0^2 = 1/(2l_{PL}^3)$, where, l_{PL}, is the Planck length, $l_{PL} \equiv \sqrt{(\hbar G/c^3)} = 1.616\ E-35\ meters$. If this is the case, then a connection with the standard model, equation, $(2-9)$, makes no sense. Numerically, φ_0^2, as determined by equation, $(2-9)$, cannot equal, $1/(2l_{PL}^3)$. Second, if we assume that, $\varphi_0^2 = 1/(2l_{PL}^3)$, then we must have canonical dimension of $L^{-3/2}$ for φ_0, which is at odds with the assumed canonical L^{-1} behavior in high energy physics. The, L^{-1}, canonical dimension of φ, is required for a Yukawa type coupling to the fermionic matter fields within the Lagrangian. Winterberg models his theory after the Landau-Ginzburg field in superconductivity, where the φ does indeed have canonical dimension of, $L^{-3/2}$. We will adhere (conform) to the standard model of particle physics, where, $\dim[\varphi] = L^{-1}$.

We emphasize that equation, $(2-8)$, has a Schroedinger like structure for φ, where, $i\hbar\partial_t$ is the Hamiltonian operator, the $-\hbar^2/(2m_\varphi)\,\nabla^2$, is the kinetic energy term, and,

$$U(\varphi) = (2\lambda\hbar^2/m_\varphi)\ |\varphi|^2 - m_\varphi c^2 \qquad (2-10)$$

, is the potential energy term. All are operators, which act on, φ. The relativistic theory, given by equation, $(2-1)$, is assumed to be an asymptotic, phenomenological limit, derivable from the non-relativistic version, equation, $(2-8)$. Lorentz $SO(1,3)$ invariance is assumed to be a dynamical, and not fundamental symmetry of nature. Equation, $(2-10)$, will be important when we make the identification of, φ, with a planckion positive mass wave function, ψ_+, coupled with a planckion negative mass wave function, ψ_- . The pair will form a quasi-bound state which we identify with a Higgs field.

III Planckion Wave Functions and a Possible Connection with the Higgs Field

Planckion wave functions permeate all of space, and, in fact, our contention is that they make up a superfluid/supersolid lattice we call space. The vacuum as exemplified by the Higgs fields, we believe, is really made up of disguised, ψ_+, and, ψ_-condensate, planckion pairs. In this section, we discuss planckion wave functions, their equations of motion, $SU(2)$ symmetry, and the lattice structure of space. We also relate the Higgs field, φ, to, ψ_+, and, ψ_-, by positing a very specific relation between them.

According to Winterberg, the positive and negative mass, planckion, wave functions, obey the following operator equations [15],

$$i\hbar\, {}^{\partial\psi_\pm}\!/_{\partial t} = \mp\, \hbar^2/(2m_{PL})\,\nabla^2\psi_\pm \pm 2\hbar c\; l_{PL}^2\,(\psi_\pm^\dagger\psi_\pm - \psi_\mp^\dagger\psi_\mp)\psi_\pm \qquad (3-1)$$

In this equation, $m_{PL} \equiv \sqrt{(\hbar c/G)} = 1.222\ E19\ GeV/c^2$, is the Planck mass, and, $l_{PL} \equiv \sqrt{(\hbar G/c^3)} = 1.616\ E-35\ meters$, is the Planck length. The potential energy operator in equation, $(3-1)$, is given by,

$$U(\psi_\pm) = \pm 2\hbar c\ l_{PL}^2\ (\psi_\pm^\dagger \psi_\pm - \psi_\mp^\dagger \psi_\mp) \qquad (3-2)$$

The potential energy, $U(\psi_\pm)$, acts on the positive and negative mass wave functions, $\psi_\pm$, respectively. The individual wave functions obey the canonical commutation relations

$$\left[\psi_\pm(\vec{x}), \psi_\pm^\dagger(\vec{x'})\right] = \delta(\vec{x} - \vec{x'}) \qquad \left[\psi_\pm(\vec{x}), \psi_\pm(\vec{x'})\right] = 0 = \left[\psi_\pm^\dagger(\vec{x}), \psi_\pm^\dagger(\vec{x'})\right] \qquad (3-3)$$

Equation, $(3-1)$, can be derived from a non-relativistic Lagrange density of the form,

$$\mathcal{L}_\pm = i\hbar\ \psi_\pm^\dagger \dot{\psi}_\pm \mp \hbar^2/(2m_{PL})\ (\vec{\nabla}\psi_\pm^\dagger) \cdot (\vec{\nabla}\psi_\pm) \mp 2\hbar c\ l_{PL}^2 [1/2\ \psi_\pm^\dagger \psi_\pm - \psi_\mp^\dagger \psi_\mp] \psi_\pm^\dagger \psi_\pm \qquad (3-4)$$

The dot over the, $\dot{\psi}_\pm$, signifies a derivative with respect to time.

It will be noticed that equation, $(3-1)$, has the form of a non-relativistic version of Heisenberg's non-linear spinor field theory equation [19-27], one of the earliest attempts at a "theory of everything". The interaction term, $U\ \psi_\pm$, the second term on the right hand side in equation, $(3-1)$, involves an inherent length scale, l_{PL}, a kind of coupling constant having inherent dimension. In contrast to Heisenberg's relativistic spinor theory, however, equation, $(3-1)$, is non-relativistic. As pointed out by Winterberg, the Hilbert space derived by equation, $(3-1)$, is therefore always positive definite.

We believe that the length scale, $l_{PL} = 1.616\ E-35\ meters$, introduced in equation, $(3-1)$, is incorrect. It is much too small. We believe that it should, more properly, be replaced by a length scale of the order, $l_+(0) = l_-(0) = 5.032\ E-19\ meters$, based on previous work using entirely different arguments. Moreover, the interaction terms in equations, $(3-1)$, and $(3-2)$, are redundant. If we assume that the positive mass planckions, and the negative mass planckions, *only interact within their own species*, then equation, $(3-1)$, should be replaced by the much simpler version,

$$i\hbar\ {}^{\partial\psi_\pm}/_{\partial t} = \mp \hbar^2/(2m_{PL})\ \nabla^2\psi_\pm \pm \hbar c\ l_\pm(0)^2\ (\psi_\pm^\dagger \psi_\pm)\psi_\pm \qquad (3-5)$$

Then, by adding the potential energy of, ψ_+ with that of, ψ_-, we obtain,

$$U(\psi_+) + U(\psi_-) = \hbar c\ l_\pm(0)^2\ (\psi_\pm^\dagger \psi_\pm - \psi_\mp^\dagger \psi_\mp) \qquad (3-6)$$

, versus two times the right hand side if we were to use equation, $(3-1)$. This seems much cleaner and less redundant. It was argued extensively in previous work by Winterberg that, ψ_+, and, ψ_-, *do not interact directly, but rather indirectly*, through fluid forces acting on each species separately. Equations, $(3-5)$, and, $(3-6)$, fit that state of affairs precisely whereas equation, $(3-1)$, does not. Notice that, $l_\pm(0)^2$, has replaced, l_{PL}^2 , in both equations, $(3-5)$, and, $(3-6)$. Moreover, the right hand of equation, $(3-6)$, is invariant under $SU(2)\sim SO(3)$ symmetry, whereas the individual equations, $(3-5)$, separately, are not.

