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as a

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Fundamental Rest Mass Quanta as
Simple Harmonic Oscillations of
the Spacetime Continuum,
Driven by Cosmic Expansion

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Abstract

In a study of fundamental quantum interactions which models the generation of discrete waveform/particles as a local oscillatory function of an expanding inertial spacetime continuum, beta decay constitutes the propagation of a portion of the energy and power of the characteristic fundamental oscillation beyond its boundaries as the discrete waveform of the electron,. The expansion of spacetime results in a drop in its linear inertial density over time that is equal to a drop in its mechanical impedance over distance, where time and distance are related by the speed of wave propagation. This drop produces a change in wave force at the boundary of the fundamental, resulting in a wave transmission recognized as the electron and concomitantly in a frequency change for the fundamental from that of the neutron to that of the proton. The value of this change in force can be quantified as the rest mass energy of the electron divided by its rest angular wavelength, i.e. its reduced Compton wavelength, and the corresponding rate of change in the linear inertial density/mechanical impedance is shown to be equal to the Hubble rate, thereby coupling beta decay to the cosmic expansion rate which is shown to be exponential. The derivative of the fundamental oscillation wave force with respect to the expansion stress is shown to be the basis of quantum gravity. The Planck scale is shown to be a differential scale, and implications for the cosmic age are investigated.

Exposition

We start our discussion with the basic mass-energy equivalence equation of relativity, which is stated in an unconventional manner, in order to isolate the mass component on the left side, as

$$m = \frac{1}{c^2} E \,, \tag{0.1}$$

where c is the presumably invariant speed of light in vacuo as

$$c = \frac{dx}{dt} \tag{0.2}$$

It is important to state that while mass is customarily treated as a bulk or volumetric density property of matter, it is phenomenologically an expression of a linear resistance to a change in momentum of a body, particle or wave mechanism. It therefore has the possibility of vector field representation. By extension, it can have tensor field representation, since a massive particle effectively redirects motion from a straight linear path, i.e. it curves that path for a point particle and can diffuse or concentrate wave motion. Since such tensor field can be decomposed into various vector components, our primary treatment of mass will be as the displacement integral of linear inertial density.

The statement for the inherent or spin energy, E_q, of a quantum, q, is Planck's quantum of action, $\hbar$, times its angular frequency, ω_q, or

$$E_q = \hbar\omega_q \,. \tag{0.3}$$

Here the angular frequency is the speed of light divided by the quantum's angular wavelength, i.e. its reduced Compton wavelength, $\bar{\lambda}_{C,q}$, as

$$\omega_q = \frac{c}{\bar{\lambda}_{C,q}} = \frac{2\pi c}{\lambda_{C,q}} \,. \tag{0.4}$$

Yet again it is the speed of light times the angular wave number, κ_q, where the angular wave number is the inverse angular wavelength,

$$\omega_q = c\kappa_q = c\frac{1}{\bar{\lambda}_{C,q}} \,. \tag{0.5}$$

Substituting (0.3) into (0.1), we see that the mass of the quantum is equal to the quotient of the invariants $\hbar$ and c times the wave number

$$m_q = \frac{1}{c^2}\hbar\omega_q = \frac{\hbar}{c}\kappa_q \,, \tag{0.6}$$

where $\hbar$ is the value of the invariant action, S, of the oscillation.

With respect to this quotient, while the action, S, is generally presented as the time integral of the Hamiltonian or total energy of the quantum, it can also be cast as the displacement integral of an impulse, J, over the distance, $\boldsymbol{x_f} = \boldsymbol{x}_f - \boldsymbol{x}_i$, of an interaction of particles and/or fields, according to Maupertuis' principle as

$$S = \int_{x_i}^{x_f} \boldsymbol{J}(x)\cdot d\,\boldsymbol{x} = t_f \int_{x_i}^{x_f} \boldsymbol{F}(x)\cdot d\,\boldsymbol{x} = \frac{2m}{t_f}\int_{x_i}^{x_f} \boldsymbol{x}_f \cdot d\,\boldsymbol{x} = m\,\boldsymbol{x}_f \cdot \frac{\boldsymbol{x}_f}{t_f} \tag{0.7}$$

