

Process Analysis through Length Consistency

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Abstract—The requirement for consistency in physics can sometimes offer a common ground between disciplines such that their fundamental equations share a common parameter set and mathematical method for equation extraction. The parameter set shared by Relativity and Quantum Wave Mechanics enables an analysis which will be seen to be very straightforward, primarily classical in nature using linear algebra concepts, yet deriving a theoretical estimate of the value of the Gravitational Constant along with dependencies never before known.

Keywords—Gravitational Constant, Physical Consistency, Quantum Mechanics, Relativity.

I. INTRODUCTION

THIS document describes a unique and novel approach applied to the simplest of cases directed toward establishing basic formulations that are length centric in order to bridge the disciplines of Relativity and Quantum Wave Mechanics in a manner consistent with both. Our particular aim is to formulate the Gravitational Constant so as to enable a first order view of its internal dependencies. The approach is shown to derive the quantum wave equation and others while also deriving General Relativity's (GR) cosmic expansion case. So we would expect the derivation and result of the space contraction case to also be correct within the confines of our models. No similar or directly related analysis has been found in the literature.

With this end in mind, we develop a covariant equating parameter set. The equations sought for each case are developed by the equating of a particular pair of those parameters. In order to develop a generally applicable set inclusive of both Quantum Mechanics and Relativity, it was necessary to establish an adequate way to relate to both intrinsic and ordinary (*non-intrinsic*) characteristics of particles.

II. PRINCIPAL COVARIANT CORRELATIONS

A. The Common Denominator of Length

The principal *facets* of our reality are: (1) breadth, (2) time, (3) mass, and (4) energy. Energy here will be that of electromagnetic (E/M) waves, but representing the total of the energy of radiation, kinetic, and potential forms. The facet descriptor in common is the parameter "length" if mass (via momentum) and energy are represented by their characteristic wavelengths. We'll call a 3 vector spatial line length "breadth" = x of $x^2 = \sum x_j^2, j=1-3$ and establish the time length as " ct ". The *parameter correlation*, we'll define here as an invariant

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based relation, has one example in: $x=ct$. Here and throughout, a subscript zero will denote at rest values while length contracted values will be assumed without notation. The equating of these two lengths, as well as those following, presupposes a valid defining action, e.g., here an observer measures the length and travel time of a light beam *made to transverse* a length segment contained within an inertial frame possibly separate from the observer's. The Bohr Correspondence Principle extends this concept so as to include particle intrinsic parameters as well. Because of the choice made of the disciplines to be bridged, we'll seek an invariant connecting the intrinsic to the ordinary characteristics of particles.

Any four vector representation will be noted as such. All four of the facet length descriptors are subject to GR compressions and expansions of the spatial scale factor (R) of the universe (given $c = Rx / Rt$). At this point we've only defined covariance between two lengths of an *inline* ordinary reality, that is, all lengths lie in the same specific direction of the 3 dimensional spatial part of space time reality. We'll represent the reality facets through the scale factor as: $R(L_x, L_t) = R(x, ct)$, in which the scale function is a simple "holder" of the forms of length.

B. Additional Ordinary Lengths

Since we're lacking the L_E invariant link to x and ct , we'll use \Leftrightarrow instead of an equal sign and define an expanded inline ordinary reality as:

$$R(L_x, L_t, L_E) \Leftrightarrow R(x, ct, hc / \varepsilon).$$

For an E/M wave,

$$p_\varepsilon = \varepsilon / c = hf / c = h / \lambda_E$$

Defining ν by the invariant $(\mathbf{v} \bullet \mathbf{v})^{1/2} (= cL_x / L_t)$, then by analogy: $\lambda = h / mv$, and so: $R(L_x, L_t, L_E, L_p) \Leftrightarrow R(x, ct, hc / \varepsilon, h / mv)$, not including the singularity of case $\nu = 0$. The L_p length is the wavelength of a *matter wave form*. In the nomenclature we've adopted, R contains an inline ordinary reality of four lengths.

C. Intrinsic Parameter Inclusion

Fundamental properties of elementary particles are facets of an *extraordinary* reality that is intrinsic to the particle. Chief among these properties are mass, electric charge, spin, magnetic moment, and location probability determinate. This latter property can be addressed most directly by postulating

that elementary particles have structural level characteristics corresponding to the ordinary matter wave form. This form, being of structural origin, must itself be consistent with its energy representation: $h/p = hc/\varepsilon = hc/mc^2$, so $p = mc$. The evidence for the h/mc form is found in this paper's derivation of particle constant J_{px} , subsequently shown to be central to Quantum Wave analysis. The intrinsic topic demands a separate reality view of a particle's structural properties. So we'll define the momentum $p = mc$ as part of a reality view of *intrinsic structure* characterized as being of 3 dimensional space κ , separate yet connected to the non-intrinsic directly observable ordinary reality characterized as being of 3 dimensional space χ . So in conjunction with this, we write: $p = mc$ with $L_p = \lambda_m = h/p$, the κ part of an expanded reality: $R(\chi; \kappa) \Leftrightarrow (x, ct, hc/\varepsilon; h/mc)$.

A connection between the two realities is seen in Special Relativity (SR):

$$m = m_0 / (1 - v^2/c^2)^{1/2}, \text{ or: } (mc)^2 = (m_0c)^2 + (mv)^2.$$

Using the mathematical artifice of complex numbers, we can model this relationship as if m_0c lies on the imaginary axis:

$mc = im_0c + mv$. If we also represent the imaginary axis as an axis k of the κ reality view above, this relation is seen to be modeled in a manner consistent with Fig. 1:

$$\mathbf{p}_2 = m_0c\mathbf{k} + mv\boldsymbol{\chi} \tag{1}$$

$$\mathbf{p}_2 = m\mathbf{k}\{\text{SqRt}(c^2 - v^2)\} + mv\boldsymbol{\chi} \tag{2}$$

in which the relationship between $(mc)\mathbf{k}$ and $(mv)\boldsymbol{\chi}$ is:

$$(mc) \sin \theta = (mv) \tag{3}$$

and their correspondence will be seen in (5A) and (5B).

Here then, Fig. 1, technically a "relationship diagram" with "implied momentum magnitudes," has momentum mv resulting from, or "derived", from mc .

Here particle velocity can be any value less than c , including zero. If the latter: $\mathbf{p}_1 = \mathbf{k}m_0c$. But in the $v > 0$ instance the resulting momentum vector must equal: $\mathbf{p}_1 + \mathbf{p}_v$, as in (1), giving reason for the dot product invariance of the 4 vector momentum: $\mathbf{p}_2 \cdot \mathbf{p}_v = \mathbf{k}m_0c$. Here \mathbf{p}_v is the 3 vector, being one of the two fully defined vectors in the diagram. The Stress Energy Tensor can be defined through the 4 vector momentum relationship as seen through the prism of Fig. 1, $\mathbf{k}p_2 - \boldsymbol{\chi}p_v$ in applicable densities per unit time: $T^{ii} = c\rho_m$ (Mass density) or its equivalence $T^{ii} = \rho/c$ (Energy density) crossing a surface of unit time. So this is p_2 density. $T^{ii} = p_v$ Momentum density in the i direction crossing a surface of unit time. $T^{ii} = \text{K.E.}$ representation of p_v density. $T^{ij} = p_i A_j$; The i th component of pressure as seen by the surface A_j , i.e.

