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A Self-Stabilized Field Theory of Neutrinos

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Abstract

In "*A Self-linking Field Formalism*" I establish a self-dual field structure with higher order self-induced symmetries that reinforce the first-order dynamics. The structure was derived from Gauss-linking integrals in $\Re^3$ based on the Biot-Savart law and Ampere's law applied to Heaviside's equations, derived in strength-independent fashion in "*Primordial Principle of Self-Interaction*". The derivation involves Geometric Calculus, topology, and field equations. My goal in this paper is to derive the simplest solution of a self-stabilized solitonic structure and discuss this model of a neutrino.

Keywords

Self-Stabilized Field Theory, First-Order Dynamics, The Biot-Savart Law, The Ampere's Law, Neutrino, Heaviside Equations, Gravitational Field, Solitons, Self-Dual, Gauss-Linking

1. Introduction

Many physicists share John Wheeler's conviction that "nature would avail itself of all the opportunities offered by the equations of valid theories." Influenced by special and general relativity, Wheeler adopted Einstein's vision of the totally geometric world, in which everything was composed ultimately only of space-time. Space-time geometry is seen as dynamic, changing geometry influenced by mass, capable of propagating, and in turn, influencing mass. Einstein later concluded that "there is no space absent field", essentially replacing the abstraction of space with physically real fields that possess energy, and showing that all energy is a source of gravity. Wheeler asked how much light it would take to create so much energy that the light would hold itself together, black hole-like; concluding that this would be achieved with a doughnut the size of the sun with a mass of about 1 million suns. He called the gravitating body made up of electromagnetic fields a "geon", but was able to show that these structures were unstable.

In a recent paper, A Self-linking Field Formalism [1] I showed that the elec-

tromagnetic field, which does support Gauss-linking, is not self-linking and hence not capable of forming stable final configurations. However, based on the work of DeTurck and Gluck, [2] I defined a self-dual, self-linking field and showed that the gravitomagnetic field of Heaviside's equation [3] is self-dual and self-linking and that first-order induced fields inherently induce second and higher order induced fields; the higher order induced fields reinforce the primary source of induction.

After finding the electromagnetic geon to be inherently unstable, Wheeler then imagined a "purer" geon—one made up of gravitational energy alone and hoped that quantum effects might make possible a geon as small as a particle: "mass without mass", but he never succeeded in this quest. That is the quest we take up here.

We are not alone in this quest. Recently [4] Alexander Burinskii has sought to unify gravity with particle physics—based on the Kerr-Newman metric solution to Einstein's field equations. In this paper, I treat this problem based on the $K^N V$ extension of the Kasner metric. These two approaches illuminate several problems that doomed earlier attempts. We review Burinskii.

2. Burinskii's Theory of Gravity and Particle Physics

Burinskii's ingenious model of gravity-based particles combines Einstein field metrics with various concepts of quantum theory, including Compton radius, Higgs symmetry breaking, super-bag models, string theory and supersymmetry, closed Wilson loops, and branes of M-theory. After identifying the main misconception of relativity approaches, he concludes that a supersymmetric pathway exists to unify gravity with particle physics; the LHC however has offered no support for supersymmetry.

Choosing to model his particle on the Kerr-Newman metric solution to Einstein's equations, Burinskii begins with the KN-metric:

$$g_{\mu\nu} = \eta_{\mu\nu} + 2Hk_\mu k_\nu, \quad H = \frac{mr - e^2/2}{r^2 + a^2\cos^2(\theta)} \tag{1}$$

Here $\eta_{\mu\nu}$ is the metric of the Minkowski invariance, m is the mass of the object, r is the radius of the KN ring singularity, $r = \cos(\theta) = 0$, which is a branch line of the Kerr space into two sheets r^+ for $r > 0$ and r^- for $r < 0$. Acknowledging that "two sheetedness represents one of the main puzzles of the KN space-time", Burinskii notes that it is not *a priori* clear that a valid model can be realized; he addresses links between the KN-metric model and quantum physics. We are most interested in his analysis of gravitational aspects of the problem.