where the impulse is the time integral of the force, $\boldsymbol{F}$, of the interaction

$$\boldsymbol{J} = \int_{t_i}^{t_f} \boldsymbol{F}(t)\; dt = \left(\frac{2m\,\boldsymbol{x}_f}{t_f^2}\right) t_f = \Delta P \tag{0.8}$$

so that the angular momentum quantum equivalent is the invariant

$$S = \hbar \,. \tag{0.9}$$

Analogously for the time integral over the same impulse we have the value, ת, (tav), which is of units mass-displacement,

$$\text{ת} = \int_{t_i}^{t_f} \boldsymbol{J}(t)\; dt = \int_{t_i}^{t_f} \boldsymbol{F}(t)\; t_f\;\; dt = \tfrac{1}{2}\boldsymbol{F}\, t_f^2 = m\,\boldsymbol{x}_f \tag{0.10}$$

so that if the velocity in the last term of (0.7) is the speed of light, then ת is also a fundamental invariant and the last term of that equation can be rearranged according to the relationship

$$\sqcap = \frac{\hbar}{c} \tag{0.11}$$

and (0.6) is

$$m_q = \sqcap \kappa_q \,. \tag{0.12}$$

Therefore, we can rephrase (0.1) for a quantum rest mass particle as

$$\sqcap \kappa_q = \frac{1}{c^2} \sqcap c \omega_q \,. \tag{0.13}$$

The economy of this approach is that the various dynamic properties of the particle can be expressed in terms of the powers of a characteristic frequency and wave number, a decidedly wave representation, as functions of a time independent base. Using the Euler convention, in which each order of differentiation for displacement and time is effected by multiplying by the orthogonal sense, *i*, times the angular wave number and frequencies respectively and each order of integration, by dividing by those parameters, substituting (0.5) with some rearrangement, differentiates (0.13) and gives

$$\sqcap \kappa_q^2 = \frac{1}{c^2} \sqcap \omega_q^2 \,. \tag{0.14}$$

Since

$$-\kappa^2 = \left(i\kappa\right)^2 = \frac{\partial^2 \theta}{\partial x^2} \tag{0.15}$$

and

$$-\omega^2 = \left(i\omega\right)^2 = \frac{\partial^2 \theta}{\partial t^2} \tag{0.16}$$

and the senses on each side cancel, this effectively makes a second order derivative with respect to displacement on the left and time on the right. This is equivalent to the familiar linear wave equation for an ideal string under tension, with the inclusion of the inertial constant to each side of the equation as

$$\sqcap \frac{\partial^2 \theta}{\partial x^2} = \frac{1}{c^2} \sqcap \frac{\partial^2 \theta}{\partial t^2} \,. \tag{0.17}$$

Dimensionally, the left term in (0.14) and in (0.17) is a linear inertial density, λ_0, and the right term, exclusive of the inverse wave speed squared, is a force, τ_0, in this case the tension force in a wave bearing medium or

$$\lambda_0 \equiv \sqcap \kappa_0^2 = \frac{1}{c^2} \sqcap \omega_0^2 \equiv \frac{1}{c^2} \tau_0 \tag{0.18}$$

Here the subscript noughts indicate the selected values as fundamental characteristics of that medium. Hence, ω_0, represents a fundamental or resonant frequency of the medium and κ_0, the corresponding wave number, and the fundamental localized oscillation or rest mass quantum, if any, corresponding to that resonant condition would be represented as

$$m_0 = \sqcap \kappa_0 = \frac{1}{c^2} \sqcap c \omega_0 = \frac{1}{c^2} E_0 \,. \tag{0.19}$$

Thus the quantum application of the central equation of relativity is shown as the expression of an underlying classical wave ontology. For this to viable, we must assume some wave mechanism for a three spatial dimensional wave that maintains a wave boundary or system of nodes over time to prevent dispersion of the wave energy. It is the nodal structure of such a model that is recognized as the quark structure of the standard model, that is quark equals node/anti-node. Such nodes and anti-nodes are inseparable, necessarily confined to the same wavelength, as described by the concept of asymptotic freedom of that model.