$F_i(A_j/A_i)$. But this is per unit time, so $F_i \Delta t = p_i$, i.e. p_v momentum ($K = 0$ value) in the i th direction resulting from a unit time impulse, as seen by A_j . So, ignoring constants:

$$T^{ii} = T^{ii} = T^{ii}.$$

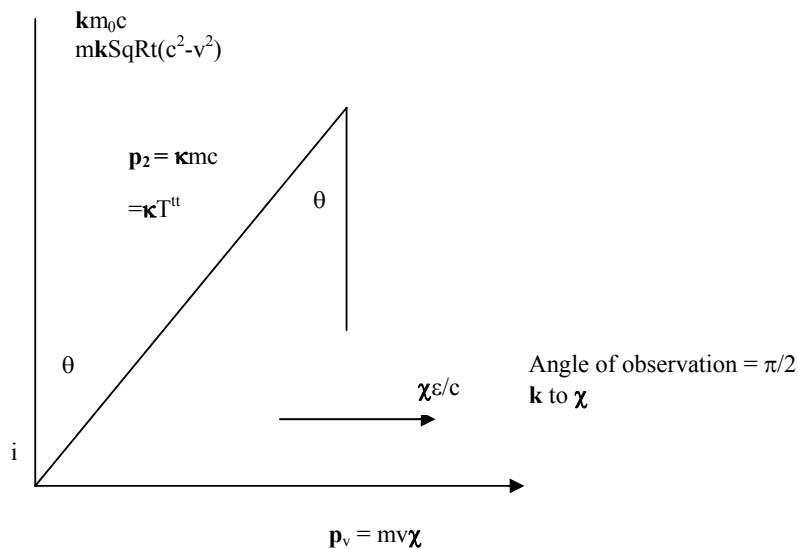


Fig. 1 Momentum Space of $R(\chi; \kappa)$

We have covariant equating elements between breadth and time, and separately between the energy and mass elements from conservation, so we may write:

$$R(\chi; \kappa) = Qx, Qct, hc / \varepsilon; h / mc \quad (\varepsilon > 0, m > 0) \quad (4)$$

Here Q is a presently undefined interface function between the pairs. But the κ space of Fig. 1 has non-zero lineal momentum magnitudes despite its stated applicability even to particles fixed in space. Given that all the implied momentum magnitudes of Fig. 1 are correct, the indication is that the κ momentums are true but not literal in direction, while the χ momentums are both true and literal. So we can say that a particle of mass m has an inherent ability to provide inline momentum of mc to the ordinary reality of χ . For example, with a valid defining action, its conversion to E/M radiation would have that literal momentum which in turn could be imparted to the space metric. Also, a particle's intrinsic spin can result in angular momentum having the value mcr with that same imparting ability.

In this latter case, for the sake of completeness, we'll speculate regarding one possible background for this κ to χ momentum transfer process. The inline χ axis is assumed fixed, so Fig. 1 definition must begin by establishing the particle inline angular momentum $J\chi$. In connection with this, the axis \mathbf{k} (toward top of figure), and a dimension φ representing the direction of \mathbf{k} axis rotation ($-\pi/2$ to $+\pi/2$) around the inline χ axis, establishes the $J\chi$ equivalent body κ plane ($\mathbf{k}\varphi$). The θ skew direction and meaning are defined by the particulars of the transfer process. Considering Fig. 1 with its complex conjugate space directly beneath it (not shown), the dual space vector mc with a generalized linear operator ($\sin \theta$) yield an identical transformation:

$$(\sin \theta) |mc > mv < mc| (\sin \theta).$$

D. Particle Constants

A κ rotating body equivalence to particle $J\chi$ can be derived from $\mathbf{k}m_0c$ and a corresponding perpendicular \mathbf{R}_0 of κ , each defined through the moment of inertia: $I = \sum_j m_j R_j^2$ by which we define the angular momentum im_0cR_0 . Our use will be analogous to the utility of "c" in Relativity. GR's fourth dimension "ict" enables ($v \ll c$) spacetime interval invariance with its resulting ease of transformations. Our "i m_0c " of κ enables Fig. 1 with its intrinsic parameter correlations.

With the restriction $\theta = 0$, we can write:

$$\begin{aligned} J_{px} &= im_0cR_0 = iI\omega_m = i(m_0R_0^2)(2\pi f) \\ &= i(m_0R_0^2)(2\pi c / \lambda_m) = im_0R_0^2(2\pi c)(m_0c / h) \end{aligned}$$

which reduces to: $J_{px} = ih / 2\pi$. In order for the Fig. 1 "particle" to be hadron, lepton or photon, we add the spin quantum number: $J_{pxs} = ih\sigma / 2\pi = iJ$. So $|J_{pxs}| = h\sigma / 2\pi = m_0cr_p$ in which we now define the parameter r_p as a non-specific radial line segment of a χ spherical coordinate system with origin at the (im_0c) axis (i.e. particle location) So: $r_p = h\sigma / (2\pi m_0c)$.

We now impose the inline condition and include the contraction factor (ρ) of SR on the lengths of χ . As we remove the $\theta = 0$ restriction, we can write: $|J_{pxs}| = h\sigma / 2\pi = m_0cr_p = mc\rho r_p = mcx$ in which we've now defined this specific inline breadth "x" of χ as being coupled with mc of κ such that magnitudes $mcx = J$ and since this is post defining action, J is an invariant relative to that particle velocity magnitude. Also, from (3): $J = (mv / \sin \theta)x = mv(x / \sin \theta) = mvX$ (a "derived" form). With "x" accepted as a variable name in either case, the $px = J$ invariant yields (5), linking intrinsic κ spin to its ordinary χ angular momentum:

$$\text{(Structural): } (2\pi / \sigma)x = (h / mc) = \lambda_m \quad (5A)$$

$$\text{And (Derived): } (2\pi / \sigma)x = (h / mv) = \lambda, v > 0. \quad (5B)$$

E. The Principle of Length Equivalence (PLE)

So Fig. 1 has defined a px invariant for our subject particles which we now take to be a fundamental relationship through which both forms of (5) define permissible active $p \leftrightarrow x$ transfer functions through their representative length equivalences (i.e. an "LE process"), but in which conservation of momentum requires all relevant ordinary lengths to be inline. The length equivalences are not the transformation operators, but the definition of their required result by virtue of the (5A) and (5B) correlations. The structural form (5A) equates the first and fourth terms in (4). And if we multiply this equation by c / v_p , with v_p a velocity defined as equal ε / p , we get: $(2\pi / \sigma)ct = (hc / \varepsilon)$, equating its second and third terms. But in structural form, or if $\theta = \pi/2, v_p = c$, so (c / v_p) is a unity multiplier. So with function Q of (4) equal to $(2\pi / \sigma)$, we can now establish the principle that any of the four terms in (4) are covariant in equating with any other and that, due to the natural requirement for consistency between disciplines, they define the result of a particular LE process, and its correlated relationships between parameters. Then:

$$R(L_x, L_t, L_E; L_p) = R\{(2\pi / \sigma)x, (2\pi / \sigma)ct, hc / \varepsilon; h / mc\} \quad (6)$$

We'll find that the scalar σ can be different for some processes. Here it is spin quantum number for mc or mv transfer. Later it will be the fine structure constant γ for

processes operating through the electric potential, and it will be shown to be μ , a mass related constant in Quantum Field analysis.

