The Nature of Quantum Gravity

by

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Abstract: A theory's equations are designed to model physical *behavior* that reflects the *nature* of physical reality. Einstein's nonlinear gravity equation is 'linearized' in the 'weak field limit' by ignoring nonlinear terms. This can be misinterpreted as affecting the nature of the field. Linearization is a mathematical artifice making equations easier to solve, having *zero effect* on the physical nature of the field itself. Thus it is false to say that the weak gravitational field is *not self-interacting*. Nor is the weak gravitational field based on mass; the field equation is based on *mass density.* These aspects of gravity are investigated by replacing curved space-time with mass density in flat space. A novel quantum gravity relation is derived and related to quantum mechanics.

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The Nature of Quantum Gravity

Over one hundred fifty years after Maxwell invented gravitomagnetic equations, and one hundred years after Einstein found that these linearized weak field equations had wave solutions, gravitational waves were directly detected [1]. Maxwell saw the similarity of Coulomb's law $\vec{\nabla} \cdot \vec{E} \sim \rho_q$ to Newton's law $\vec{\nabla} \cdot \vec{G} \sim \rho_m$ and postulated a gravitational analogy with Faraday's electromagnetic law and proposed the existence of a gravitomagnetic field, $\vec{C}$:

$$\vec{\nabla} \times \vec{B} \sim \rho_q \vec{v} + \frac{\partial \vec{E}}{\partial t} \quad \Rightarrow \quad \vec{\nabla} \times \vec{C} \sim -\rho_m \vec{v} + \frac{\partial \vec{G}}{\partial t} . \tag{1}$$

Heaviside found the gravitomagnetic field too weak to be physically significant, a conclusion unchallenged for over a century [2]. But not until 2011 did *Gravity Probe B* [3] confirm the *physical existence* of the gravitomagnetic field. Ignoring $\partial \vec{G} / \partial t$, acceleration of mass density ρ_m induces a C-field circulation proportional to ρ_m and local velocity $\vec{v}$ [4]:

$$\vec{\nabla} \times \vec{C} \sim -\rho_m \vec{v} . \tag{2}$$

Maxwell's electromagnetic fields interact with charge but are *uncharged*, hence do *not* interact with themselves. But gravitomagnetic fields *do* possess energy, hence mass equivalence, and thus *do* self-interact; *self-interaction is the most significant aspect of the gravitational field.* In flat space, *density of mass-energy* plays the role of *space-time curvature* for gravity. But despite that the weak field exists in Minkowski space, many physicists *believe in* curved space-time, though it's been repeatedly shown that gravity can be formulated in flat space [5,6,7]. Many textbooks are quite clear on this—Weinberg noted [8]:

> *"… The geometric interpretation of the theory of gravity has dwindled to a mere analogy."*

And Padmanabhan [9]:

> *"…this* geometrical interpretation *is a peculiar feature not shared by any other field theory* […] *there is a direct connection between the principle of equivalence and the possibility of describing gravity as a geometrical phenomenon.* […] *A gravitational field is locally indistinguishable from a suitably chosen non-inertial frame…"*

While Ohanian and Ruffini [10]:

> *"The principle of the equivalence of gravitation and acceleration is true only in a limited sense. If rotational degrees of freedom are taken into consideration… then the equivalence fails."*

Since $\vec{\nabla} \times \vec{C}$ inherently implies rotational degrees of freedom, equivalence fails. And if equivalence fails, the possibility of describing gravity as a geometrical phenomenon vanishes. This is further confirmed by their statement:

> *"That the linear equations imply the full nonlinear equations is a quite remarkable feature of Einstein's theory of gravitation.",*

which implies that *mass-energy density* is equivalent to *curved space-time*!