Specifically, Burinskii identifies "weakness of gravity as an illusion", as the primary impediment to the theory of quantum gravity. Referring to the famous MIT and SLAC bag models [5] which are similar to solitons, he observes that "the question of consistency with gravity is not discussed usually for solitonic models, as it is conventionally assumed that gravity is weak and not essential at

scale of electroweak interactions." He then claims that the assumption of weakness of gravity is "an illusion, related to underestimation of the role of spin in gravity." He ties this perception to gravitational frame-dragging seen by Gravity Probe B [6] or the Lens-Thirring effect in Kerr geometry. In the KN-metric of Equation (1) the null field ($k_\mu k^\mu = 0$) $k_\mu(x)$ determines the direction of frame-dragging. Nevertheless, the spin of elementary particles is extremely high. In dimensionless units ($G = c = \hbar = 1$) the electron spin/mass ratio is about 10^{22}. Finally, he concludes: "similar to cosmology where giant masses turn gravity into the main force", the giant spin of particles makes gravity strong!

3. Analysis of Gravitational Angular Momentum

Burinskii observed that spin and mass are the two key parameters, both in the Kerr model and the quantum particle. Physicists generally learn classical mechanics before quantum mechanics, and quantum mechanics before general relativity; the progression is from the very real spin of a top, to the confusing quantum spin of a cubit, to the "frame-dragging" of a spinning mass. These conceptual frameworks tend to obscure the physical reality of the phenomena. This is unfortunate; in 1915 Einstein and deHaas [7] experimentally proved that the magnetic field possesses angular momentum. We observe that the gravitomagnetic field is angular momentum! The circulation of the gravitomagnetic field, denoted by $\nabla \times \boldsymbol{C}$ actually circulates, with magnitude $|\boldsymbol{C}|$ providing the rotational frequency, $\sim t^{-1}$. In other words, in Heaviside's framework, the spin is the circulating C-field. In [8] I show that the Heaviside equations are valid at all field strengths, which contradicts the usual interpretation that the linearized equations are a "weak field approximation", although recent analyses of gravitational waves from inspiraling neutron binaries and colliding black holes have shown that these "weak field" equations work surprisingly well in strong field situations.

In the rest of this paper we will view the primordial gravitational field as a perfect fluid universe, as treated by Kerson Huang in *A Superfluid Universe* [9]. The field has non-zero density; the fluid supports vortical spin (and particle spin if we can develop a stable particle field structure.) We relate the C-field to angular momentum as follows:

$\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$ angular momentum as mental construct associated with spinning objects.

$\boldsymbol{C} \sim \boldsymbol{r} \times \boldsymbol{p}$ angular momentum phenomena ($g = c = 1$) of the gravitomagnetic field.

A number of physicists, including Feynman, Weinberg, Ohanian & Ruffini, have pointed out that the "geometric" formulation of gravity is quite unnecessary, and that it is sufficient to regard the gravitational field as a physical field with energy density. In this field-based framework it is actually redundant to deal with "spin", which is a useful concept for spinning objects, but much less suitable for field dynamics.

4. Induction of Angular Momentum in a Gravitational Field

In *The Primordial Principle of Self-interaction*, I derive

$$\nabla \times \boldsymbol{C} = -\rho \boldsymbol{v} + \frac{\partial \boldsymbol{G}}{\partial t} \tag{2}$$

where $\rho \boldsymbol{v} \sim \boldsymbol{G} \times \boldsymbol{C}$ and $v = c$. Equation (2) specializes Heaviside for all $\boldsymbol{v}$ including $|\boldsymbol{v}| < c$. The $\boldsymbol{G} \times \boldsymbol{C}$ is analogous to Poynting vector $\boldsymbol{E} \times \boldsymbol{B}$ and represents a field disturbance propagating in the field with momentum density $\boldsymbol{p} \sim \boldsymbol{G} \times \boldsymbol{C} \sim \rho \boldsymbol{v}$ where $\rho \sim \boldsymbol{G} \times \boldsymbol{C} / c^2$ and $|\boldsymbol{v}| \equiv c$ is velocity of stress propagation in the field. The example given in the self-interaction paper is based on gravitational waves radiating from inspiraling neutron stars or black holes. Alternatively, we can consider a local energy density that travels in the local gravitational field with $|\boldsymbol{v}| < c$. This local energy has equivalent mass density $\rho_m = \rho_E / c^2$. From Heaviside's equation we see that this induces a local circulation of the field, represented by $\nabla \times \boldsymbol{C}$ ($\sim -\rho \boldsymbol{v}$).