While (5) and (6) define active px transfer functions via length equivalences, a *passive space-time extension* can be established, e.g. $x > h\sigma / 2\pi p$. So the transfer process is always related to the relevant LE, but a passive extension does not. Generally speaking, the following transfer details have results which are not surprising, but their derivations are important because they are unique and demonstrative of PLE validity.

III. DETAILS OF (5) & (6) LENGTH EQUIVALENT ACTIONS
($\sigma=1/2$ UNLESS NOTED OTHERWISE)

A. Fundamental Correlations

$$L_E = L_p : hc / \varepsilon = h / mc \text{ or } \varepsilon = mc^2,$$

as also seen in Special Relativity.

$$L_p = L_x : h / p = 4\pi x \text{ Or: } \Delta x \Delta p = h / 4\pi \quad (7)$$

valid in both forms of (5).

$$L_E = L_t : hc / \varepsilon = 4\pi ct \text{ Or: } \Delta \varepsilon \Delta t = h / 4\pi \quad (8)$$

also valid in both structural and derived forms since (7)/ $v_p =$ (8).

Spacetime extensions of the derived forms lead to the Heisenberg relations. Quantum Mechanic's Schrodinger probability wave equation derives from (5B). For comparison, in structural form we expand (5A) as:

$$2\pi x / \sigma = h / mc = \lambda_m$$

Dividing this equation by c we get:

$$2\pi t / \sigma = h / \varepsilon = 1 / f_m ; \lambda_m f_m = c$$

With a particle characteristic angular frequency of:

$$\omega_m = 2\pi \varepsilon / h = 2\pi mc^2 / h$$

For a single particle in lineal motion, the derived form (5B) expands as:

$$2\pi x / \sigma = h / p = \lambda$$

Dividing this equation by v_p we get:

$$2\pi t / \sigma = h / E = 1 / f ; \lambda f = E / p = v_p,$$

with characteristic frequency: $\omega = 2\pi E / h$.

Eigenvalue total energy "E" of χ is composed of kinetic energy K and potential energy P . So: $E = K + P$. And, using the expanded (5B):

$$h\sigma / 2\pi t = p^2 / 2m + P = (1 / 2m)(h\sigma / 2\pi)^2 (1 / x^2) + P \quad (9)$$

an inline equation. We'll define a probability function, a sinusoidal wave $\psi(x_j, t) = \beta(x_j)e^{-i\omega t}$ where subscript $j = 1, 2, 3$ automatically implies summation over the ordinary spatial coordinates. With inline $J = h\sigma / 2\pi$, (9) becomes:

$$J\psi / t = (1 / 2m)J^2(\psi / x^2) + P\psi \quad (10)$$

The classical equation for transverse sinusoidal waves is:

$$\frac{\partial^2 \psi}{\partial x_j^2} = (1 / v_p^2) \left(\frac{\partial^2 \psi}{\partial t^2} \right).$$

Application to our probability function yields:

$$\frac{\partial^2 \psi}{\partial x_j^2} = -(\omega / v_p)^2 \psi \quad (11)$$

The forms ψ / x^2 and ψ / t in (10) suggest a change in representation using replacements:

$$(1 / 2m)(h\sigma / 2\pi)^2 (1 / x^2) \psi \rightarrow A_k \left(\frac{\partial^2 \psi}{\partial x_j^2} \right)$$

and:

$$(h\sigma / 2\pi t) \psi \rightarrow A_E \frac{\partial \psi}{\partial t}$$

where A_k and A_E are constants to be determined.

Using (11):

$$A_k \frac{\partial^2 \psi}{\partial x_j^2} = -A_k (2\pi f / v_p)^2 \psi$$

But

$$f / v_p = 1 / \lambda = \sigma / 2\pi x$$

from the expanded (5B). So:

$$A_k \frac{\partial^2 \psi}{\partial x_j^2} = -(A_k \sigma^2 / x^2) \psi$$

and from (10):

$$-(A_k \sigma^2 / x^2) \psi = (1 / 2m)(h\sigma / 2\pi)^2 (1 / x^2) \psi$$

So:

$$A_K = - (1/2m)(h/2\pi)^2 = (1/2m)J_{px}^2,$$

recall that $J_{px} = i\hbar / 2\pi = i\hbar$

Now:

$$A_E \frac{\partial \psi}{\partial t} = A_E (-i2\pi f) \psi,$$

and, from the expanded (5B):

$$f = \sigma / 2\pi t.$$

So:

$$A_E \frac{\partial \psi}{\partial t} = -A_E (i\sigma / t) \psi$$

and then from (10):

$$-A_E (i\sigma / t) \psi = (h\sigma / 2\pi t) \psi$$

So:

$$A_E = -h / 2\pi i = J_{px}$$

Then we can rewrite (10) as:

$$i\hbar(\partial \psi / \partial t) = -(1/2m)\hbar^2 \nabla^2 \psi + P\psi$$

This is the Schrodinger probability wave equation with transforms:

$$E \rightarrow J_{px} \left(\frac{\partial \psi}{\partial t} \right) \text{ and } p^n \rightarrow (-J_{px})^n \nabla^n \psi \quad (12)$$

Comparing this equation with (10), we see that σ and the inline vector χJ have become irrelevant. The Quantum Wave equations have forced the transfer angular momentum of analysis: $J \rightarrow J_{px}$.

The Dirac Equation follows from these transforms as applied to (1):

$$(mc)^2 = E^2 / c^2 = (m_0c)^2 + p_v^2 = (\beta m_0c + \alpha \bullet p_v)^2$$

This latter squared parenthesis is made true by the α and β 4 X 4 matrices. So:

$$E = \beta m_0c^2 + c\alpha \bullet p_v$$

and with transforms (12) applied:

$$i\hbar(\partial \psi_j / \partial t) = (\beta m_0c^2 - c\alpha \bullet i\hbar \nabla) \psi_j, j=1 \text{ to } 4.$$

$$L_p = L_t (\sigma = 1)$$

Consider an E/M field in close contact with an accelerating object. Let m_N be that portion of object mass m connected to an E/M field such that both equally contain a momentum m_Nc in the inline direction defined by the object's acceleration. Then: effective $\theta = \pi/2$ and: $h / m_Nc = 2\pi ct$, or:

$$m_Nc = h / (2\pi ct) \quad (13)$$

Here $2\pi ct$ is the time length correlated with m_Nc . We define p as that E/M field momentum. Applying the length equivalence to this momentum, we can write:

$$h = 2\pi ctp.$$

Differentiating with respect to t : $2\pi cp + 2\pi ct \frac{dp}{dt} = 0$

But $\varepsilon = cp$ and the χ reaction force in the E/M field due to the accelerating object is: $\frac{dp}{dt} = -m_Na$, so this becomes:

$$\text{E/M } \Delta\varepsilon = (-ct)(-m_Na) = ctm_Na \quad (14)$$

with k_B = the Boltzmann Constant, (13) and (14) yield:

$$m_Nc = k_B \Delta T / at = h / (2\pi ct), \text{ So: } \Delta T = ah / (2\pi ck_B)$$

which is Unruh's Law.