With such assumption, the inertial density for such fundamental quantum remains stable over time, that is the inertial density of the wave bearing medium within the boundaries of the quantum waveform remains constant, here expressed as the ratio of mass to wavelength,

$$\lambda_0 = \frac{\hbar \kappa_0}{\bar{\lambda}_{C,0}}, \tag{0.20}$$

with the corresponding related wave force expressed as

$$\tau_0 = \hbar \omega_0^2 . \tag{0.21}$$

This is so even within the context of an expanding wave bearing continuum, i.e. an expanding spacetime.

Though the density in (0.20) expressed as mass per angular wave length remains constant, that (1) density and (2) the corresponding angular wave number expressed in terms of some external length standard or rod, x_0, i.e. a meter or some other arbitrary measure, would be expected to decrease and increase respectively according to the expansion rate of spacetime. Thus, in a condition in which time t_2 follows time t_1 and $x_{02} > x_{01}$, the fundamental inertial density of spacetime decreases over time

$$\lambda_{01} = \frac{\hbar \kappa_{01}}{x_{01}} > \frac{\hbar \kappa_{01}}{x_{02}} = \lambda_{02} \tag{0.22}$$

while the angular wave number, expressed in terms of some length standard that is current and held to be invariant over time increases non-linearly,

$$\frac{\lambda_{01}}{\hbar \kappa_{01}} = \frac{\theta_{01}}{x_0} < \frac{\theta_{02}}{x_0} = \frac{\lambda_{02}}{\hbar \kappa_{02}} . \tag{0.23}$$

This change in the wave number with respect to a standard is equal to the difference in the frequency squared divided by the square of the wave speed, relating this expression to (0.18)

$$\frac{\kappa_{02} - \kappa_{01}}{x_0} = \frac{\Delta \kappa_0}{x_0} = \frac{\Delta^2 \theta}{x_0^2} = \frac{\Delta^2 \theta}{c^2 t_0^2} = \frac{\Delta \omega_0^2}{c^2} . \tag{0.24}$$

Note that the second order change of the wave phase in the middle term indicates an accelerating change in phase count arising from a linear change in spatial extension which can be represented as a vector field. The wave number change in this context represents a strain in the spacetime continuum, ε, outside the boundary of the oscillation, assuming a constant mass/energy density within the boundary of the wave. The ratio of this change with the square of the standard, when interpreted as a cross-section, indicates a related stress component which can be represented by a dyadic or tensor field.

In the next to last term, the same change is shown to be an accelerating change. Note that the speed of light squared simply normalizes the time and displacement standards, thus in a natural system equals 1. The acceleration with respect to spacetime expansion is linear, that is straight line, but with respect to a rest mass oscillation it represents an angular acceleration, i.e. a change in angular velocity and frequency, thus spin energy, and by virtue of (0.1) and (0.19), an increase in mass and inertial density with respect to an assumed to be invariant standard, x_0.

As a spatial strain, ε_x, with respect to the left hand side of (0.18) we have,

$$\Delta\lambda_{01} = \frac{\Delta x_0^2}{x_0^2}\lambda_{01} = \varepsilon_x \lambda_{01} \tag{0.25}$$

and as an acceleration or time strain, ε_t, with respect to the right hand side we have,

$$\frac{\Delta\tau_{01}}{c^2} = \frac{\Delta t_0^2}{t_0^2}\frac{\tau_{01}}{c^2} = \varepsilon_t \frac{\tau_{01}}{c^2}. \tag{0.26}$$

The change of λ_0 due to the spatial strain and the change of τ_0 due to the time strain reflects the expansion rate of spacetime, X_e, which we might surmise that it is equal to the Hubble rate, H_0, or

$$X_e = H_0. \tag{0.27}$$

This expansion rate equals the decrease in the spacetime inertial density (outside any wave boundaries) with respect to time and the decrease in the mechanical impedance, Z_0, of that spacetime with respect to displacement as

$$X_e = \frac{d\lambda_0}{dt} = d\left(\frac{\tau_0}{c}\right)\frac{1}{cdt} = \frac{dZ_0}{dx} \tag{0.28}$$

where the impedance is the ratio of the wave force to the wave speed of

$$Z_0 = \frac{\tau_0}{c}. \tag{0.29}$$

In terms of the inertial constant, we have the expansion rate expressed in terms of a space strain and time on the left and in terms of a time strain and space on the right,

$$X_e\left(\varepsilon_x, t\right) \equiv \daleth\frac{d\kappa_0^2}{dt} = \frac{1}{c^2}\frac{\daleth d\omega_0^2}{dt} = \frac{\daleth d\omega_0^2}{cdx} = \frac{\daleth d\kappa_0 d\omega_0}{dx} \equiv X_e\left(\varepsilon_t, x\right). \tag{0.30}$$