Equation (2) is valid for $v = c$ and $v \neq c$, but the physics is significantly different. If a discrete "particle" or localized density could move at the speed of light $v = c$, it could induce very little circulation, as the circulation at any point near the particle cannot be supported due to the fact that the local particle has moved away from the local induction at the speed of light, and no longer supplies energy to the local induction. Gravitational waves, on the other hand, are not local, but are continuously generated by the inspiraling bodies over a period of time, ending with the merger of the bodies. Thus induction that is invoked at the head or leading edge of the wave may still be supported at a point by the equivalent mass density of the trailing wave, *i.e.*, the energy of the extended wave as it continues to move past the point in question. Note that this is further affected by the Wilson-loop-like nature of the plane wave which distributes $\boldsymbol{G} \times \boldsymbol{C}$ energy across an (equal phase) surface. Unlike a local particle, which induces circulation at a distance $\boldsymbol{r}$ from the particle, the wave-front "surrounds" the point $\boldsymbol{r}$ and cancels the circulation of interior points.

Although the induction Equation (2) is valid for $v = c$ and $v \neq c$, we are not interested here in macro-situations of the cosmological variety. We are instead interested in local disturbances moving in an ultra-high-density field. Such fields are assumed available at the big bang and potentially at the Large Hadron Collider. Let us to note the local density by ρ and the velocity of this moving density by $\boldsymbol{v}$, and let us ignore $\partial \boldsymbol{G} / \partial t$. This simplifies our equation to:

$$\nabla \times \boldsymbol{C} = -\rho \boldsymbol{v}. \tag{3}$$

Our goal is to be compatible with Einstein's metric-based approach to gravity in general and comparable to Burinskii's treatment of gravity in particular.

5. The *KNV*-Metric Theory-of-Gravity

The general metric solution to Einstein's equations has the form $\mathrm{d}s^2 = g_{\mu\nu} \mathrm{d}x^\mu \mathrm{d}x^\nu$ where μ and ν range 0 to 3, with $\mathrm{d}x^0 = c\mathrm{d}t$. Thus g_{00} is the metric cor-

responding to $c^2\mathrm{d}t^2$ and

$$\mathrm{d}s^2 = g_{00}c^2\mathrm{d}t^2 + \text{other terms}.$$

In the Schwarzschild metric $g_{00} = -(1+2\phi) \sim \mathrm{e}^{-2\phi}$ with $\phi \sim M/r$ the position-dependent gravitational potential. In *Physics of Clocks in Absolute Space and Time* [10] the $\mathrm{d}t$ increment is a time measurement performed by a clock so the clock rate is seen to be a function of potential energy at the location of the clock. As a consequence, the solution to Einstein's equations are static; the metric depends only on position, not on time. The Kerr metric is complicated by the addition of angular momentum terms, but remains static, distributed over all space but unchanging in time. General relativity, in the case of Schwarzschild and Kerr, is the "one-body" problem; a small *test mass m* is assumed not to have any effect on the system, which consists of mass *M*, with or without rotation. Mass *M* is assumed to exist *a priori*, thus solutions do not evolve; they are distributed over all space for all time, making it difficult to explain the evolution of particles from a gravity field.

Burinskii, in searching for soliton-like solutions of the nonlinear gravitational field invokes the famous MIT and SLAC bag models, "which are similar to solitons", but notes that these models are "soft, deformable, and oscillating." These characteristics do not describe the static metrics mentioned above; however they do provide features desirable for evolving fields into particles. We next investigate metric solutions of Einstein's equations that are "soft, deformable, and oscillate", in other words, metrics that do evolve over time. We search for solutions of the type described by Petrov [11] wherein:

"(Space-time) is an arena; in which physical fields interact and propagate (…) The space-time itself is a dynamic object."