This process is contained within χ . The efficiency m_N/m of the transfer of acceleration force to the E/M field is dictated by the intimacy of their connection.

B. General Relativity

$$L_x = L_t : x = ct$$

$$L_E = L_x : hc / \varepsilon = 4\pi x$$

Note that all the lengths of (6) have the linearity associated with the ability to equate to the flat metric reference $x = ct$. We now define the *grid* as a function $x'(x)$ in which both x and x' are inline lineal, i.e. parameters defined within the context of a single dimension (i.e. *lineal*) and a particular direction (i.e. *inline*), but x' lacks the time linearity of (6).

In our simplest of cosmological models, with x and x' seen as increasing in the direction "r" of spherical coordinates, we will see the equivalence between spatial curvature and grid expansion or compression for a given curvature constant K .

$K > 0 \rightarrow$ Spherical curvature = expansion of grid, $x' > x$

$K = 0 \rightarrow$ Flat space (η_{ab}) = no change in grid, $x' = x$

$K < 0 \rightarrow$ Saddle like curvature = compression of grid,

$x' < x$

Here then our LE equations will define the result of energy transfer into the x' grid in the direction "r" of a non-viscous universe. So any point within r is defined by both the flat metric X and a generally different number x' . Note that for the general case of inline χ axis in any direction relative to its basis vectors, that basis would have to be orthonormal with LE equations defining column vectors and lineal transformation matrices.

C. GR $K > 0$ ($\sigma = 1$)

We have:

$$\varepsilon x = hc / 2\pi.$$

Differentiating with respect to

$$t: x' \left(\frac{d\varepsilon}{dt} \right) + \varepsilon \left(\frac{dx'}{dt} \right) = 0.$$

Having left the linearity of (6), we've attached the prime indicator to x .

$$(hc / 2\pi x) \left(\frac{dx'}{dt} \right) = -x' \left(\frac{d\varepsilon}{dt} \right) \text{ or } \frac{dx'}{dt} = (2\pi x x') \left(-\frac{d\varepsilon}{dt} / hc \right) \quad (15)$$

Implying positive spherical spatial curvature, an increasing $x'(t)$ in conjunction with a decreasing χ E/M $\varepsilon(t)$.

We will look at the GR conservation equations for correlation to basic energy to space relationships. These can be derived from: $\Lambda_b T^{ab} = 0$ where Λ_b is the covariant derivative. For energy conservation, this becomes:

$$0 = \Lambda_a T_t^a = \frac{dT_t^a}{da} + \Gamma_{ab}^a T_t^b - \Gamma_{at}^b T_b^a,$$

where Γ are the Christoffel symbols. We define ρ_χ as energy density equivalent to electromagnetic pressure (P_v) per unit area of T^{ii} . For radiation:

$$\rho_\chi = 3P_v.$$

So: T^{ab} is diagonal as

$$(+\rho, -\rho_r / 3, -\rho_\theta / 3, -\rho_\phi / 3).$$

and so for the Robertson - Walker metric:

$$T^{tt} = \rho \text{ and } T_r^r = T_\theta^\theta = T_\phi^\phi = -\rho_\chi / 3,$$

and its affine corrections are: $\Gamma_{tt}^t = 0$, and

$$\Gamma_{rt}^r = \Gamma_{\theta t}^\theta = \Gamma_{\phi t}^\phi = (1/R) \left(\frac{dR}{dt} \right),$$

the Hubble constant (H). With this, the conservation equation simplifies to:

$$\frac{dT_t^t}{dt} = \frac{d\rho}{dt} = -[(3H)T_t^t - (3H)(-\rho_\chi / 3)] = -3(\rho + \rho_\chi / 3)H$$

Combining energy densities:

$$\left(\frac{dR}{dt} \right) / R = \left(-\frac{d\rho}{dt} \right) / 4\rho \quad (16)$$

Here, fractional energy density loss per unit time translates to a fractional gain in R . Compare this with (15):

$$\frac{dx'}{dt} = (2\pi x x') \left(-\frac{d\varepsilon}{dt} / hc \right).$$

Energy loss per unit time translates to an actual x' gain. But we can change the form of this Length Equivalent equation to match the GR form: From above: $L_\varepsilon = L_x: \varepsilon x = hc / 2\pi$ so (15) becomes:

$$\left(\frac{dx'}{dt} \right) / x' = (2\pi x) \left(-\frac{d\varepsilon}{dt} \right) / (2\pi \varepsilon x) = \left(-\frac{d\varepsilon}{dt} \right) / \varepsilon = \left(-\frac{d\rho}{dt} \right) / \rho \quad (17)$$

The parameters x and x' refer to the same point "R". However, comparing (16) and (17), we see that (17) yields a Hubble constant four times greater than GR for any given $\left(\frac{d\rho}{dt} \right) / \rho$. But this is understandable since x' is an inline lineal parameter representing a transfer of energy *only* into the single dimension of r , while GR is seen to adiabatically translate energy from an expansion in the three dimensions of κ plus a pressure loss equivalent to a fourth dimensional loss of energy related to the red shift of ρ_χ . Note that *why* the field is created is discernable in this GR derivation – expansion requires energy and results in an obvious source energy loss. Specifically, E/M radiation energy loss clearly and directly translates to metric expansion.

For the large scale metric curvature, $K = 0$. This does not result in a transfer function, but rather a boundary condition which leads to the equation:

$$\frac{dR}{dt} = HR = R(8\pi G \rho_m / 3)^{1/2}.$$

There are three $K > 0$ cases to consider ("∞" means proportional):

1. Inflation, ρ is constant, but $\frac{d\varepsilon}{dt} < 0$ (State changes replenish ρ) (Class I)

$$\frac{dR}{dt} \propto R \quad (18)$$

2. Radiation dominated, therefore including red shift and volume related $\frac{d\rho}{dt}$. (Class II)

$$\frac{dR}{dt} \propto R[(1/R)(1/R^3)]^{1/2} = 1/R \Rightarrow R \propto t^{1/2} \quad (19)$$

3. Matter dominated, therefore including only volume related $\kappa \frac{d\rho_m}{dt}$. (Class III)

$$\frac{dR}{dt} \propto R(1/R^3)^{1/2} = (1/R)^{1/2} \Rightarrow R \propto t^{2/3} \quad (20)$$