To check this conjecture concerning the Hubble rate, we need some gauge of the change in wave force, $d\tau_0$, where the fundamental wave force, τ_0, must of necessity be equal to the stress force across the spacetime fabric, since it is the localized oscillation of this stress that is an individual fundamental quantum. We might look, therefore, to the neutron as a fundamental oscillation of the tensor field (or three dimensional spinor field) of spacetime given by $m_0c^2 = \hbar\omega_0$, and to the phenomena of beta decay as an instance of transmission of a portion of that oscillation's power and energy beyond the neutron wave boundary in response to a drop in the inertial density and mechanical impedance of spacetime with cosmic expansion. The wave force of the electron, τ_e, then is a function of the change in impedance times an invariant wave speed as

$$\tau_e = \sqcap\omega_e^2 = \sqcap d\omega_0^2 = d\tau_0 = cdZ_0 \tag{0.31}$$

and we would expect the expansion rate to equal

$$X_e\left(\varepsilon_t, x\right) = \frac{dZ_0}{dx} = \frac{dZ_0}{cdt} = \frac{1}{c^2}\frac{d\tau_0}{dt} = \frac{\sqcap\omega_e^2}{c^2}\frac{1}{dt}. \tag{0.32}$$

Using the CODATA [1] values for electron mass and its reduced Compton wavelength, and $\hbar$ and c to get the inertial constant, gives a value for the differentiation of the electron spin energy with respect to its angular wavelength of

$$d\tau_0 = E_e\kappa_e = \frac{m_e c^2}{\lambdabar_{C,e}} = \sqcap\omega_e^2 = 0.2120136...N, \tag{0.33}$$

and an expansion rate, using (0.25), of

$$X_e\left(\varepsilon_x, t\right) = \frac{d\tau_0}{c^2}\frac{1}{dt} = \lambda_0\varepsilon_x\frac{1}{dt} = 2.35896879...x10^{-18}\,\Delta m/m/s. \tag{0.34}$$

This number, the rate of change in a meter unit of spacetime, per second, times the number of meters per <u>m</u>ega<u>p</u>ar<u>s</u>ec, gives the expansion rate in terms of the Hubble constant or

$$H_0 = X_e\left(3.08572x10^{22}\,m/mps\right) = 72,791.17172\,m/mps/s \tag{0.35}$$

A study by Ron Eastman, Brian Schmidt and Robert Kirshner in 1994 and quoted in Kirshner's recent book, <u>The Extravagant Universe</u>, found an H_0 = 73 km/s/mps +/- 8km [2] and an article in the *Astrophysical Journal*, 533, 47 - 72, (2001) by Freedman, W. L. et al. gives the final results from the Hubble space telescope key project to measure the Hubble constant as H_0 = 72 km/s/mps [3]. There are $3.08572x10^{22}$ meters per megaparsec.

Note that the conventional measure of the Hubble rate is in terms of a velocity per scale of distance or per megaparsec, and carries the connotation of an explosion or movement of celestial bodies apart from each other, whereas this interpretation, which is mathematically equivalent, is of an expansion or strain of spacetime itself with a concomitant change in any distance metric which is generally held to remain fixed.