From elementary quantum mechanics, we know that, $\psi_\pm^\dagger \psi_\pm d^3\vec{x}$, represents the probability of finding the planckion fields, $\psi_\pm$, within volume $d^3\vec{x}$. Both $\psi_\pm$ have canonical dimension, $L^{-3/2}$, where, L, stands for length (or inverse momentum). Moreover, the respective, positive and negative mass, planckion number densities are defined by,

$$n_\pm \equiv \psi_\pm^\dagger \psi_\pm = n_\pm(\vec{x}, t) \qquad (3-7)$$

These quantities tell us how many positive and negative mass planckions are contained within one cubic meter, centered around space-time point, $(\vec{x}, t)$. Unless otherwise stated, MKS units are utilized throughout the paper.

The continuity equation reads,

$$\partial n_\pm/\partial t + \vec{\nabla} \cdot (n_\pm \overrightarrow{v_\pm}) = 0 \qquad (3-8)$$

In this equation, $\overrightarrow{v_\pm}$, is the velocity of, $n_\pm$, respectively. Equation, $(3-8)$, is satisfied, provided the $\psi_\pm$ planckion currents are defined as,

$$\overrightarrow{J_\pm} \equiv n_\pm \overrightarrow{v_\pm} = \mp\, i\hbar/(2m_{PL})\, [\psi_\pm^\dagger \vec{\nabla} \psi_\pm - \psi_\pm \vec{\nabla} \psi_\pm^\dagger] \qquad (3-9)$$

We note that the particle number operator,

$$N_\pm \equiv \int \psi_\pm^\dagger \psi_\pm d^3\vec{x} = \int n_\pm d^3\vec{x} \qquad (3-10)$$

, satisfies the commutation relation,

$$i\hbar\, \dot{N}_\pm = [N_\pm, H] \qquad (3-11)$$

, where, H, is the Hamiltonian operator. Also,

$$i\hbar\, \dot{\psi}_\pm = [\psi_\pm, H] \qquad (3-12)$$

The dot over a variable denotes a derivative with respect to time, i.e., $\dot{\psi}_\pm = \partial \psi_\pm/\partial t$.

Finally, equations, $(3-1)$, and the simplified version, equations, $(3-5)$, when both the positive and the negative mass planckions are included as a pair, are invariant under the following $SU(2)\sim SO(3)$ group transformations.

$$\psi_{\pm} \to -\psi_{\mp}, \qquad \psi_{\pm}^{\dagger}\psi_{\pm} \to -\psi_{\mp}^{\dagger}\psi_{\mp}, \qquad m_{PL} \to -m_{PL}, \qquad t \to -t \qquad (3-13)$$

Invariance under the Lorentz group has to be derived dynamically, and is not an inherent symmetry of either equations, $(3-5)$, nor, $(3-6)$.

To obtain the fundamental equation relating the Higgs field, φ, to the planckion wave functions, ψ_{+} with ψ_{-}, we next assume that the potential energy of the φ field equals the potential energy of the planckion wave functions, ψ_{+} with ψ_{-}, when added together. Mathematically, let,

$$U(\varphi) = U(\psi_{+}) + U(\psi_{-}) \qquad (3-14)$$

The operator, $U(\varphi)$, acts on the non-relativistic φ, whereas the operators, $U(\psi_{+})$, and, $U(\psi_{-})$, act on the non-relativistic ψ_{+} and ψ_{-}fields, respectively. However, if φ is assumed to be a composite of the ψ_{+} and ψ_{-} wave functions, then the energy stored by virtue of position, the potential energy of φ, should equal the energy stored by virtue of position for the sum of $U(\psi_{+})$, with, $U(\psi_{-})$. Thus, we believe that equation, $(3-14)$, is justified.

We next substitute equations, $(2-10)$, and, $(3-6)$, into equation, $(3-14)$. We find then that,

$$(2\lambda\hbar^2/m_{\varphi}) \; |\varphi|^2 - m_{\varphi}c^2 = \hbar c \; l_{\pm}(0)^2 \; (\psi_{\pm}^{\dagger}\psi_{\pm} - \psi_{\mp}^{\dagger}\psi_{\mp}) \qquad (3-15)$$

This can also be written as,

$$(2\lambda\hbar^2/m_{\varphi}) \; |\varphi|^2 - m_{\varphi}c^2 = \hbar c \; l_{\pm}(0)^2 \; (n_{+} - n_{-}) \qquad (3-16)$$

, where, we have used the equations, $(3-7)$. Equation, $(3-15)$, or, equivalently, $(3-16)$, is the basic equation connecting the Higgs field to the planckion wave functions. These are very interesting equations. They essentially state that should the respective planckion number densities balance, as in an undisturbed (unperturbed) vacuum, then the right hand sides vanish, and we are left with,

$$|\varphi|^2 = m_{\varphi}^2 c^2/(2\lambda\hbar^2) = \mu^2/(2\lambda) = v^2/2 \qquad (3-17)$$

, in agreement with equation, $(2-9)$. Equation, $(3-17)$, will be recognized as the vacuum ground state solution. If, $n_{+} \neq n_{-}$, then we no longer have a ground state solution. It would be comparable to raising or lowering the water level in an ocean, to use a rough analogy. If, $n_{+} \neq n_{-}$, then the vacuum is perturbed in either the positive or negative pressure sense. In other words there is a net vacuum pressure, or equivalently, a net vacuum energy density.

Notice that the combination given by the right hand side of equations, $(3-15)$ or, equivalently,$(3-16)$, is charge-less, spin-less, and colorless. For a vacuum in the unperturbed state, it is also massless. For an unstressed vacuum, $n_+ = n_-$, and the right hand side of equation, $(3-6)$, vanishes. The rest mass for the Higgs is really found on the left hand side of equation, $(3-16)$, where we consider specifically equation, $(2-10)$. The left hand side has the Higgs mass as a built-in feature for the vacuum in the undisturbed, or, what is equivalent, for the vacuum in the ground state. If the vacuum is perturbed, and, $n_+ \neq n_-$, then the mass of the Higgs will be affected by the vacuum potential energy of its associated, ψ_+ and ψ_- pair.

From previous work [18], we estimated that,

$$l_+(0) = l_-(0) = 5.032\,E - 19\,meters, \qquad n_\pm(0) = (l_\pm(0))^{-3} = 7.848\,E54\,m^{-3} \qquad (3-18)$$

This holds for the undisturbed vacuum. The, $l_\pm(0)$, is the nearest neighbor distance of separation between both positive mass planckions, as well as, negative mass planckions. We derived the above equation, $(3-18)$, in reference [18] using independent arguments. The estimated values are fairly accurate, but may have to be modified in future work. Nevertheless, we believe that the order of magnitude is valid.