We can set $x' = R$, and determine (18) to (20) grids. H is constant in the inflation case and we can characterize the grid's consumption of momentum impulse using a half-life constant t_x , that is:

$$(1/2)x'(t + t_x) = x'(t).$$

With \mathcal{L}_a unit length, these Class I equations are satisfied by the expansion:

$$\text{Grid } x' = \mathcal{L} \exp(x / \mathcal{L}),$$

with $x = Ht\mathcal{L}$, and $H = (\text{NatLog } 2) / t_x$. Class II and III expansions are additive to the spacetime extension $x(t=0)$. So:

$$\text{Grid } x' = x(t=0) + \mathcal{L}(x / \mathcal{L})^n, n = 1/2 \text{ or } 2/3, x = ct.$$

D. $GR K < 0$ ($\sigma = 1/2$)

In contrast to section C, in this section expected metric compression defines $d\varepsilon/dt$ whose availability is a given. Gravity's compression of grid requires the use of the reciprocal length replacement $x \rightarrow \mathcal{L}^2 / x'$ in order to accomplish its characterization. In the following, the structural form of (7) is used in (21A) and the derived form in (23). L_m = the length GM / c^2 with G as the Gravitational Constant.

$$hc / \varepsilon = 4\pi(\mathcal{L}^2 / x') \text{ Or: } hcx' = 4\pi\mathcal{L}^2 \varepsilon \quad (21)$$

$$\text{or: } \varepsilon = (h / 4\pi L_m) c L_m x' / \mathcal{L}^2 = m_L c^2 L_m x' / \mathcal{L}^2 = m_L (GM / x) \quad (21A)$$

But going back to (21):

$$(h / 4\pi)(\frac{dx'}{dt}) = (\mathcal{L}^2 / c)(\frac{d\varepsilon}{dt}) \quad (22)$$

Dividing by the derived form of x :

$$(h / 4\pi x)(\frac{dx'}{dt}) = (\mathcal{L}^2 / cx)(\frac{d\varepsilon}{dt}) \text{ so:}$$

$$\mathcal{R} p_v v' = (\mathcal{L}^2 / cx)(\mathcal{R} \frac{d\varepsilon}{dt}) \quad (23)$$

This defines an LE process repeated \mathcal{R} times.

Now the spherically symmetric, time independent metric of vacuum space, influenced by the gravitational field of a centrally located spherical mass, defines the Schwarzschild Solution:

$$ds^2 = (1 - 2L_m / r) dt^2 - dr^2 / (1 - 2L_m / r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2$$

There are no terms explicitly dependent on the time, so the Killing vector $\xi = (1, 0, 0, 0)$ defines the conservation of energy associated with this independence. The conserved energy *per unit mass* is this vector's dot product with the four velocity:

So:

$$\varepsilon = -\xi \bullet \mathbf{u} = -g_{ab} \xi^a u^b = -(c^2 / 2)(1 - 2L_m / r) d\tau / dt$$

(with units added).

Because particle velocities are $\ll c$, $ds = d\tau = d\tau$ and we may write this as: $\varepsilon = c^2 L_m / r$ in which ε now represents the delta energy from the flat basis. Later we'll show that the metric's $r = x = 0$ geometrical singularity is void. Now instead of energy per unit mass we'll use the equally valid mass m_L of (21A), so: $\varepsilon = m_L c^2 L_m / r = m_L GM / r$ which is identical to LE (21A).

That the metric is modified by the forces of both Coriolis and centrifugal source is explicit in the Stress Energy Tensor. In particular, the ($K = 0$) momentum dynamic of T^{ii} can relate centrifugal force to it's ($K < 0$) effect on the metric. The 1918 Thirring - Lense Cartesian (TLC) analysis [1] quantitatively defined this (weak field, slow motion) effect which results from a z axis rotating spherical shell of mass within χ . Here,

$$g_{ab} = \eta_{ab} + h_{ab},$$

with

$$\mathbf{h}_{ab} = (h_{0x}, h_{0y}, 0) = -(4/3)(M / r) | \boldsymbol{\omega} \text{ cross } \mathbf{x} |$$

in which $\boldsymbol{\omega}$ is angular velocity and \mathbf{x} is a vector in the \mathbf{xy}

plane. This is essentially: $h_{0\chi} = -M\mathcal{V}/r$. In the following analysis we add the effective impulse time as seen in the equivalent terms for our rotating shell:

$$\Delta p / \Delta t = Ma = M(d\mathcal{V} / dt) = M(\mathcal{V}\omega) = M\mathcal{V}(\mathcal{V} / r) = M\mathcal{V} / (r / \mathcal{V})$$

Although the (TLC) is a non-intrinsic analysis, we can include the intrinsic T^t by first looking at two related cases. In the case of a spinning bucket of water, the centrifugal force acting on peripheral water is balanced by the pull of lower level water at its center resulting in a concave surface with analog to the curved space of gravitation. The (TLC) analysis is a variant of this. A second consideration is that of a man swinging a rope with a ball at its end so that it goes in a circular fashion. The balance to the centrifugal force on the ball is provided by the man's hand. But if the rope is long enough and the man's hand is used only as a guide for that rope, the rope itself provides the balance if it's allowed to be pulled along (at velocity v) with the ball's increasing diameter of circular movement. The pulled rope has an analog to the compressed metric grid of gravitation.

We define "S" as a scale, and S_l as a point on that scale, measured from the gravitational mass edge and equivalent to $S = ct$ but a constant of time (i.e. a fixed ruler). In (23), the flat metric parameter x is time linear and we know that the gravitational field is static, so: ($K=0$) $|dx/dt| = v$, a static velocity at any specific point measured by S along x . With inline $p_v = M_g v$, we define the active $x = S_l - vt$, S_l and $x > 0$. Although a product of 3 vector χ , we can define the metric mass equivalent M_g as a fixed static inline lineal parameter despite its being subject to variable compression along its length.

Centrifugal force is given by:

$$M\mathcal{V}^2 / r = \Delta p / \Delta t = M\mathcal{V} / (r / \mathcal{V}).$$

From particle spin related angular momentum (see section II D.), we have $iJ = J_{pxs} = im_0 cr_p$. So we reason that $M = (\text{particle})\Sigma m_0$ and the centrifugal force applied to

$$M_g \text{ is } Mc / (r_p / c) = \Delta p / \Delta t.$$

Then:

$$\frac{d\epsilon}{dt} = (-Mc^2) / (r_p / c) = -Mc^3 / r_p.$$

So within the gravitational mass the centrifugal momentum originates as Mc . Equating the transformed $K = 0$ lineal momentums: $Mc / S = M_g v / \mathcal{L}$ establishes the $K < 0$

metric potential well encompassing particles in their formation, as then also in any mass of particles. It is important to note that this $v(S)$ of $K = 0$ is consistent with the

$$(v_p = c, v < c): \theta = \pi / 2, (h / 4\pi x) = p_v$$

correlations of (23) and therefore with the Fig. 1 transfer momentum of particle mc . Here the transformation operator is the conductance of spin related force to the space metric.