We would now like to see if the derivation of gravity can be modeled as a function of this same expansion. We would anticipate the presence of a tensor field at the boundary of the fundamental oscillation given above, in response to the expansion of spacetime. While that boundary can be visualized as generally spherical, we can analytically superimpose a concentric unit cube within that boundary with no loss of rigor. If that cube represents the total stress in a 3 dimensional space which is a component of a 4 dimensional expanding spacetime, the 6 centripetal tension force vectors, τ_0, acting on that cube in response to a change in the 4-stress of spacetime, T_0, operating through one of the diagonals,[1] gives the following relationship,

$$T_0 = 6\sqrt{3}\frac{\tau_0}{A_0} = 6\sqrt{3} f_0 = \gamma_3 f_0 \tag{0.36}$$

where f_0 is a unit tension stress, γ_3 is the factor relating the 4-stress and 3-tension stress components, and A_0 is a unit cross-sectional area, where

$$A_0 = ƛ_0^2 = ƛ_{C,n}^2 . \tag{0.37}$$

With some rearrangement of (0.36), we have

$$\gamma_3^{-1} T_0 = \frac{\tau_0}{A_0}, \tag{0.38}$$

with the total derivative for an invariant T_0 being

$$\gamma_3^{-1} dT_0 = \frac{\partial T_0}{\partial \tau_0} d\tau_0 - \frac{\partial T_0}{\partial A_0} dA_0 = \frac{1}{A_0} d\tau_0 - \frac{\tau_0}{A_0^2} dA_0 = 0 . \tag{0.39}$$

Separating and inverting this function we have the two following differential equations, the first of which is straight forward,

$$d\tau_0 = \gamma_3^{-1} A_0 dT_0 \equiv \left(\gamma_3^{-1}\kappa_0^{-2} dT_0\right) \tag{0.40}$$

and the second one expressing various parsings of interest, especially those in which the tension stress force is removed from the equation,

$$\begin{aligned} dA_0 &= -\gamma_3^{-1}\frac{A_0^2}{\tau_0} dT_0 = -\frac{\tau_0}{\gamma_3^{-1} T_0^2} dT_0 = -\frac{A_0}{T_0} dT_0 \\ &= -A_0 d\ln T_0 \equiv \left(-\kappa_0^{-2} d\ln T_0\right) \end{aligned} \tag{0.41}$$

Equation (0.40) represents the centripetally directed tension force at the boundary of the quantum oscillation resulting from the expansion stress. It is the force of quantum gravity or a gravitational quantum, dG_0, and judging from our earlier comment concerning the neutron as the fundamental or resonant oscillation, should be equal to the neutron reduced Compton wavelength squared divided by $6\sqrt{3}$, or

$$dG_0 = \gamma_3^{-1} A_0 dT_0 = \gamma_3^{-1} ƛ_{C,n}^2 dT = \gamma_3^{-1} T_0 dA = 4.244...x10^{-33}\, N . \tag{0.42}$$

A quantum formulation for Newton's Gravitational Law is

$$F_{m_1 m_2 k} = n_{M1} n_{M2} n_{ƛ}^{-2} dG_0 \tag{0.43}$$

where n_{Ma} is the number of fundamental unit masses in each of two aggregate bodies, 1 and 2, and $n_{ƛ}$ is the distance of separation of the centers of the two bodies in multiples of

[1] Note that it is the vertices of an n dimensional figure that defines its position and extent, so that exclusive of rotation, extension of any two cubic vertices along a common diagonal suffices to redefine the cube.

the fundamental unit value of $\lambdabar_0$. An aggregate mass is the product of the number of quanta in that aggregate times the fundamental unit of mass, m_0, or with rearrangement

$$n_{Ma} = \frac{M_a}{m_0} \tag{0.44}$$

and the separation of the two bodies of mass is the product of the number of unit lengths in that separation and the fundamental quantum unit length, or

$$n_r = \frac{R}{\lambdabar_0}. \tag{0.45}$$

Substituting equation (0.44) and equation (0.45) into equation (0.43), gives

$$F_{M_1M_2k} = \frac{M_1M_2}{R^2}\left(\frac{\lambdabar_0^2}{m_0^2}dG_0\right) \tag{0.46}$$

Assuming that the gravitational quantum is equivalent to the formulation from equation (0.40) and substituting from its middle term, gives the following, in which the stress differential is normalized in its relationship to dG_0 as $dT_0 = 1$,

$$F_{M_1M_2k} = \frac{M_1M_2}{R^2}\left(\gamma_3^{-1}\frac{\lambdabar_0^4}{m_0^2}dT_0\right) = \frac{M_1M_2}{R^2}G_N. \tag{0.47}$$