It is only for a gravitationally stressed vacuum that, $n_+ \neq n_-$. In fact, we identified, $(n_+ - n_-) > 0$, with dark energy [18], where the total vacuum mass density, $\rho = \rho_{gg}$, equals,

$$\begin{aligned}
\rho(\vec{x}) &= \rho_+ + \rho_- \\
&= m_{Pl}\,(n_+ - n_-) \\
&= 0 \qquad (undisturbed\ vacuum\ fluid) \qquad (3-19) \\
&\neq 0 \qquad (disturbed\ fluid;\ gravitational\ field)
\end{aligned}$$

Moreover, the total vacuum pressure, $p = p_{gg}$, or equivalently, the total vacuum energy density, $u = u_{gg}$, in a region of space is given by,

$$\begin{aligned}
p &= p_+ + p_- \\
&= m_{Pl}\,c^2\ (n_+ - n_-) \\
&= u = u_+ + u_- \\
&= 0 \qquad (undisturbed\ vacuum\ fluid) \qquad (3-20) \\
&\neq 0 \qquad (disturbed\ fluid;\ gravitational\ field)
\end{aligned}$$

Equations, $(3-19)$, and, $(3-20)$, define space within our model, and the identification with dark energy is not due to Winterberg. It is important to note that these equations hold only if we have 100% excited states within that space. In other words, within the gravitationally stressed vacuum, all Higgs fields, and thus all planckion pair wave functions, $\psi_{\pm}$, are activated, and, physically displaced from equilibrium.

We can rewrite equation, $(3-16)$, in a slightly different form. Using equation, $(3-18b)$, we find that,

$$(2\lambda\hbar^2/m_{\varphi})\ |\varphi|^2 - m_{\varphi}c^2 = \hbar c/l_{\pm}(0)\ [(n_+ - n_-)/n_{\pm}(0)] \qquad (3-21)$$

Or, upon inserting some numerical values,

$$(2\lambda\hbar^2/m_{\varphi})\ |\varphi|^2 = 125.35\ GeV/c^2 + 392.9\ GeV/c^2\ [(n_+ - n_-)/n_{\pm}(0)] \qquad (3-22)$$

We have substituted the numerical value for, $l_{\pm}(0)$, specified in equation, $(3-18a)$, to obtain $\hbar c/l_{\pm}(0) = 392.9\ GeV/c^2$. The second term on the right hand side of equation, $(3-22)$, allows us to effectively increase, or decrease, the mass of the Higgs boson, depending on how gravitationally stressed the vacuum is. It is essentially a linear relationship, where, $|\varphi|^2$, is the dependent variable, and the, $(n_+ - n_-)$, is the independent variable. We know that, $n_{\pm}(0)$, is specified by equation, $(3-18b)$.

For, $n_+ > n_-$, we have dark energy, and an increase in effective mass for the Higgs boson. For, $n_+ < n_-$, we have the opposite of dark energy, or, what we will call, "light energy", and a decrease in effective mass for the Higgs boson. Here there is net negative pressure, or net negative energy density, in the vacuum by equation, $(3-20)$. If the net negative vacuum pressure is severe enough, i.e., if we have extreme light energy, then the mass of the Higgs boson can be made to vanish entirely, i.e., the right hand side of equation, $(3-22)$, vanishes. For that to happen, the condition to be satisfied is,

$$[(n_+ - n_-)/n_{\pm}(0)] = -125.35/392.9$$

$$= -.319 \qquad (3-23)$$

Because, $125.35\ GeV/c^2$ is the mass of the Higgs boson when, $n_+ = n_-$, we consider the rest mass of the Higgs to be the effective binding energy for the undisturbed vacuum. This binding energy is not due to a direct interaction between ψ_+ and, ψ_-, but rather, due to fluid forces acting on each separate species. These fluid forces are such as to force the, ψ_+, and the ψ_-, to rub shoulders with one another spatially. Remember that the Higgs field is considered in this work to be an effective, phenomenological, and *non-relativistic* field. We can think of the right hand side of equation, $(3-22)$, as the effective potential energy of one Higgs particle within the vacuum, where the vacuum potential energy, the interaction term, can directly influence its mass.

In a somewhat different guise, equation, $(3-21)$, can be rearranged, and rewritten further as,

$$|\varphi|^2 = m_\varphi^2 c^2/(2\lambda\hbar^2) + \hbar c m_\varphi/(2\lambda\hbar^2)\ 1/l_\pm(0)\ [(n_+ - n_-)/n_\pm(0)]$$

$$= \mu^2/(2\lambda) + \mu/(2\lambda)\ 1/l_\pm(0)\ [(n_+ - n_-)/n_\pm(0)]$$

$$= \mu^2/(2\lambda)\ \{1 + \xi/l_\pm(0)\ [(n_+ - n_-)/n_\pm(0)]\} \qquad (3-24)$$

, where we have made use of the definition, equation, $(2-5)$, and equation, $(2-6)$.

We could choose the Higgs coherence length, ξ , in equation, $(3-24)$, to equal, $l_\pm(0)$, on the right hand side for further simplification, but there is no reason to assume that the coherence length of the Higgs, its scattering size, should equal the nearest neighbor distance of separation between the positive mass, or, between the negative mass, planckions. Indeed, that would seem a coincidence, and it is more natural to assume that, $\xi > l_\pm(0)$. Numerically we find that, $\xi/l_\pm(0) = 3.132$, although this estimate may have to be revised later, as $l_\pm(0)$ is but an approximation. See equation, $(3-18a)$, and the discussion that follows thereafter. *The important point is that the orders of magnitude match, i.e., ξ is comparable to, $l_\pm(0)$, and that, $\xi > l_\pm(0)$.* Remember that $l_\pm(0)$ is obtained through entirely different arguments [18], and its proximity to the Compton wavelength of the Higgs boson, led us to suspect a connection with the Higgs field in the first place. We suspect that we may be on the right track with the identification, summarized by equation, $(3-15)$, or, $(3-16)$. The electroweak symmetry breaking scale matches, fairly closely, the proposed nearest neighbor lattice distance between individual plankions. This seems to us to be more than a coincidence.

What remains is to show that the equations of motion for, φ, and those for, $\psi_\pm$, are consistent with equations, $(3-15)$, and, $(3-16)$. Moreover, the continuity equation associated with each field has to be satisfied. From equations, $(2-8)$, and $(3-5a,b)$, it follows that,

$$-i\hbar\, {}^{\partial\varphi^\dagger}\!/_{\partial t} = -\hbar^2/(2m_\varphi)\ \nabla^2\varphi^\dagger - m_\varphi c^2\varphi^\dagger + (2\lambda\hbar^2/m_\varphi)\ |\varphi|^2\varphi^\dagger \qquad (3-25a)$$

$$-i\hbar\, {}^{\partial\psi_\pm^\dagger}\!/_{\partial t} = \mp\ \hbar^2/(2m_{PL})\ \nabla^2\psi_\pm^\dagger \pm \hbar c\ l_\pm(0)^2\ (\psi_\pm^\dagger\psi_\pm)\psi_\pm^\dagger \qquad (3-25b)$$

We next rewrite equation, $(3-24)$, as follows,

$$|\varphi|^2 = \mu^2/(2\lambda) + \mu/(2\lambda)\ l_\pm(0)^2\ [(\psi_+^\dagger\psi_+ - \psi_-^\dagger\psi_-)] \qquad (3-26)$$

, where we have utilized equations, $(3-7)$, and, $(3-18b)$. We differentiate equation, $(3-26)$, with respect to time by operating with the differential operator, $i\hbar\partial/\partial t$. This gives,

$$i\hbar\,[(\partial_t\varphi^\dagger)\varphi+\varphi^\dagger\partial_t\varphi]=i\hbar\,\mu\,l_\pm(0)^2/(2\lambda)\,[\dot{\psi}_+^\dagger\psi_++\psi_+^\dagger\dot{\psi}_+-\dot{\psi}_-^\dagger\psi_--\psi_-^\dagger\dot{\psi}_-]\qquad(3-27)$$

Using equations, $(2-8)$, $(3-1)$, and, $(3-25)$, this simplifies. After some remarkable cancellations, we obtain,

$$\hbar^2/(2m_\varphi)\,[(\nabla^2\varphi^\dagger)\varphi-\varphi^\dagger(\nabla^2\varphi)]=\hbar^2\Lambda/(2m_{PL})\,[(\nabla^2\psi_+^\dagger)\psi_+-\psi_+^\dagger(\nabla^2\psi_+)+(\nabla^2\psi_-^\dagger)\psi_--\psi_-^\dagger(\nabla^2\psi_-)]\qquad(3-28)$$

, where the connecting length scale, Λ, between, φ, and, $\psi_\pm$, is defined as,

$$\Lambda\equiv[\mu/(2\lambda)]\,l_\pm(0)^2=3.095\,E-19\,meters\qquad(3-29)$$

This length scale connects the Higgs mass, with the nearest neighbor distance of separation, between either positive mass, or negative mass, planckions, within the lattice.