Upon reaching balance between centrifugal force and resulting grid compression, $\frac{d\epsilon}{dt} = 0$, source of the field then only being the grid potential gradient, which derives from the energy balance of (23):

$$M_g v v' = -(\mathcal{L}^2 / x) M c^2 / r_p \text{ Or: } \frac{dx'}{dt} = -(\mathcal{L}^2 c^2 / r_p M_g)(M / x)(1 / v), K = 0.$$

and the $K=0$ accelerating field is:

$$\frac{d^2 x'}{dt^2} = (\mathcal{L}^2 c^2 / r_p M_g)(M / x^2)(1 / v) \frac{dx}{dt}, \text{ but } dx/dt = -v.$$

Now then, for $K < 0$ (and $K=0$):

$$\frac{d^2 x'}{dt^2} = -(\mathcal{L}^2 c^2 / r_p M_g)(M / x^2) \quad (24)$$

and the gravitational constant

$$G = (\mathcal{L}^2 c^2 / r_p M_g) \quad (25)$$

For $K < 0$, we now have the passive steady state $x = ct$. So the compression grid supporting (24) is defined by the equation:

$$\text{Grid } x' = L_m \text{ NatLog } (x / \mathcal{L}),$$

with L_m as the length GM / c^2 . The formational $K = 0$ centrifugal force was

$$F_g = M_g \frac{dv'}{dt} = -(Mc^2 / r_p)(\mathcal{L}^2 / x^2)$$

using (24). So in terms relative to acceleration, this radial transmission of defining force was reduced by the factor $TRF = (\mathcal{L}^2 / x^2)$ and the $K < 0$ grid is only a regional static metric curvature. We also see that the $K < 0$ $x'(x)$ minimum grid defines the x value as \mathcal{L} , which is >0 . The grid's blend into flat is seen in its derivative:

$$\left(\frac{dx}{dt} - \frac{dx'}{dt}\right)t = ct(1 - L_m/x)$$

The Einstein equivalence principle that the gravitational field is identical to local acceleration, lets us use (24) to define a flat metric inline lineal tether mass M_{g0} in a field w/o the TRF, as it relates to M_g in that same field but with the TRF. Although neither M_{g0} nor M_g are defined as variable parameters along any length x , for the moment we'll suspend that independence for M_g only and write:

$$(Mc^2/r_p)(\mathcal{L}^2/x^2)(1/M_g) = (Mc^2/r_p)(1)(1/M_{g0})$$

So locally:

$$(M_{g0})(\mathcal{L}^2/x^2) = M_g$$

again reflecting the diminished extent of the $K < 0$ grid compression of x' . So while M_{g0} refers to the entire metric, M_g must refer only to a portion.

IV. COMPARISONS

A. An Estimation of the Gravitational Constant

So M_{g0} is a flat metric parameter encompassing the entire grid in any analysis regardless of K value. This allows us to estimate it, and thereby the constant G defined by (25), by means of a one dimensional model treating the $K > 0$ expansion of the universe as a single event of momentum and energy gain. We'll choose an expansion starting point after the inflationary period so that we can use horizon length to more accurately define the energy's effect on universe size. That is, we'll intentionally exclude the energy associated with the excess of actual over horizon size in order to more closely tie photon temperature decline to the class II & III expansionary momentum (see Fig. 2).

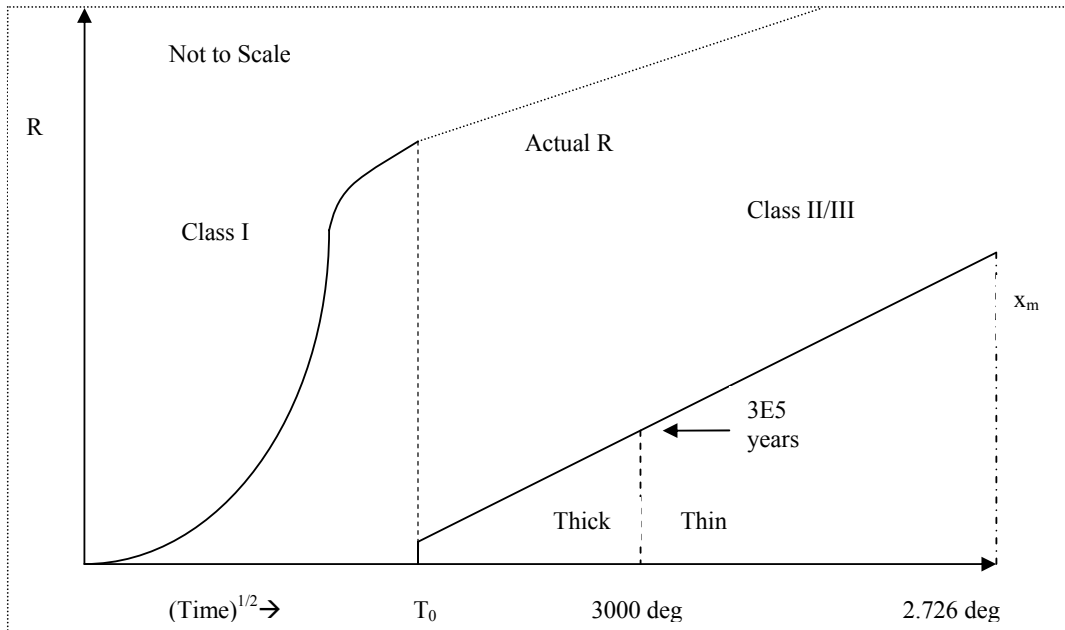


Fig. 2 Idealized Cosmic Expansion

The expansion of the universe has extended the radial distance to x_M . With x_M now a specific radius, the energy imparted is: $\epsilon_g = Fx_M = \eta k_B T_0 V$ where F is the effective average force, V is present (x_M) volume, T_0 is the expended background energy temperature, k_B = the Boltzmann constant, and η is present photon density. The total metric mass M_{g0} has experienced an increase in lineal momentum such that: $F = M_{g0}v/t$, where velocity $v = Hx_M$, and t is the

"Hubble time" age of the universe which we define as $1/H = 15.75E9$ years ($H = 71$ (km/sec)/Mpc). Then:

$$\epsilon = M_{g0}H^2x_M^2 = \eta k_B T_0 V \tag{26}$$

We'll choose slightly minimal H and T_0 values in order to exclude the Class I/II transitional energy from both sides of (26). So:

$$M_{g0} = t^2 \eta k_B T_0 (4\pi/3) x_M \quad (27)$$

Now, since the point of decoupling of matter and energy, ηV has remained essentially constant in an optically thin universe. At that point, the horizon length $x = 300,000$ light years and $T = 3E3$ degrees [2]. T is a photon temperature determined from the cosmic background frequency spectrum ($k_B T = hf$). The red shift factor (R_1 / R_2) leads to the scale factor to photon temperature relation: $R_2 / R_1 = T_1 / T_2$. Presently $T = 2.726$ so $x_M = (3E3/2.726)x = 3.3 E8$ light years.