In keeping with earlier development, we restate the relationship between the above postulated quantum mass, m_0, and length, $\lambdabar_0$, the latter stated as the reduced Compton wavelength,

$$m_0 = \frac{\hbar}{c}\lambdabar_0^{-1} = \frac{\daleth}{\lambdabar_0}. \tag{0.48}$$

We substitute from equation (0.48) into the bracketed term of equations (0.46) and (0.47), and get

$$G_N = \frac{\lambdabar_0^4}{\daleth^2}dG_0 = \gamma_3^{-1}\frac{\lambdabar_0^6}{\daleth^2}dT_0 = 6.673198...x10^{-11}\,m^3/kg-s^2\,, \tag{0.49}$$

where the CODATA value is given as $6.6742(10)x10^{-11}$ showing that Newton's constant is not a free parameter in this model.

Since (0.21) is the wave force of the fundamental oscillation where

$$\tau_0 = \daleth\omega_0^2 = m_n c^2 \lambdabar_{C,n}^{-1} \tag{0.50}$$

we can solve for the second half of the above total derivative at (0.41) for the change in unit cross-section and find that it is equal to the Planck area,

$$\begin{aligned} d\mathrm{A}_0 &= -\gamma_3^{-1}\frac{\mathrm{A}_0^2}{\tau_0}dT_0 = -\frac{\mathrm{A}_0}{T_0}dT_0 = -\mathrm{A}_0 d\ln T_0 \equiv \left(-\kappa_0^{-2}d\ln T_0\right) \\ &= -\gamma_3 T_0^{-1}dG_0 = -2.6116...x10^{-70}m^2 = -\mathrm{A}_{Pl} \end{aligned} \tag{0.51}$$

This indicates two important developments, first the logarithmic nature of the change in the expansion stress, therefore of the cross-section, and second the fact that the Planck scale represents a differential area and not a measure of an absolute scale.

With this development, we can get the spin energy density/stress, T_0, of the neutron, as

$$T_0 = \gamma_3 \frac{dG_0}{d\mathrm{A}_0} = \frac{\mathrm{A}_0}{d\mathrm{A}_0} dT_0 \tag{0.52}$$

and finally

$$T_0 = \gamma_3 \frac{E_0}{ƛ_0^3} = \gamma_3 \frac{m_0 c^2}{ƛ_0^3} = \gamma_3 \frac{\hbar \omega_0^2}{ƛ_0^2} = \gamma_3 \frac{\tau_0}{\mathrm{A}_0} = 1.6887...x10^{38}\, N/m^2 . \tag{0.53}$$

Note that the last term of (0.53), with substitution from (0.42), rearrangement and inversion gives the inverse ratio of the wave force which is the basis of the strong force, and its differential, which is the basis of gravity, as a pure number

$$d\ln T_0 = \frac{dT_0}{T_0} = \frac{dG_0}{\tau_0} = 5.9215...x10^{-39} . \tag{0.54}$$

With respect to the Planck area, substitution from the above development gives its familiar representation

$$\begin{aligned} d\mathrm{A}_0 &= -\gamma_3 \frac{\hbar \omega_0^2}{\gamma_3^2 \lambda_0^{\,2} c^4 \mathrm{A}_0^{-2}} dT_0 = \left(-\gamma_3^{-1} \frac{\mathrm{A}_0}{\lambda_0^{\,2}} dT_0 \right) \frac{\hbar \omega_0^2 ƛ_0^2}{c^4} \\ &= -G_N \frac{\hbar c^2}{c^4} = -G_N \frac{\hbar}{c^3} \end{aligned} \tag{0.55}$$

Taking the square root of (0.55), we can show the Planck length as a differential length value, as

$$dƛ_0 = \left| d\mathrm{A}_0 \right|^{\frac{1}{2}} = ƛ_0 \sqrt{d\ln T_0} = l_{Pl} = 1.6161...x10^{-35}\, m . \tag{0.56}$$

Cosmological Implications

Basic to our discussion is the assumption that spacetime is expanding relative to our local frame of reference. This means that over time a local fixed unit length standard becomes an ever decreasing proportion of some linear measure of the cosmic extent. If we project backwards in time, we can assume that at some point that measure of cosmic extent was equal to the current local length standard or unity.