We next implement the mathematical identity,

$$[(\nabla^2a)b-a(\nabla^2b)]=\vec{\nabla}\cdot[(\vec{\nabla}a)b-a\vec{\nabla}b]\qquad(3-30)$$

, on both the left and right hand side of equation, $(3-28)$. This renders,

$$(1/m_\varphi)\,\vec{\nabla}\cdot\left[\left(\vec{\nabla}\varphi^\dagger\right)\varphi-\varphi^\dagger\vec{\nabla}\varphi\right]=(\Lambda/m_{PL})\,\vec{\nabla}\cdot[\left(\vec{\nabla}\psi_+^\dagger\right)\psi_+-\psi_+^\dagger\vec{\nabla}\psi_++\left(\vec{\nabla}\psi_-^\dagger\right)\psi_--\psi_-^\dagger\vec{\nabla}\psi_-]\qquad(3-31)$$

Now, using equation, $(3-9)$, the right hand side reduces to,

$$(2\Lambda/i\hbar)\;[\vec{\nabla}\cdot\vec{J_+}-\vec{\nabla}\cdot\vec{J_-}]\qquad(3-32)$$

Notice that the mass, m_{PL}, has factored out. Similarly, the left hand side, becomes,

$$(2/i\hbar)\;[\vec{\nabla}\cdot\vec{J}]\qquad(3-33)$$

The Higgs current, $\vec{J}$, has been defined as,

$$\vec{J}=\vec{J}\,(\varphi)\equiv n_\varphi\vec{v_\varphi}=(i\hbar/2m_\varphi)\left[\left(\vec{\nabla}\varphi^\dagger\right)\varphi-\varphi^\dagger\vec{\nabla}\varphi\right]\qquad(3-34)$$

, where, $n_\varphi\equiv\varphi^\dagger\varphi$, is the Higgs number density. The mass, m_φ, also factors out in deriving expression, $(3-33)$. We therefore obtain for equation, $(3-31)$, after substitution of expressions, $(3-32)$, for the right hand side, and, $(3-33)$, for the left hand side,

$$[\vec{\nabla}\cdot\vec{J}]=\Lambda\;[\vec{\nabla}\cdot\vec{J_+}-\vec{\nabla}\cdot\vec{J_-}]\qquad(3-35)$$

Or, using the continuity equation for, φ, as well as for, ψ_+, and, ψ_-,

$$\partial_t n_\varphi = \Lambda\,[\partial_t n_+ - \partial_t n_-] \qquad (3-36)$$

The continuity equation holds for both left and right hand sides. The equations of motion for, φ, as well as those for, ψ_+, and, ψ_-, are all consistent with our basic ansatz, equation, $(3-26)$.

One may have noticed that the units for Higgs number density, $n_\varphi \equiv \varphi^\dagger \varphi$, are peculiar because, in the standard model of particle physics, $dim[\varphi] = L^{-1}$. We remedy this by bringing the Λ in equations, $(3-35)$, and, $(3-36)$, over to the left hand side. Then, $\Lambda^{-1}\,\vec{J}$, and, $\Lambda^{-1}\,n_\varphi$, have the correct dimensions for a physical current, and a physical number density, respectively. This we interpret as the real Higgs current, and the real Higgs number density. One will notice then, that the number density increase in Higgs field with respect to time, is directly related to the increase in number density of positive mass, minus that of negative mass planckions. Because of the symmetry between planckions, a positive increase in ψ_+ number density leads directly to the same corresponding decrease in ψ_- number density. See equation, $(3-36)$. We will see later that, $(n_+ - n_-) = 2\Delta n$, where, Δn, is the increase (decrease) in $n_\pm(0)$ for $n_+(n_-)$. One also has the flow equation, $(3-35)$. When the, Λ, is brought over to the left hand side, the $\psi_\pm$ planckion current flow is directly related to the Higgs current flow into, or out of, a region of space. Higgs fluid flow and planckion fluid flow are thus inextricably linked through equations, $(3-35)$, and, $(3-36)$.

We close this section with the following very important observation. If space has a natural cutoff in length, as indicated by, $l_\pm(0)$, then the Planck mass, the Planck energy, the Planck temperature, etc. all have to be modified in value. Take the Planck mass for example. We know that, by definition, $m_{PL} = \sqrt{(\hbar c/G)}$, and, $l_{PL} = \sqrt{(\hbar G/c^3)}$, where, G, is Newton's constant. These relations allow us to write, $m_{PL} = \hbar/(l_{PL} c)$. If l_{PL} is allowed to go down to the normal Planck length, $l_{PL} = 1.616\,E-35\,meters$, then and only then, does, $m_{PL} = 1.222\,E19\,GeV/c^2$, its customary assumed value. But if we introduce a natural cutoff length for the vacuum of, $l_+(0) = l_-(0) = 5.032\,E-19\,meters$ (see equation, $(3-18a)$, then l_{PL} can only approach $l_\pm(0)$. And, as a consequence,

$$m_{MPL} = m(\psi_\pm) = \hbar/(l_\pm(0)c) = 392.9\,GeV/c^2 = 6.994\,E-25\,kg \qquad (3-37)$$

We call this the modified Planck mass, m_{MPL}, and, $l_\pm(0) = l_{MPL}$, is the modified Planck length. This is precisely the term that sits in front of the second term in equation, $(3-22)$, and is our version of the Planck mass in equations, $(3-1)$, and $(3-5)$. The, m_{MPL}, should also be substituted in place of, m_{PL}, in equations, $(3-19)$, and, $(3-20)$. The, m_{PL}, in all those equations should, more properly, be replaced by, m_{MPL}, because we assume an intrinsic length scale which deviates from the Planck scale.

Moreover, we have introduced with this work, a modified version of Planck energy, Planck Temperature, etc. Using the length scale defined above, we find that,

$$E_{MPL} = m_{MPL}c^2 = 392.9\ GeV \qquad T_{MPL} \equiv E_{MPL}/k_B = 4.555\ E15\ Kelvin \qquad (3-38)$$

The, k_B, is Boltzmann's constant, and, T_{MPL}, is the modified Planck Temperature. It is interesting to note that all particles in the standard model were frozen out at a temperature just below $10^{16}\ Kelvin$ [30-33]. Equation, $(3-38)$, seems to fit that general scheme. Could it be possible that no elementary particles can form above the temperature indicated by equation, $(3-38b)$? This would be a remarkable proof that the proposed theory is correct.