After the inflationary epoch, at photon temperatures dropping to about $10E12$ degrees, electromagnetism became effective, leptons acquired mass, and the atomic mass formations of the Hadron era began [2]. Since Fig. 1 now has definition, we can calculate our effective expansion starting point from: $k_B T_0 = mc^2$, which for neutron quark confinement yields: $T_0 = 10.9E12$ deg K. We'll use (27) to calculate M_{g0} . Let $S = \text{sec./year} = 3.15E7$.

Presently, $\eta = 4E8$ photons/m³ [2]. Then, in MKS values:

$$M_{g0} = [(15.75E9)S]^2 (4E8)(1.38E-23)(10.9E12)(4\pi/3) * (3.3E8)(3E8)S = 1.942 E59 \text{ kg.}$$

Independent of K, the M_g effective radius of influence is given by:

$$(4\pi/3)x_{ME}^3 = \int [(4\pi x_M^2)(\mathcal{L}^2 / x_M^2) dx_M],$$

where the right hand parentheses are surface area times the TRF. So $x_{ME} = (3\mathcal{L}^2 x_M)^{1/3}$. This integral defines the relation between $r = x_{ME}$ of M_g and $TRF=1, r = x_M$ of M_{g0} , so the ratio between our model's inline lineal parameters is:

$$x_{ME} / x_M = M_g / M_{g0} = (3\mathcal{L}^2 x_M)^{1/3} / x_M = (3\mathcal{L}^2 / x_M^2)^{1/3} = 6.75E-17.$$

So: $M_g = 1.31E43$ kg.

The now specific $r_p = h / 4\pi m_0 c = 1.05E-16$ meters, with $m_0 =$ proton mass, the effective value for an atomic mass. So from (25): $G = (3E8)^2 / (1.05E-16 * 1.31E43) = 6.54E-11$ m³/kg s², compared to the empirical value $6.67E-11$ m³/kg s².

Reasonable values have been assigned to all parameters. Nevertheless, the lack of generally accepted precision regarding these parameters prevents definitive precision in our final result. In particular, the important Hubble Constant has

measured values from 2001 through 2013 of 71.1 ± 1.9 (km/sec)/Mpc. Regardless, these calculations remain a significant indication of the validity of the LE analysis.

Additional comparisons are:

- The radius of the universe is estimated to be $1.8E10$ Light years. x_M above = $3.3E8$ LY.
- Its age is estimated as = $13.7E9$ years. Our $t = H^{-1} = 15.75E9$ years.
- Its total visible mass is $6E51$ kg (+ ten times more as "dark matter"?).
- M_g and $M_{g0} = 1.3E43$ kg and $1.9E59$ kg respectively
- Atomic diameters are about $1E-8$ cm, $2r_p = 3.9E-11$ cm for an electron.
- Nucleus diameters are $1E-13$ to $1E-12$ cm, $2r_p = 2.1E-14$ cm for proton or neutron.

From (26), the energy of grid modification is $\mathcal{E}_g = \eta k_B T_0 (4\pi/3)(x')^3 = 7.7E72$ joules for the expansion to x_M or the grid compression energy in the $K = 0$ balance.

Both the standard GR view and the LE view agree on the static nature of the gravitational field after its formation. But in the LE analysis, due to the dynamic of field formation as having its source in the summed centrifugal forces of its particle content of mass, we are led to the summation:

$$Mc^2 / r_p = \Sigma mc^2 / r$$

over all particles. At the macro level, M equals the total mass and r_p effectively equals that of the proton. But at the single particle level, m is actual and $r_p = h / 4\pi m_0 c$ for the specific particle of mass. So electron to proton gravitational fields would be of ratio $(m_e / m_p)^2$ not (m_e / m_p) . This provides a definitive means of proof of the LE analysis.

Our field equation is applicable along a radius emanating from its center of gravitational mass, effectively beginning at its edge + \mathcal{L} . The particle's formational radius is r_p . As measured from its classical radius, that particle's potential would be at 10% of its ($2r_p$) reference value at about $x_f = (2+10)r_p$. This value is approximately the Compton wavelength ($h / m_0 c$), in agreement with [3]. For fermions, both electromagnetic and Pauli exclusion forces are typically present. So absolute electron gravitational measurement is difficult but, at particle level, an electron vs. proton comparative experiment is believed to be feasible.

In considering whether r_p dependence on atomic composition violates Equivalence Principles, we must distinguish between types of processes we are considering. The acceleration of a test mass (m) toward Earth (M) is defined by (24), and the force of attraction between the test

mass and Earth is m times (24) if we stipulate for both statements that $M \gg m$ to the degree that m does not perceptively modify the gravitational metric potential between them. This force has been said to show a greater degree of attraction if the test mass baryon to total mass ratio is higher [4], but its evidence of this has seemingly been contradicted in other experiments [5]. But note that the r_p dependence of (24) is that of gravitational source M alone and so does not alter the free fall acceleration independence from test mass m , or the inverse square gravitational field relation.

The definition of terms in $F = ma$ differ according to process. A specific applied force (F) applied to an *inertial test mass* defines a resulting acceleration (a). On the other hand, an existing gravitational acceleration defined by (24) applied to a *gravitational test mass* defines an equivalent force (F). But *without* the $M \gg m$ stipulation, this latter equivalent force is smaller due to the effective gravitational mass being less than its inertial value. In this case, a greater baryon to total mass ratio would decrease this difference and might be interpreted as a “new force addition” [6]. The fact is that the electron contribution to the gravitational attractive force of m is very small, on the order of $(m_e / m_p)^2$ versus unity, and therefore difficult to determine in atomic masses.

B. Variability and Dependencies

We first review the essential points of GR’s gravitational field derivation. We relate surface integrals of field to volume integrals of source. In Electrostatics:

$$\oint_S \mathbf{E} \cdot \mathbf{n} da = 4\pi \int_V \rho dv$$

where \mathbf{n} is the volume’s surface normal. By analogy in GR:

$$\oint_S \mathbf{g} \cdot \mathbf{n} da = -4\pi \int_V G\rho_m dv$$

where $\mathbf{g} = d^2x'/dt^2$

In contrast to the GR $K>0$ case, *why* the gravitational field is created is *not* discernable through this equation, and what follows are only changes in representation. Using the divergence theorem:

$$\oint_S \mathbf{g} \cdot \mathbf{n} da = \int_V \nabla \cdot \mathbf{g} dv$$

So:

$$\int_V (\nabla \cdot \mathbf{g} + 4\pi G\rho_m)dv = 0.$$

and:

$$\nabla \cdot \mathbf{g} = -4\pi G\rho_m.$$

But \mathbf{g} is a conserved field so with Φ as its scalar potential,

$$\mathbf{g} = -\nabla\Phi \text{ and } \nabla \cdot (-\nabla\Phi) = -4\pi G\rho_m$$

or:

$$\nabla^2\Phi = 4\pi G\rho_m.$$

Through analogy, with the metric as potential, we use substitutions:

$$(\nabla^2\Phi \rightarrow R_{ab}) \text{ and } (4\pi G\rho_m \rightarrow 8\pi GT^{ab})$$

and to maintain conservation we add the additional term to

$$R^{ab} : 8\pi GT^{ab} = R_{ab} - (1/2)g_{ab}R.$$

This metric curvature is generally “read” with the substitution:

$$(\nabla \rightarrow \Gamma_{\mu}^a) \text{ e.g. } g = \Gamma_{\mu}^a g_{\mu}.$$

As regards field creation, the LE analysis begins at a fundamental level in describing a *discernable* compression of metric by means of the intrinsic momentum mc and suggests dependencies beyond knowing through only the Stress Momentum Tensor’s simple declaration of the existence of momentum transfer. For example:

(1) Particle Constituency r_p variability. Mass/energy ratio in stars also becomes a factor -- With

$$M = M_1 + M_2 \text{ and } M_1 = (\rho / c^2)V, \sigma = 1$$

$$M_2 = (\rho_m)V, \sigma = 1/2,$$

We can derive a composite gravitation. Here there is an *implied* view of the photon as being of κ coincident with its E/M wave of χ .