This is compatible with Einstein's contention that "space-time does not claim existence on its own, but only as a structural quality of this field", consistent with our search for a stable structure of the field, which we hope will explain the existence of particles. Rejecting the static metrics we focus on Kasner's exact solution for $D > 3$ space-time dimensions, in the Narlikar and Karmarkar formulation,

$$\mathrm{d}s^2 = c^2\mathrm{d}t^2 - \sum_{j=1}^{D-1}(1+nt)^{2p_j}\,\mathrm{d}x_j^2 \tag{4}$$

subject to $\sum_{j=1}^{D-1} p_j = 1$ and $\sum_{j=1}^{D-1} p_j^2 = 1$.

Vishwakarma [12] observes that the conventional Kasner metric interpretation is "obscure and questionable". In [13] I have interpreted the Kasner metric based upon my ideas and upon work done by Narlikar, Karmarkar, Vishwakarma, and Kauffmann. This is the K^NV-metric; K^NV represents Kasner, Karmarkar, Klingman, Kauffmann, Narlikar and Vishwakarma. I describe this next.

Vishwakarma, attempting to explain the metric, chooses to interpret momentum density $\boldsymbol{p} = \rho\boldsymbol{v}$, and observes that $(1+nt) \Rightarrow n = t^{-1}$. He then formulates

the dimensionally correct relation $n=\sqrt{gp/c}=\sqrt{g\rho(v/c)}\sim t^{-1}$, but the physical meaning of parameter n remains mysterious.

In [14] I prove that $(\boldsymbol{r}\times)\equiv(\nabla\times)^{-1}$ therefore our previous relation $\boldsymbol{C}=\boldsymbol{r}\times\boldsymbol{p}$ is equivalent to $\nabla\times\boldsymbol{C}\sim\boldsymbol{p}$ (when $g=c=1$); dimensional scale factor (g/c^2) leads to $\boldsymbol{C}=(g/c^2)\boldsymbol{r}\times\boldsymbol{p}\sim t^{-1}$. This is seen to agree with $n=t^{-1}$ so I exchange the mysterious term n for the well understood C-field and write the K^NV metric as:

$$\mathrm{d}s^2=c^2\mathrm{d}t^2-\sum_{j=1}^{D-1}(1+Ct)^{2p_j}\,\mathrm{d}x_j^2\,. \tag{5}$$

I choose the simplest momentum density $\boldsymbol{p}=(p_1,p_2,p_3)=(0,0,1)$ thus reducing the metric to:

$$\mathrm{d}s^2=c^2\mathrm{d}t^2-(1+Ct)^2\,\mathrm{d}z^2-\mathrm{d}x^2-\mathrm{d}y^2 \tag{6}$$

which represents a space-time defined by a gravitational field evolving in the z-direction.

Recall that the gravitomagnetic field of Heaviside's equation is self-dual and self-linking; first-order fields induce higher order fields with positive feedback, potentially self-stabilizing. Assume that a "vacuum fluctuation" or "symmetry breaking" event occurs at a local origin and results in gravitational waves propagating along the z-axis. The linearized metric yields:

$$\bar{h}_{\mu\nu}=\bar{h}_{\mu 0}(t-z),\ \bar{h}_{\mu 0}=-\bar{h}_{\mu z},\ h_{\mu\nu}=\begin{bmatrix}0&0&0&0\\0&h_{xx}&h_{xy}&0\\0&h_{yx}&h_{yy}&0\\0&0&0&0\end{bmatrix} \tag{7}$$

where $h_{\mu\nu}$ is considered the wave's metric perturbation. We focus on the transverse behavior of the field: the plane wave propagates in *z*, so non-zero components are:

$h_{xx}=-h_{yy}$ traceless;

$h_{xy}=+h_{yx}$ transverse.

This last relation $h_{xy}-h_{yx}=0$ corresponds to angular momentum which, recall, is the nature of the C-field.

We next consider an arbitrary point at position $\boldsymbol{r}$ with respect to the origin of the event, as shown in **Figure 1**. The C-field invoked at $\boldsymbol{r}$ by $+\boldsymbol{p}$ and $-\boldsymbol{p}$ is given by:

$$\boldsymbol{C}(\boldsymbol{r},t)=\boldsymbol{r}\times\left(\boldsymbol{p}(z(t))-\boldsymbol{p}(-z(t))\right) \tag{8}$$

and the local energy density at $\boldsymbol{r}$ is $\left|\boldsymbol{C}(\boldsymbol{r},t)\right|^2$. The axial symmetry implies that $\boldsymbol{r}(\theta,\phi)$ is independent of ϕ hence the energy distribution is symmetrical with respect to the z-axis and time-energy history at $\boldsymbol{r}$ is shown in **Figure 2**.