The Scope of Gravity

GR is a classical theory based on applying calculus to continuous space-time. So *how far does continuity extend*? Most assume from CMB to Planck length: $\sim 10^{27}$ to $\sim 10^{-35}$ meter. Gravity *acts on* neutrons [11] with size ~ 10^{-15} m, but few believe significant gravitational effects *derive from* microscopic mass. Yet

> *General Relativity is not based on mass, but mass-energy density, $T_{\mu\nu}$.*

So if *point particles* are infinitely dense, we should expect to find gravitational phenomena associated with them. But if neither point particles nor infinite densities exist, *what is realistic*? Experiments set an upper bound on electron size $\sim 10^{-19}$ m, so $\rho \cong (m_e) \times (10^{57})\, kg/m^3$ is a *lower* bound electron mass density, ($m_e \sim 10^{-31}$ kg), thus *density* ranges from $10^{57} m_e$ *to infinity*, a nontrivial factor.

> *"No general procedure exists for solving Einstein's field equations analytically; one guesses solutions as best one can."* [10]

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -8\pi G\, T_{\mu\nu} \qquad (3)$$

Nonlinear equations are linearized to solve intractable equations. Maxwell's gravitomagnetic equations derived from general relativity are called *weak field* equations, viewed as linearizing Einstein's nonlinear field equations and flattening space. Many physicists believe that in the *weak field limit* of general relativity the field is *not self-interacting.* But…

> *Linearizing an equation for convenience does not alter the nature of a real physical field in any way, only the nature of the model field.*

It does <u>not</u> mean that a 'linear' gravitomagnetic field will not interact with itself.

> *The process of linearization of equations is an artificial technique designed to simplify the mathematics. It does not change the <u>nature</u> of the physical field modeled by the equations.*

Real self-interacting fields do <u>not</u> become non-self-interacting simply because a simplifying approximation is applied to the self-interactive field equations. Making a *modeling equation* linear does <u>not</u> change the *physical nature* of a field. *It merely makes the equation incapable of describing its behavior*. Then an *iterative procedure* is required to accurately describe the behavior of the self-interacting field. Physicists are quite comfortable with an analogous perturbation theory technique required to extend simple Schrödinger solutions.

If a *local energy density* ρ induces a C-field circulation, with a corresponding increase in local mass density, $\Delta\rho$, the first order equation becomes

$$\vec{\nabla}\times\vec{C} \sim (\rho+\Delta\rho)\vec{v}\,. \tag{4}$$

This self-interacting situation can be formulated in iterative fashion and the solution appears as shown in fig 1.

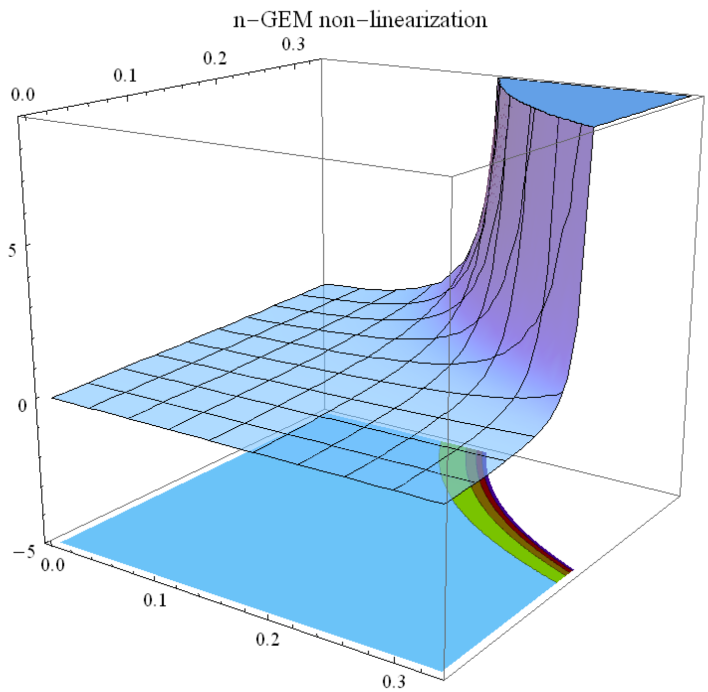


Fig 1. The n-GEM diagram depicts C-field circulation $|\vec{\nabla}\times\vec{C}|$ as a function of two parameters; mass density ρ and velocity $\vec{v}$. The diagram is symmetrical in these two parameters. If the mass density increases the circulating C-field energy increases, thereby increasing the local mass density. If the velocity of the system increases the circulating C-field energy increases, thereby increasing the local mass density. This process continues as long as the force accelerates the system.