To take this a step further, for elementary particles to form in the Winterberg model, we need vortices set up within the vacuum. An elementary particle is just that, a stable vortex, where the kinetic energy of this excitation gives the elementary particle its mass, and the direction of motion, its spin. An unstable vortex reflects an unstable particle. At energies approaching equation, $(3-38a)$, the vacuum loses its superfluid properties and the vortices can no longer sustain themselves. In other words, we enter another phase for the vacuum, where super-fluidity is completely lost. Perhaps we have indeed reached an energetic limit for the production of elementary particles at a scale approaching approximately, $392.9\ GeV$. This is an interesting prediction of the model we are presenting. Perhaps there is no desert region in particle physics between roughly, $100\ GeV$, and $10^{15}\ GeV$, as is customarily thought.

IV Application

In this section, we consider a specific application of our fundamental equation, $(3-15)$, or equivalently, equation, $(3-24)$. We consider the case of a $p\bar{p}$ collision such as is found at the LHC experiments at $CERN$. What happens within the vacuum, and what physical quantities can be determined? These results are highly speculative. Nevertheless, specific values for measurable quantities can be determined.

It has been estimated [34,35] that the energy density reached in the latest series of LHC collider experiments, where $p\bar{p}$ annihilation takes place, is of the order of, $u(6.5\ TeV) = .640\ GeV/fm^3 = 1.024\ E35\ J/m^3$, where, $1fm = 10^{-15}\ meters$. This is for a nominal collision energy of, $13\ TeV$. Incidentally, in LHC heavy ion, $Pb-Pb$ collisions, energy densities can reach higher values, as high as, $12-14\ GeV/fm^3$, with a Nucleon-Nucleon exchange energy of, $\sqrt{s_{NN}} = 5.02\ TeV$. The analysis presented here in this section, can be carried over into those realms as well.

We know that for one Higgs field, any increase in vacuum potential energy is given by the second term on the right hand side of equation, $(3-22)$. We multiply this by the excited Higgs number density, which we call, Δn. The, Δn, must equal, $\Delta n = \Delta N/\Delta V$, where, ΔN, is the number of excited (activated) Higgs, within the impacted or affected volume, ΔV, the volume within which the fields have been excited. The, ΔN , is a subset of the total number of Higgs fields within, ΔV, which we call, N_0. We therefore have,

$$\Delta n/n_0 = \Delta N/N_0 \qquad (4-1)$$

Here, n_0, is the normal number density of Higgs with, or without, any excitations. From previous work [18], we estimate this number to equal, $n_0 = n_{\pm}(0) = 7.848\ E54\ m^{-3}$. See equation, $(3-18b)$. The, ΔN, and, N_0 , are both defined within the impacted volume, ΔV.

Thus far, we have the energy density, which is being created in a LHC, $p\bar{p}$ collision, and we set this equal to, the number density of the excited Higgs, multiplied by the increase in vacuum potential energy for one Higgs field. Therefore, by equation, $(3-22)$,

$$\begin{aligned} .640\ GeV/fm^3 &= \Delta(VPE1H) * (\Delta n) \\ &= [392.9\ GeV\ * (n_+ - n_-)/n_{\pm}(0)] * (\Delta n) \qquad (4-2) \end{aligned}$$

The, $\Delta(VPE1H)$, represents the change in vacuum potential energy for one Higgs, given by the second term on the right hand side of equation, $(3-22)$.

Now the, $(n_+ - n_-)/n_{\pm}(0)$ term on the right hand side of equation, $(4-2)$, can be written a variety of ways. One formulation is,

$$\begin{aligned} (n_+ - n_-)/n_{\pm}(0) &= [(n_+(0) + \Delta n) - (n_-(0) - \Delta n)]/n_{\pm}(0) \\ &= 2\Delta n/n_0 \qquad (4-3) \end{aligned}$$

, where the, $n_0 = n_{\pm}(0)$, is known. The factor of two is due to the two different species of planckions involved. The number density of positive mass planckions momentarily increases in region, ΔV, whereas the number density of negative mass planckions decreases in the same region, over the nominal (unperturbed) value, $n_0 = n_{\pm}(0)$. Moreover, the increase in, n_+, is equal, in magnitude, to the decrease in, n_-, as demonstrated in reference [18].

We use equation, $(4-3)$, to simplify equation, $(4-2)$, and obtain,

$$.640\ GeV/fm^3 = 392.9\ GeV * 2(\Delta n)^2/n_0 \qquad (4-4)$$

Using the value of, $n_0 = n_{\pm}(0)$, specified in equation, $(3-18b)$, we can solve this equation for, Δn. The result is,

$$\Delta n = 2.528\ E48\ m^{-3} \tag{4-5}$$

Moreover, we can calculate the ratio,

$$\Delta n/n_0 = \Delta N/N_0 = 3.221\ E-7 \tag{4-6}$$

This small, but not insignificant fraction, tells us that only a tiny portion of the Higgs fields are actually excited, or activated, within volume, ΔV.

We next calculate the vacuum mass density, and the vacuum pressure. The former quantity we identified with dark energy, in previous work [18]. See equations, $(3-19)$, and, $(3-20)$. However, equations, $(3-19)$, and, $(3-20)$, apply only if we have 100% excited states within the disturbed volume, ΔV. In this instance, we do not. If less than 100% of the Higgs fields are excited within volume, ΔV, then we have to modify equations, $(3-19)$, and, $(3-20)$, as follows,

$$\begin{aligned}\rho'_{gg} \equiv \rho_{gg\ Modified} \equiv \rho_{gg}(\Delta N/N_0) &= m_{MPL}(n_+ - n_-)(\Delta N/N_0) \\ &= m_{MPL}(2\Delta n)(\Delta n/n_0) \\ &= [392.9\ GeV/c^2]2(\Delta n/n_0)^2(7.848\ E54) \quad (4-7)\end{aligned}$$

And,

$$\begin{aligned}p'_{gg} \equiv p_{gg\ Modified} \equiv p_{gg}(\Delta N/N_0) &= m_{MPL}c^2(n_+ - n_-)(\Delta N/N_0) \\ &= m_{MPL}c^2(2\Delta n)(\Delta n/n_0) \\ &= [392.9\ GeV]\ 2(\Delta n/n_0)^2(7.848\ E54) \\ &= u'_{gg} \qquad (4-8)\end{aligned}$$

The ratio, $(\Delta N/N_0)$, stands for that fraction of the Higgs fields, which are actually excited, as a result of this collision. This is also equivalent to the number of planckion pairs, which are affected (activated, or, excited) by the collision. Note that the modified pressure, p'_{gg}, is also the vacuum pressure, or, equivalently, the vacuum energy density, u'_{gg}.

Equations, $(4-7)$, and, $(4-8)$, are consistent with equation, $(4-2)$. This we show next. The increase in vacuum potential energy for one Higgs, $\Delta(VPE1H)$, is given by the right hand side of equation, $(3-21)$, or equivalently, by the second term on the right hand side of equation, $(3-22)$. This can be written still another way utilizing equation, $(4-8)$, as

$$\begin{aligned}\Delta(VPE1H) &= 392.9\ GeV * (2\Delta n/n_0) \\ &= u_{gg}/n_0 \qquad (4-9)\end{aligned}$$

This makes good sense because then, $u_{gg} = n_0 * \Delta(VPE1H)$, for 100% excitations within volume, ΔV. The, u_{gg}, is the vacuum energy density given by equation, $(3-20)$.