6. Evolution of Local Energy Propagation through the Field

We have shown above that continuous waves generated by collapsing astro-bodies propagate at the speed of light, but, by virtue of their continuous distribution

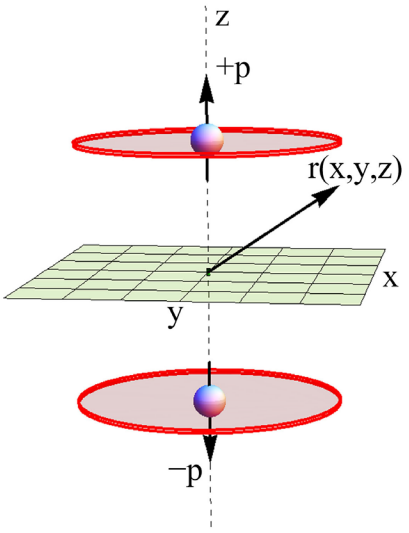

Figure 1. An event or fluctuation at the origin causes density variations to move away along an axis. This effect is calculated at a position $\boldsymbol{r}$ with respect to the origin.

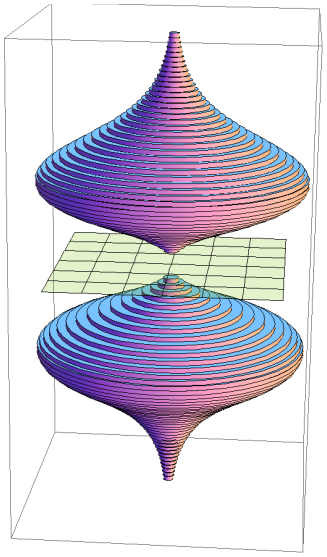

Figure 2. The energy-time history of the C-field energy induced that point $\boldsymbol{r}$ by outgoing momentum. Axial symmetry about the z-axis is ϕ -independent.

over region of space, have the ability to induce circulation at surrounding points. As we are most interested in micro-bodies, *i.e.*, particles, we now focus on local induction from slower-than-light propagation of dense regions of fields, described by $\nabla \times \boldsymbol{C} = -\rho \boldsymbol{v}$, $v < c$. We assume the existence of turbulence in an ultra-high-density region of the field and begin our analysis with the local vortex field. We've seen for the $K^N V$-metric solution that the motion of a locally dense region through the field induces vortical circulation at any point near the axis of propagation, yielding essentially a vortex moving through the field. Our energy-time-history diagram (**Figure 2**) is based on the existence of energy density

$\boldsymbol{C}\cdot\boldsymbol{C}$ at $\boldsymbol{r}$ over a period of time, beginning with the approach of the locally dense region to the point, peaking at the moment of closest approach to $\boldsymbol{r}$, and trailing off as the dense region moves away from the specified point of interest.

There appear to be to two physical possibilities inherent in this situation. As the induced local energy at $\boldsymbol{r}$ must be sourced from the momentum density of the moving high-density region, this loss of energy occurring at every point $\boldsymbol{r}$ will dissipate energy of the original moving source, slowing down the source region, decreasing its momentum, and dispersing the energy of the source and the induced field over an expanding region of space. This process may be thermodynamically interesting but would not seem to contribute to particle formation.

An alternative possibility is that the process is self-stabilizing, and will sustain the propagation of a locally dense region through space in solitonic fashion. This is the process we now investigate.