(2) κ Overlay Field. Mass to Photon generation within stars represents continual κ to χ momentum transfer. If the intrinsic reality extends beyond the particle itself, a concept never proven but suggested by Quantum Entanglement, Bernoulli’s Theorem would suggest the necessity of balance to this κ momentum depletion (with *TRF*). Consider a solid angle of a steradian with origin at a star’s center. With η_s equal to the number of photons per second passing through that angle beyond the star’s outermost photon generational region, the energy flow in χ is $hf_s\eta_s$, and with $t = r/c$, the balancing κ potential would be:

$$-hf_s\eta_s(r/c)(\mathcal{L}^2 / r^2) = -h\eta_s f_s(\mathcal{L}^2 / rc),$$

an additive potential to that driving the gravitation of (24). Now: $\mathbf{g} = -\nabla\Phi$ so, *per unit test mass*:

$$\Delta g = -h\eta_s f_s(\mathcal{L}^2 / r^2 c)$$

which is in the direction consistent with the star luminosity to gravitational field strength correlation which indicates a stronger field than mass equivalency alone indicates [7].

C. Length Equivalence Process Screens

The length equivalent process of $L_E \rightarrow L_x$ requires that a quantum energy packet defines a corresponding quantum length x_0 (Subscript zero denotes quantum values in this section). A process quantum

$$hc / \epsilon_0 = L_E = (2\pi / \sigma)x_0$$

has what could be called a screen of $(2\pi / \sigma)$ defining the energy length to spatial length transformation (or vice versa).

The process rate defines 2 dimensional screens. For cosmic expansion/compression:

For $K > 0$: (15) is:

$$[dx' / dt] = [(2\pi / \sigma)(xx')] [(-d\epsilon / dt) / hc]$$

energy loss --> x' expansion

For $K < 0$: (22) is:

$$[dx' / dt] = [(2\pi / \sigma)(\mathcal{L}^2)] [(d\epsilon / dt) / hc]$$

energy loss--> x' compression

Per unit time, the process rate has these corresponding brackets:

[Expanded or compressed lengths] <--- [screen] <-- [energy quanta].

So: A volume of "N" photons of inverse wavelength L_0^{-1} , over unit time, becomes a length modification of:

$$\Delta x' = [(2\pi / \sigma)a_s] [NL_E^{-1}] \tag{28}$$

with $a_s = (xx')$, $K > 0$, or $a_s = \mathcal{L}^2$, $K < 0$. Process rate translates to force. The difference in a_s shows why gravitational forces are generally significantly less than that of the expansion forces evident in the universe and also why that expansionary rate increases as the scale factor increases, given a constant *mc* transfer rate.

D. Quantum Electrodynamics (QED)

Each fundamental type of Length Equivalent process defines its own applicable screen. In QED, electric potential defines the exchange coupling factor which, with a_s , reflects the strength of a given interaction. Its fundamental Fine Structure Constant (γ) is defined over a catalyst length of x through which the repulsion energy between two electrons is assumed to occur by means of an exchange of a virtual photon

which we here relate to that x length through the applicable screen. In MKS units, with the usual $C_0 = (4\pi k_0)^{-1}$, an electron creates a potential gradient $C_0 e / x$ in which "e" is an electron charge. The mutual electric potential energy of this electron and a second a distance x apart is: $\epsilon = C_0 e^2 / x$. Then

$$L_x = \gamma L_E (\sigma = 1) : 2\pi x = \gamma (hc / \epsilon) = (\gamma hc) / (C_0 e^2 / x)$$

and so:

$$\gamma = 2\pi C_0 e^2 / hc,$$

as defined, and equal to the pure number (137)⁻¹. Note that the so called virtual photon is equivalent to the metric compression $\Delta x'$ as seen in the following:

$$\epsilon = (\gamma hc) / (2\pi x) \tag{29}$$

and so:

$$\Delta \epsilon = (\gamma hc / 2\pi \mathcal{L}^2) \Delta x'.$$

The general and specific views embodied in the PLE here are:

[Intrinsic prop.] <----> [Energy field] <----> [Length Comp.]
[Charge] <-----> [Electric Potential] <----> [Photon Equiv.]

But note that particle/antiparticle annihilation would be expected to result in a residual spin 0 metric potential energy well leading to subsequent particle formation (or its energy equivalent).

Rearranging (29) to match the L.E. process quantum form above:

$$hc / \epsilon_0 = (2\pi / \gamma)x_0,$$

an invariant based relation for this QED process type. And in a parallel to (28):

$$\Delta x' = [(2\pi / \gamma)\mathcal{L}^2] [\Delta \epsilon / hc]$$

As seen in Section III, parameter correlations of (6) still hold although often centered on changes in representation and its interpretation rather than energy driven changes in form. Our final example of length consistency across disciplines is of this former type which is found within the spontaneous symmetry search that seeks the true minimum potential energy (Φ) of a system. With ϕ as the quantum field, we analyze $\partial\Phi / \partial\phi = 0$ points to find these minimums since expansions will converge there. In order to determine whether the fields found have mass, the field terms are often compared to the Klein-Gordon (KG) equation. This equation also derives from

(1) and the Wave Equation transforms (12), as did the Dirac, and thereby brings in the parameter correlations of (6).

Per unit volume, the following terms are in \mathcal{L}^{-2} dimensions:

The KG equation is:

$$(1/c^2) \frac{\partial^2 \phi}{\partial t^2} = \nabla^2 \phi - (m^2 c^2 / \hbar^2) \phi$$

with Lagrangian spatial density (summed over index j):

$$(1/c^2)L = (1/2) \left(\frac{\partial \phi}{\partial x_j} \right)^2 - (1/2) (m^2 c^2 / \hbar^2) \phi^2 .$$

So if L, or its series expansion, contains the term $(1/2)\mu^2\phi^2$ (in which μ is an inverse length), comparison with the KG equation indicates that it describes a mass density of $m = \hbar\mu / c$. But note that this also comes directly from the LE parameter correlation of (7) for this particular process type: $\hbar / mc = (2\pi / \mu)$ per unit volume.

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