The change in vacuum potential energy for ΔN Higgs fields is equation, $(4-9)$, multiplied by, ΔN. Therefore,

$$\Delta(VPE\Delta NH) = \Delta(VPE1H) * \Delta N = (u_{gg}/n_0) * \Delta N \qquad (4-10)$$

In the case of a $LHC\ p\bar{p}$ collision, the left hand side equals, $.640\ GeV/fm^3 * \Delta V$. Since, $\Delta N = \Delta n * \Delta V$, we can divide equation, $(4-10)$, by ΔV, to obtain,

$$.640\ GeV/fm^3 = (u_{gg}/n_0) * \Delta n$$

$$= u_{gg} * \Delta N/N_0 = u'_{gg} \qquad (4-11)$$

We notice that the right hand side introduces the reduced vacuum energy density, equation, $(4-8)$. The reduced energy density, u'_{gg}, is simply the 100% energy density, u_{gg}, multiplied by, $\Delta N/N_0$. Equations, $(4-7)$, and, $(4-8)$, are thus consistent with equation, $(4-9)$.

We know the value for, $\Delta N/N_0$, as it is specified by equation, $(4-6)$. Therefore we can find numerical values for the vacuum mass density, ρ'_{gg}, and the vacuum pressure, $p'_{gg}, = u'_{gg}$. Using equations, $(4-7)$, and, $(4-8)$, we find that,

$$\rho'_{gg} = 1.139\ E18\ kg/m^3 = .640/c^2\ GeV/fm^3 \qquad (4-12)$$

And,

$$p'_{gg} = u'_{gg} = 1.024\ E35\ J/m^3 = .640\ GeV/fm^3 \qquad (4-13)$$

These values come as no surprise, as they reinforce our original assumption. They also hold only within the excited volume, ΔV, and, moreover, they represent dark energy, according to previous work [16,18].

We next want to find, ΔV, the impacted volume. To determine, ΔV, we first need the total number of collisions per second. According to the $CERN$ documents, there are about 10^9 $p\bar{p}$ collisions per second, at the 6.5 TeV energy level [36]. And so, per second, we have an energy release of, $13\ E9\ TeV$. This energy is either given up in the production of new particles, or transmitted to the vacuum. Let's assume that all gets dissipated first within the vacuum, and from there, the production of elementary particles can occur. Then we can set, using equations, $(4-9)$, and, $(4-10)$,

$$13\ E9\ TeV = [392.9\ GeV * 2\Delta n/n_0] * \Delta N \qquad (4-14)$$

The, ΔN, here refers to the number of excited Higgs fields being produced per second. Using the result of equation, $(4-6)$, we can solve this equation for, ΔN. The solution is,

$$\Delta N = 5.135\ E16\ (excited\ Higgs\ produced/second) \qquad (4-15)$$

We can evaluate, ΔV, by the relation, $\Delta V = \Delta N/\Delta n$. From equations, $(4-5)$, and $(4-15)$, we find that,

$$\Delta V = 2.031\ E-32\ m^3 \qquad (4-16)$$

This is equivalent to a ball of radius, $1.693\ E-11\ meters$, being produced each and every second. The state of matter in that ball is, of course, in a state of a quark-gluon plasma. Alternatively, we could just as well have taken the total amount of energy being produced per second, which is, $13\ E9\ TeV$, and divide that by $.640\ GeV/fm^3$, to obtain the same result.

We next want to calculate planckion displacements. For that, we will need some additional relations. From previous work [18], we have derived the equations,

$$n_{\pm}(x) = n_{\pm}(0)\ \ e^{\pm\kappa x^2/(2\,m_{PL}\,c^2)}$$

$$\equiv n_{\pm}(0)\ \ e^{\pm y} \qquad (4-17)$$

In equation, $(4-17)$, the variable, y, is defined as, $y \equiv \frac{1}{2}\kappa x^2/(m_{PL}c^2)$. It is the ratio of planckion elastic potential energy, to planckion rest mass energy. To be correct, we will replace the, $m_{PL}c^2$, above, by the modified Planck rest mass energy, indicated by equation, $(3-38a)$. We modeled planckion displacements as a harmonic oscillator with spring constant, $\kappa = \kappa_+ = \kappa_-$. When a positive mass, or a negative mass, planckion, is displaced a distance, x , from equilibrium, $x = 0$, there are elastic restoring forces working to bring the planckion back to equilibrium position. The spring constant, κ, is assumed to be the same for both the positive, and the negative mass, planckion. The fluid forces of Winterberg are ultimately responsible for these restoring forces. We have to be careful with the, $m_{PL}c^2$, term; as, mentioned, it has to be replaced with the modified version, $m_{MPL}c^2$, equation, $(3-38a)$, which we will do henceforth.

Another important note is the following. Many individual Higgs fields, or equivalently, positive and negative mass, planckion pairs are excited. The, x^2, above, is some sort of root mean square average, i.e., $x^2 = < x^2 > = x_{rms}^2 = \sum_{i=1}^{\Delta N} (x_i^2/\Delta N)$, where the individual positive and negative planckion displacements are given by, $x_i \neq 0$. The individual displacements, x_i , follows some sort of distribution, $\{x_i\}$, because it cannot be assumed that all displacements are the same. Obviously then, the individual, $y_i \equiv \frac{1}{2}\kappa x_i^2/(m_{MPl}\,c^2)$, also follow a distribution, $\{y_i\}$. And, $y = \sum y_i/\Delta N$. The, ΔN, as always, equals the number of excited Higgs fields, equivalent in our model, to the number of excited positive and negative mass, planckion pairs, within, ΔV. We strongly suspect that the distribution that, $\{y_i\}$, follows, is actually that of a Planck black body photon distribution function, based on previous work. We cannot go into the details, here, as this would take us too far afield. The individual energy ratios, $y_i \neq 0$, leads to an increase in vacuum potential energy. We will call the, $y \equiv \sum y_i/\Delta N \neq 0$, the *vacuum activation function*.

We can substitute equation, $(4-17)$, into equation, $(4-3)$. Doing this, we find that,

$$
\begin{aligned}
Y &\equiv 2\,\Delta n/n_0 \\
&= (e^{y} - e^{-y}) \\
&= 2\sinh(y) \qquad (4-18)
\end{aligned}
$$

The mathematical identity, $2\sinh(y) = (e^{y} - e^{-y})$, has been employed to obtain the third line in equation, $(4-18)$. We can call, $Y \equiv 2\,\Delta n/n_0$, the *vacuum activation factor*. The, Y, can be positive, negative, or zero. If, $Y > 0$, then $n_+ > n_-$, and we have dark energy, where there is net positive vacuum pressure. If, $Y < 0$, then $n_+ < n_-$, and we have the opposite of dark energy, or what we refer to as "light energy". Here we have net negative vacuum pressure, or equivalently, net negative vacuum energy density. See the discussion following equation, $(3-22)$. And if, $Y = 0$, then, $n_+ = n_-$, and we have neither dark energy, nor light energy. The vacuum is unperturbed, and not stressed in either the positive or negative sense. Here, $n_+ = n_- = n_\pm(0) = n_0$. This would be analogous to having a calm ocean, with essentially no waves or ripples upon its surface. For small values of, y, where, $y << 1$, the function, $sinh(y)$, can be approximated by, y. In this instance, equation, $(4-18)$, tells us that, $Y \cong 2y$. Otherwise, $Y = 2\sinh(y)$.