If either mass density ρ or velocity $\vec{v}$ increases, C-field circulation and, hence its energy density, increases as shown. What *time constant* is associated with iterative self-interaction? We postulate that self-interaction proceeds at the speed of light. Then what *terminates* the self-interaction?

Assuming *no minimum level* of self-interaction, how does this process end? It ends whenever *the accelerating force is exhausted.* As long as local mass is accelerated, *self-induced C-field circulation energy induces more C-field circulation energy.* Growth of C-field energy appears unlimited in principle—only practical limitations apply. So an iterative solution depends upon how long the local acceleration is applied. If we accelerate a particle, then after a period of acceleration the relevant C-field equation is

$$\vec{\nabla} \times \vec{C}' = \kappa \, \rho' \vec{v} \tag{5}$$

where κ includes the sign and the G and c^2 terms and ρ' is the new mass density. If we integrate both sides over the relevant local volume, *V:*

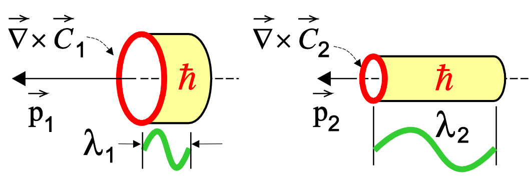
$$\frac{1}{\kappa} \int_V \left(\vec{\nabla} \times \vec{C} \right) dV = \int_V \rho' \vec{v} \, dV = \vec{v} \int_V \rho' \, dV = m\vec{v} = \vec{p} \, . \tag{6}$$

Consider an electron. Since $m\vec{v} = \vec{p}$ we apply deBroglie's relation:

$$\vec{p} = \frac{h}{\lambda} \, . \tag{7}$$

Multiply both sides by $\vec{\lambda}$ to obtain the dynamical relation: (8)

$$\frac{1}{\kappa} \int_V \vec{\lambda} \cdot \left(\vec{\nabla} \times \vec{C} \right) dV = h$$



which is *a novel quantum gravity relation*. If the self-interactive nature of the local field is accurately modeled by an iterative procedure, the electron or other fundamental particle will be accompanied by a circulating wave field characterized by wavelength λ in a local region of space. This *particle <u>and</u> wave* picture supplants the Copenhagen School's *particle <u>or</u> wave*. Per John Bell, identification of a <u>real</u> field with the wave function leads to a deBroglie-Bohm-like [12] model of physics. This wave function is associated with the gravitomagnetic C-field circulation as a helical wave packet, effectively the wave packet of the electron.

The cartoon cylinders shown above are illustrative. A more realistic picture of the induced C-field is shown in fig 2.

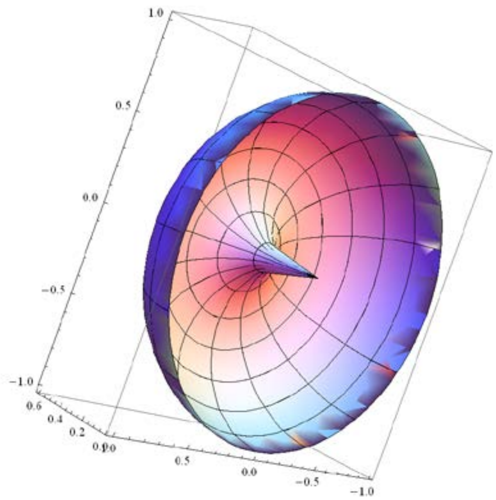


Fig 2 The 'leading edge' of the induced C-field wave function is shown for a constant magnitude surface $|\vec{C}| = k$.