7. Analysis of Solitonic Mechanisms

Recall that the self-linking field formalism shows that second-order induction reinforces the primary inducing agent, *i.e.*, local momentum density $\rho\boldsymbol{v}$. Following Duckworth's description of the electromagnetic force $\boldsymbol{F}_{ij}$ between two current elements $\mathrm{d}\boldsymbol{j}_i$ and $\mathrm{d}\boldsymbol{j}_j$ a distance $\boldsymbol{r}_{ij}$ apart we write the gravitomagnetic equivalent,

$$\mathrm{d}\boldsymbol{F}_{ij}=\frac{\left[\mathrm{d}\boldsymbol{p}_j\right]\times\left[\mathrm{d}\boldsymbol{p}_i\times\boldsymbol{r}_{ij}\right]}{r_{ij}^3}\quad\Rightarrow\quad\mathrm{d}\boldsymbol{p}_j\times\mathrm{d}\boldsymbol{C}_i,\tag{9}$$

since $\mathrm{d}\boldsymbol{C}_i=\mathrm{d}\boldsymbol{p}_i\times\frac{\boldsymbol{r}_{ij}}{r_{ij}^3}$ where $\mathrm{d}\boldsymbol{p}_i$ is the mass current element inducing the field.

Thus Equation (9) is seen to be compatible with the Lorentz force law $\boldsymbol{F}=\boldsymbol{p}\times\boldsymbol{C}$ for the force on momentum $\boldsymbol{p}$ in gravitomagnetic field $\boldsymbol{C}$. In *A Self-linking Field Formalism* I show first-order C-field induction from momentum source density $\boldsymbol{p}_0$, and then derive the second order C-field induction from the momentum of the first-order field, $\boldsymbol{p}_1\sim\boldsymbol{C}_1\cdot\boldsymbol{C}_1$. as shown in Figure 3.

From the above it follows that:

$\mathrm{d}\boldsymbol{F}_{01}=\mathrm{d}\boldsymbol{p}_1\times\mathrm{d}\boldsymbol{C}_0=0$ since $\boldsymbol{C}_0\parallel\boldsymbol{p}_1$

$\mathrm{d}\boldsymbol{F}_{02}=\mathrm{d}\boldsymbol{p}_2\times\mathrm{d}\boldsymbol{C}_0\neq0$ since $\boldsymbol{C}_0\perp\boldsymbol{p}_2$

The force between $\boldsymbol{p}_0$ and $\boldsymbol{p}_1$ is zero since these mass density current flows are orthogonal to each other. On the other hand, the force acting between $\boldsymbol{p}_0$ and $\boldsymbol{p}_2$ is maximal or minimal according to whether these flows are parallel or anti-parallel.

In Figure 3 we see that first order momentum $\boldsymbol{p}_1$ associated with the circulation of $\boldsymbol{C}_0$ induced by $\boldsymbol{p}_0$ will induce the second order circulation represented by the circle of radius δ about $\boldsymbol{p}_1$. This circulation presents two momentum components $+\boldsymbol{p}_2$ at distance $\boldsymbol{r}-\delta\boldsymbol{r}$ and $-\boldsymbol{p}_2$ at $\boldsymbol{r}+\delta\boldsymbol{r}$ which are parallel and anti-parallel, respectively, to the primary source momentum $\boldsymbol{p}_0$. We consider the forces of each component.

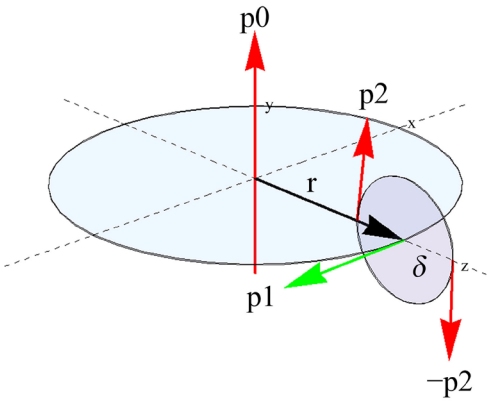

Figure 3. Momentum density $\boldsymbol{p}_0$ (red) induces C-field circulation at position $\boldsymbol{r}$. The C-field circulation at $\boldsymbol{r}$ yields momentum density $\boldsymbol{p}_1$ (green) orthogonal to $\boldsymbol{p}_0$. Momentum $\boldsymbol{p}_1$ induces the C-field at distance δ from $\boldsymbol{p}_1$. This induced C-field yields momentum density $\boldsymbol{p}_2$ (red) with components parallel and anti-parallel to $\boldsymbol{p}_0$.

$$\frac{\text{Force}}{r^2} \cong +\frac{\mathrm{d}\boldsymbol{F}_{02}}{\left|\boldsymbol{r}+\delta\boldsymbol{r}\right|^2} - \frac{\mathrm{d}\boldsymbol{F}_{02}}{\left|\boldsymbol{r}-\delta\boldsymbol{r}\right|^2} > 0 \tag{10}$$