We have seen that for a $13\ TeV\ p\bar{p}$ collision, equation, $(4-6)$, holds. Therefore, equations, $(4-18)$, with $(4-6)$, tells us that,

$$y \equiv \tfrac{1}{2}\kappa x^2/(m_{MPL}\,c^2) \cong \Delta n/n_0 \qquad (4-19)$$

, where, the displacement, x, is some sort of root mean square average, $x = x_{rms} = \surd(\sum x_i^2/\Delta N)$. Note that $\Delta n/n_0$ is very small, and therefore, we have set, $sinh(y) \cong y$. We have estimated the planckion spring constant, κ, in previous work [18], and found that it equals, $\kappa = 1.194\ E30\ Newtons/meter$. We also believe that, $m_{MPL}c^2 = 392.9\ GeV$, by recent arguments. And finally, $\Delta n/n_0$, is worked out in equation, $(4-6)$. All these values allow us to calculate the, $x = x_{rms}$, in equation, $(4-19)$. Using equation, $(4-19)$, we estimate that,

$$x = x_{rms} = 1.842\ E - 22\ meters \qquad (4-20)$$

This is a small fraction of the nearest neighbor distance of separation between either the positive mass, or, the negative mass, planckions, within the super-lattice in the undisturbed state. According to equation, $(3-18a)$, that distance was estimated to equal, $l_+(0) = l_-(0) = 5.032\ E - 19\ meters$.

Again, in reality, a whole spectrum of individual displacements, $\{x_i\}$, are possible for the individual, $\psi_\pm$, pairs, up to and even approaching the $13\ TeV$ collision energy. However, the average root mean square displacement, x_{rms}, is much, much less than that calculated if we had a single, $13\ TeV$ exchange, as many, many planckion pairs are necessarily involved in displacements. The exact number is, $\Delta N = 5.135\ E16\ per\ second$, as indicated by equation, $(4-15)$.

We now wish to make a few important remarks. First, the $6.5 - 6.5\ TeV\ proton - antiproton$ collision produces a positive energy density in the amount of, $.640\ GeV/fm^3$. This will attract the positive mass planckions towards, and repel the negative mass planckions away from, the point of impact, $\vec{x}$, as shown in reference [18]. The vacuum fluid thus acquires dark energy in the amount given above, at, and immediately surrounding, point $\vec{x}$. In this region, which we can call region, A, we have, $n_+ > n_-$, and, $2\Delta n > 0$. The positive mass planckions, which are drawn in, and the negative mass planckions, which are pushed out, must produce in the neighboring region, region, B, a *negative vacuum pressure hole*. In the surrounding region, B, we must therefore have, $n_+ < n_-$, and, $2\Delta n < 0$, forming a negative vacuum energy halo centered around the point of impact. The energy produced by the collision will quickly dissipate through the production of elementary particles, or through the vacuum wave propagating outwards. In other words, the vacuum will quickly reestablish itself to normal conditions where, $n_+ = n_-$, and, $2\Delta n = 0$, in all regions. This, we believe, happens almost instantaneously, within about, $10^{-22} seconds$. It is within this time frame that the Higgs boson is thought to appear, when the vacuum reasserts itself, and falls back into its equilibrium position. This is the picture we imagine. The positive and negative, three-dimensional, vacuum energy density wavelet, produced by the collision quickly dissipates, and flattens out the vacuum to normal equilibrium conditions within short order.

Second, in the case of a LHC collision, extreme dark energy in region, A, and extreme light energy in region, B, is produced by the collision. As mentioned, this quickly dissipates. See equation, $(4-13)$, which holds for region, A. In region, B, we expect negative this amount within the vacuum. In region, B, we have extreme net negative vacuum pressure.

Third, in a previous paper [18], we conjectured that the vacuum has a maximum resilience of about, $1\ E34\ J/m^3$. If the vacuum energy density exceeds this amount, then space itself may suffer "gravitic breakdown", the gravitational version of dielectric breakdown. There is now non-localized conduction of planckion currents, and space loses its lattice superstructure. We consider this next. Interestingly, for a $13\ TeV\ p\bar{p}$ collision, an energy density in the amount, $.640\ GeV/fm^3 = 1.024\ E35\ J/m^3$, is being produced, and this pushes us beyond this limit. We will interpret this as a subset of the excited Higgs fields breaking their, $\psi_+, with\ \psi_-$, bond.

Let, $\Delta N^{(0)}$, refer to the number of excited Higgs fields, whose bonds remain intact, and let, $\Delta N^{(1)}$, designate those excited Higgs fields where the $\psi_+, with\ \psi_-$, bond has been broken, within volume, ΔV. Then,

$$\Delta N = \Delta N^{(0)} + \Delta N^{(1)} \qquad (4-21a)$$

, or, what is equivalent,

$$\Delta n = \Delta n^{(0)} + \Delta n^{(1)} \qquad (4-21b)$$

It is specifically the, $\Delta N^{(1)}$, or alternatively, the, $\Delta n^{(1)}$, which experience gravitic breakdown. From equation, $(3-23)$, we know that,

$$2y = 2\Delta n/n_0 > -.319 \ \rightarrow\ \psi_\pm\ binding\ intact\ \rightarrow\ \Delta n^{(0)}\ \rightarrow\ \Delta N^{(0)} \qquad (4-22a)$$

$$2y = 2\Delta n/n_0 \leq -.319 \ \rightarrow\ \psi_\pm\ binding\ broken\ \rightarrow\ \Delta n^{(1)}\ \rightarrow\ \Delta N^{(1)} \qquad (4-22b)$$

If condition, $(4-22a)$, is satisfied, then there is sufficient vacuum pressure such that the Higgs field has an effective mass greater than zero. In other words, there is effective binding. But if condition, $(4-22b)$, holds, then there is sufficient net negative vacuum pressure, in region, B, such that the Higgs field disintegrates, i.e., we have an effective mass less than zero. In other words, the ψ_+wave function dissociates itself from the ψ_-wave function, spatially. If any dissociation occurs, it is conjectured that the vacuum will reestablish itself very quickly, within the lifetime of the Higgs boson, about $10^{-22}\ seconds$.

As mentioned previously, we believe that the collection of individual vacuum activation variables, $\{y_i\}$, may actually follow a Planck blackbody distribution function. When we have a severe proton-antiproton collision, the individual, $y_i \equiv \frac{1}{2}\kappa x_i^2/(m_{MPl}\, c^2) = \frac{1}{2}\kappa x_i^2/(392.9\ GeV)$, will split into two camps. Some of the y_i will follow condition, $(4-22a)$, and the rest will satisfy condition, $(4-22b)$. We can call the former, the subset, $\{y_i^{(0)}\}$, and the latter, the subset, $\{y_i^{(1)}\}$. Taken together they form, $\left\{y_i^{(0)}\right\} + \left\{y_i^{(1)}\right\} = \{y_i\}$. Again, it would take us beyond the scope of this paper to investigate this more thoroughly. Researching this has to be left for future work. However, to summarize, the $LHC\ 13\ TeV\ p\bar{p}$ collision may actually create *sufficient net negative* vacuum pressure, or, *sufficient net negative* vacuum energy density in region, B, which in turn, causes a partial and temporary disintegration of the vacuum itself. In other words, the Higgs bond may be broken for a subset of the excited Higgs fields.