Jaaskelainen notes [13]:

> *"If the wave function gives the density of stuff rather than just the probability of finding it then there will be a gravitational field associated with a given wave function."*

His basic equation for describing a single particle density is

$$\rho_m = m\,|\,\psi(\vec{r})\,|^2 \tag{9}$$

which, plugged into $\vec{\nabla}\times\vec{C} \sim \rho_m\,\vec{v}$, yields

$$\vec{\nabla}\times\vec{C} \sim \rho_m\,\vec{v} \quad\rightarrow\quad m\vec{v}\,|\,\psi(\vec{r})\,|^2 \quad\rightarrow\quad \vec{p}\,|\,\psi(\vec{r})\,|^2 \quad\rightarrow\quad \frac{\hbar}{\lambda}|\,\psi(\vec{r})\,|^2 \tag{10}$$

and hence

$$\vec{\lambda}\cdot\vec{\nabla}\times\vec{C} \sim \hbar\,|\,\psi(\vec{r})\,|^2 \tag{11}$$

Integrating $\int_V |\,\psi(\vec{r})\,|^2\, dV = 1$ yields our quantum gravity relation (8).

Summary and Conclusions

Most discussion of quantum gravity is phrased in terms of

> *"The microscopic domain ruled by quantum gravity and the macroscopic scale described by general relativity."* [14]

with *space* and *time* considered *real* phenomena rather than mere bookkeeping devices for organizing measurements of real energetic phenomena. But gravitational waves were formulated in the flat space of the Maxwell-Einstein "weak field" equations which focus on mass-energy density. Mass density implies

1.) The highest density is in the smallest space (electron, etc.) and
2.) acceleration of high density mass induces C-field circulation.

Others suggest "*the wave function as matter density*" [13] and "*kinetic energy as concealed motion*" [15] while ignoring the self-interactive gravitomagnetic field. Current physics treats the formalisms of *theories* of quantum gravity, whereas maximum clarity obtains from focus on the *nature* of quantum gravity. A theory is a model; the essence of physics is design and study of models that capture behavior of the real world. Linear models of weak fields that ignore nonlinear terms of the model do *not* accurately describe the physically real gravitational field that is self-interacting; the self-interactive *nature* of the C-field determines the behavior. The key paradigm:

> *Linearizing a field equation does* not *alter the fundamental nature of the self-interactive field.*

In special relativistic frames, C-field self-interaction is dynamic only when the particle is accelerated, i.e., if $d\vec{v}/dt = 0$ then $d(\vec{\nabla}\times\vec{C})/dt \equiv 0$. Only when velocity increases does the C-field circulation energy density increase and self-induce further density increase, continuing as long as the local mass is accelerated. This can be modeled iteratively; relativistic *'mass increase'* is essentially C-field circulation *kinetic energy,* which acts in *Lenz-law*-like fashion to *oppose* any change in momentum,

$$\frac{d}{dt}\int(\vec{\nabla}\times\vec{C})\,dV \sim -\frac{d\vec{p}}{dt}, \qquad (12)$$

explaining *physical conservation of momentum*, of which Feynman said [16]

> *"The reason why things coast forever has never been found out.*
> *The law of inertia has no known origin."*

Self-induced C-field circulation explains particle 'tunneling' through a narrow electromagnetic potential barrier and provides a *particle-AND-wave* picture compatible with interference phenomena and quantized orbits and provides a Born-like probability density. [17] Consequences beyond the scope of this essay follow from this self-interactive model, from elementary particles to MOND and cosmological 'jets' extending hundreds of light years. An energy-exchange-based theory of magnetic moments traversing a nonuniform field, implies, if proved correct by experiment, conservation of angular momentum based on the above C-field approach. [18] The Einstein-deHaas effect completes this conservation picture.

The low-hanging fruit almost hits one in the face…

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