Thus the attractive force on flow $+\boldsymbol{p}_2$ at distance $\boldsymbol{r}-\delta\boldsymbol{r}$ is always stronger than the repulsive force due to $-\boldsymbol{p}_2$ at $\boldsymbol{r}+\delta\boldsymbol{r}$, therefore the net force acts to move $\boldsymbol{p}_1$ nearer to $\boldsymbol{p}_0$. This effectively reduces the radius $\boldsymbol{r}$ and consequently increases the velocity $\boldsymbol{v}_1 = \boldsymbol{p}_1/m$ due to conservation of angular momentum, $mvr = const$.

We observe that the distance $\boldsymbol{r}$ was arbitrary, therefore the same logic applies to $\boldsymbol{r}-\delta\boldsymbol{r}$ and the net positive (attractive) force continues to shrink the vortex radius, while speeding up the velocity of the vortex wall. The geometry is shown in **Figure 4**. (black = radius *r*, red = velocity *v*)

There is a further consequence of the shrinking vortex radius. The mass density of the induced C-field increases with velocity according to special relativistic inertial formula $m = \gamma(v,c)m_0$. We denote this by writing:

$$\rho_1'(v_1) = \gamma(v_1')\rho_1(v_1) \tag{11}$$

Therefore, the naïve interpretation of the shrinking radius and increasing speed is that the vortex would shrink to a point on the $\boldsymbol{p}_0$ axis, however $\boldsymbol{v}$ is assumed to be limited by $\gamma(v,c)$ to less than the speed of light, and the increased mass density decreases the centripetal force and acts to limit the shrinkage. The net result is that a vortex with arbitrary finite radius will shrink to a smaller but still finite vortex! All of these consequences point toward a soliton-like stability!

8. Analysis of Vortex Propagation

$$\nabla \times \boldsymbol{C} = -\boldsymbol{C}(\boldsymbol{r}) \cdot \boldsymbol{C}(\boldsymbol{r})\boldsymbol{v} \tag{12}$$

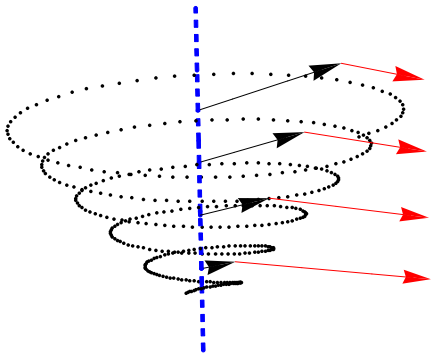

Figure 4. The C-field vortex shrinks such that the wall velocity $\boldsymbol{v}$ increases as radius $\boldsymbol{r}$ decreases, analogous to a spinning skater pulling in her arms.

The above analysis implies that the local vortex in the gravitational field, traveling through the field with initial velocity $\boldsymbol{v}_0$, self-induces circulation in the vortex wall that shrinks the vortex radius and increases the mass density (inertia) and the velocity of the wall. Two facts of physics tend to limit the shrinkage: the wall velocity is limited by the speed of light, and the angular momentum is conserved. As we are most interested in microscopic regions of ultra-high density, we make the further assumption that the angular momentum is quantized, *i.e.*, $mvr = h$, where

$$m = \int \mathrm{d}^3 x \, \rho = \int \mathrm{d}^3 x \, \boldsymbol{C} \cdot \boldsymbol{C} \,. \tag{13}$$

We can obtain the mass m by integrating over both sides of Equation (12) as follows:

$$\int \mathrm{d}^3 x \nabla \times \boldsymbol{C}(\boldsymbol{r}) = -\int \mathrm{d}^3 x \, \boldsymbol{C}(\boldsymbol{r}) \cdot \boldsymbol{C}(\boldsymbol{r}) \boldsymbol{v} \tag{14}$$

which can be rewritten:

$$\int \mathrm{d}^3 x \nabla \times \boldsymbol{C}(\boldsymbol{r}) = -m\boldsymbol{v} = -\boldsymbol{P} \tag{15}$$