V Summary and Conclusions

We have proposed an intimate connection between the Higgs field, φ, and the $\psi_+ \; with \; \psi_-$ planckion wave functions, of Winterberg. Our working ansatz is that the potential energy of the the, ψ_+ field, added to that of the, ψ_- field, equals the potential energy of the Higgs field. See equation, $(3-14)$, or more specifically, equation, $(3-15)$. We showed that this identification does not violate the non-relativistic field equations for, $\psi_+ \, , \psi_-, and \; \varphi$. See equations, $(3-26)$, $(3-27)$, and what follows thereafter. In fact, the separate field equations almost lead to just such an identification, given the order of magnitude estimates of the two terms on the right hand side of equation, $(3-22)$. Also, the continuity equations are satisfied for all the fields concerned, as shown by equations, $(3-35)$, and $(3-36)$. The connecting length scale, equation, $(3-29)$, establishes the link between the Higgs field of elementary particle physics, and the super-lattice substructure of space. Our ansatz is thus consistent with the field equations for all the fields involved, φ, $\psi_+ \; and \; \psi_-$, as well as with their respective continuity equations.

The Higgs particle is treated as a composite particle. Thus, it is a phenomenological construct, and one that can be shown to display $SO(3) {\sim} SU(2)$ invariance. Following Winterberg, Lorentz invariance, or $SO(1{,}3)$ symmetry is a dynamical, and not fundamental symmetry of nature. In the Winterberg model, the special theory of relativity, together with its generalization, the general theory of relativity, and quantum mechanics are two, separate, asymptotic limits of a more underlying theory, the planckion model. Because they are two separate branches, they can never be unified directly, but rather indirectly, through $SO(3)$ symmetry, the symmetry of space and the vacuum.

Equations, $(3-15)$, or, equivalently, equation, $(3-16)$, is our fundamental relation, where an inherent length scale, $l_\pm(0) = 5.032 \; E-19 \; meters$, is built in. This is the distance of separation between nearest neighbor positive mass, or nearest neighbor negative mass, planckion wave functions. We can treat this as a kind of coupling constant but one with inherent dimension. This follows as a non-relativistic version of Heisenberg's non-linear spinor theory. See equation, $(3-5)$. Some other equivalent formulations of our key equation connecting the Higgs field, φ, to the $\psi_+$and ψ_-wave functions are equations, $(3-21)$, $(3-22)$, $(3-24)$, and, $(3-26)$.

An interesting consequence of introducing a fundamental length scale for space, is that the Planck mass, the Planck energy, the Planck temperature, etc. all assume new values. We called these values, the modified Planck values. Given the nearest neighbor distance of separation for an undisturbed vacuum, we estimated the new values are those given in equations, $(3-37)$, and, $(3-38)$. The Planck scale is that scale where presumably, quantum mechanics, and gravity merge. So too is the case with the modified Planck scale. However, the modified value is much, much less, energy-wise, than the traditionally accepted Planck energy, $E_{PL} = 1.222\ E19\ GeV$. We now have a modified value, $E_{MPL} = 392.9\ GeV$, which is very close to the electroweak symmetry breaking scale of, $174\ GeV$. We even forwarded the notion that no new elementary particles can form above a temperature of roughly, $T_{MPL} \equiv E_{MPL}/k_B = 4.555\ E15\ Kelvin$. See equation, $(3-38)$. Within the Winterberg model, for the formation of elementary particles, stable vortices have to be set up within the vacuum. This is not possible above this cutoff energy level, $E_{MPL} = 392.9\ GeV$. See the discussion following equation, $(3-38)$.

In section IV, we looked at a direct application of our fundamental equation, relating the Higgs field to a composite $\psi_{\pm}$ planckion pair. We considered what might take place in a $13\ TeV\ proton - antiproton$ collision, such as is found in LHC experiments. Given a produced energy density of, $.640\ GeV/fm^3$, per collision, we calculated that the fraction of excited Higgs produced is, $\Delta N/N_0 = 3.221\ E-7$, where, N_0, is the total number of Higgs within the impacted volume, ΔV. See equation, $(4-6)$. The vacuum is stressed with a mass density, and pressure given by equations, $(4-7)$, and $(4-8)$, respectively. When numerical values are substituted, we obtain equations, $(4-12)$, and, $(4-13)$. Furthermore, if we assume that a billion collisions occur each and every second, a quark-gluon ball of radius, $r = 1.693\ E-11\ meters$, forms having a volume given by equation, $(4-16)$. Within that volume, the number of excited Higgs particles produced per second amounts to, $\Delta N = 5.135\ E16$, which is equation, $(4-15)$. This is a small subset of the total number. The number of activated, or, excited Higgs fields corresponds to the number of positive and negative mass planckion pairs, which are physically displaced from equilibrium. The root mean square planckion displacement for both the positive mass, and the negative mass, planckion is estimated to equal, $x = x_{rms} = 1.842\ E-22\ meters$. See equation, $(4-20)$. In actual fact, the planckion elastic potential energy follows a distribution, where we have a spectrum of displacements from equilibrium. The above displacement from the unperturbed vacuum is an average value.

It was conjectured that if extreme negative vacuum pressure exists, then the Higgs field could disintegrate. In other words, the, ψ_+ no longer binds to the, ψ_-. For that to happen, condition, $(3-23)$, or equivalently, condition, $(4-22b)$, has to be satisfied. For such instances where we have extreme net negative vacuum pressure, the Higgs loses its ability to maintain a mass, and hence, no spatial binding between the, ψ_+, and the, ψ_- , is feasible. It is thought that such conditions can actually occur in the vicinity surrounding a $13\ TeV$ collision, in region, B, causing a temporary and highly localized subset of the excited Higgs fields to disintegrate. See the discussion surrounding equations, $(4-21a, b)$ and, $(4-22a, b)$. The Higgs boson is thought to occur when the vacuum reestablishes itself, within a time frame of approximately, $10^{-22} seconds$. Any imbalance in positive and negative mass planckion number densities quickly rectifies itself. We conclude that a $13\ TeV\ p\bar{p}$ collision may be strong enough to cause a subset of the excited Higgs particles to momentarily lose their binding energy.

This paper is highly speculative, and much work remains to be done to prove our contention that a fundamental relationship exists between the Higgs particle, and the planckion, ψ_+ , with ψ_- , wave functions. Higher accelerator energies would obviously lead to more excited Higgs fields, more partial Higgs field disintegrations within the vacuum, and a greater number of Higgs bosons being produced. Considering various energy level collisions might enable us to select the proper distribution function for, $\{y_i\}$. The standard model of particle physics could be looked at from the perspective of replacing the Higgs particle with a positive, and a negative mass, planckion wave function. What, if anything, would change? How would the Yukawa coupling between the, $\psi_\pm$ pair, and the fermionic matter fields play out? We could also look at replacing the L^{-1}canonical Higgs field, with a $L^{-3/2}$ Higgs version, to make a connection with the Landau-Ginzburg theory in condensed matter physics. What would that imply? How would things change continuity equation wise? Finally, we might consider what happens when an elementary particle such as an electron passes through the vacuum? How would the vacuum respond, and how specifically, is the mass for that particle created through its vortex structure. Can we establish a pattern between the different generations of elementary fermionic matter fields? These and other further questions will have to be addressed in future work.

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