We now analyze the momentum $\boldsymbol{P}$ of the moving vortex represented by the integration over the C-field circulation shown as the left-hand term of Equation (15). As these sections have detailed the shrinkage of the vortex, the left-hand side obviously changes (at least initially) as a function of time, hence we can write the time derivative of Equation (15) as:

$$\frac{\mathrm{d}}{\mathrm{d}t} \int \mathrm{d}^3 x \nabla \times \boldsymbol{C}(\boldsymbol{r}) = -\frac{\mathrm{d}\boldsymbol{P}}{\mathrm{d}t} \,. \tag{16}$$

Here the right-hand term, $\mathrm{d}\boldsymbol{P}/\mathrm{d}t$ is a force, in particular, a Lenz-law-like force acting on the vortex due to the change in circulation integrated over the region of the vortex. This region, as we have described, shrinks as the vortex shrinks; this implies a negative change on the left-hand side, canceling the minus sign on the right, and leading to a positive force on the moving vortex, accelerating it from an unknown initial value to a final velocity limited by the speed of light.

9. Interpretation of Vortex Dynamics of Neutrino

Previous papers develop the Heaviside equations from a primordial principle of self-interaction, in a manner that is field-strength independent. We have shown that this formulation is completely equivalent to Einstein's general relativistic field equations. This key result conflicts with the GR conception of the "linearized" field equations leading to a "weak field approximation" from which Heaviside's equations are derived. Our derivation does not require or imply any "weak field" conception, instead, our derivation implies that these equations work for all field strengths, up to and including the strengths expected at the big bang, thus enabling the use of these equations in all gravitational regimes. Clifford Will [15] and others have written of the apparent validity of this assumption, but have been unable to explain this fact.

Another key result is provided by the $K^N V$-metric solution of Einstein's field equations, which have only density-dependent solutions. This too conflicts with many physicists' stated belief that general relativity applies only to "large mass" problems. This is clearly not the case.

Additionally, we recall Burinskii's invocation of the MIT and SLAC "bag" models which are "similar to solitons", but are *soft*, *deformable*, *and oscillating*. We've seen that this dynamic model is compatible with our $K^N V$-metric solution and with the enhanced Heaviside treatment of vortices arising in turbulent high density fields.

Our conclusion is that vortices in gravitomagnetic fields are potentially self-stabilizing and dynamically shrink and speed up, limited by speed of light c and by quantum spin $\hbar$.

I postulate that this solitonic behavior describes *neutrinos* generated from local ultrahigh density gravitomagnetic field turbulence, of the kind expected post-big bang and in the "perfect fluid" generated at the Large Hadron Collider in collisions of heavy nucleons. I've not yet modeled the "oscillations" currently assumed for neutrinos, but such oscillations would appear to be compatible with this neutrino model.

Neutrinos are typically associated with weak nuclear interactions. For most of the history of the Standard Model neutrinos were considered to be massless, and move at the speed of light. Circa 1980 it was realized that neutrinos have small but finite mass and circa 2011 neutrinos were measured propagating at approximately the speed of light over many kilometers; even through mountain ranges [16].

In 1981 Mohapatra and Senjenovic [17] proposed a "seesaw mechanism" for understanding neutrinos. In particular their theory addressed the strange behavior of neutrinos with regard to left-right symmetry. All neutrinos are "left-handed", *i.e.*, the spin is given by the left-hand rule, which states that the circulation curls in the direction of the left fingers when the left thumb points in the direction of the source momentum. Almost a half-century of experiments has failed to detect a neutrino with right-hand spin; the reason is not known for this handedness; other electromagnetic and strong nuclear reactions exhibit both left

and right spin symmetry. Therefore it is significant that our gravitational model of the neutrino is left-handed. This is the meaning of the minus sign associated with the momentum: $\nabla \times \boldsymbol{C} \sim -\boldsymbol{p}$; a plus sign would indicate right-hand circulation.

Therefore our gravitational model is compatible with and provides a still-missing explanation of, neutrino handedness. It supports the Majorana particle model in which the neutrino is its own anti-particle; a collision between a left-handed neutrino traveling right and a left-handed neutrino traveling left will cancel both spin and momentum, thus annihilating both particles.

Conflicts of Interest

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

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