The current concept of a big bang start of cosmic spacetime expansion implies an initial condition of maximum inertial density, possibly infinite, which decreases with the expansion of space from an extremely small volume, possibly zero, i.e. from a singularity. Instead of emergence from a singularity, the space component of spacetime can be modeled as a boundary on the next higher dimensional manifold, itself under expansion, analogous to a circle drawn on the surface of an expanding balloon. Alternately, we might imagine a spherical balloon of fixed size with a circular wave emanating from one spot, widening in diameter as it approaches an equator before shrinking again as it nears the antipode. An analogous inertial spacetime oscillates on a cosmic scale between a maximum density and rarification, between a maximum compression and maximum extension. The fact that the expansion appears to be accelerating indicates that the expansion rate is best understood exponentially. We can then take the condition of maximum density as unity instead of as a singularity, and gauge any expansion with respect to that unity for A_0 and $\lambdabar_0$ as inversely related to the associated increase in stress T_0 due to expansion according to equations (0.51) and (0.56).

The current expansion factor, $\kappa_{\exp}$, the ratio of the current fundamental neutron scale to the Planck length, is equal to the inverse square root of the differential natural log of the expansion stress,

$$\kappa_{\exp} = \frac{\lambdabar_0}{d\lambdabar_0} = \sqrt{d\ln T_0}^{-1} = 1.29952...x10^{19} \quad (1.1)$$

As this expansion is at an exponential rate, in terms of doubling from an initial condition of maximum density equal to the linear inertial density of the neutron scale, λ_0, cosmic expansion, C_x, is

$$C_x = \ln 2\left(\kappa_{\exp}\right) = 9.00764...x10^{18} \text{ light seconds } = 2.8544...x10^{11} \text{ light years} \quad (1.2)$$

Note that the last term would indicate, if interpreted as a straight line increase at the speed of light, an expansion age of the cosmos of 285.44 billion years.

As developed above, the expansion rate is

$$X_e = H_0 = 2.35896...x10^{-18}\,\Delta/\text{m s} \quad (1.3)$$

If we interpret this as a straight line expansion rate from an initial singularity, inverting would give the age of the cosmos in current units as

$$X_e^{-1} = 13.433 \text{ billion years} \quad (1.4)$$

However, if the Hubble rate is exponential or compounding, the following gives the Hubble time, τ_H, as a time in current units for a doubling in spatial linear extent, or

$$\tau_H = \ln 2 X_e^{-1} = 9.311 \text{ billion years} \quad (1.5)$$

The product of the expansion rate and the expansion factor is the number of doublings or

$$X_e \kappa_{\exp} = 30.655... \text{ doublings } = 285.43 \text{ billion years} \quad (1.6)$$

Following this logic, if the wavelength of the cosmic microwave background is approximately 3.3*mm* and indicates an expansion along with spacetime from a primal epoch of beta decay as gauged by the electron Compton wavelength, $\lambda_{C,e}$, dividing the natural log of such expansion by the natural log of 2 gives the number of doublings based on those parameters or

$$\ln\left(\frac{.0033}{\lambda_{C,e}}\right)\left(\ln 2\right)^{-1} = \frac{\ln 1.360...x10^9}{\ln 2} = 30.34... \text{ doublings } = 282.5 \text{ billion years} \quad (1.7)$$

in very close agreement with equation (1.6).

This observation indicates that $\lambdabar_0$, related to the reduced electron Compton wavelength, $\lambdabar_{C,e}$, by the ratio 0.000543…, remains stable as spacetime and the CMB expands and indicates that such quanta did not have a geometry of the Planck scale at an early epoch, which instead of starting from a singularity with all the physical dilemma that entails, started expansion from a maximum finite density. The Planck length, then, is the ratio of the neutron reduced Compton and the cosmic extension from an initial compact condition of maximum density, and continues to decrease with expansion.

Alternately, but not contradictory, if we think of the cosmic extent of 3-space as a fixed unit, what appears mathematically from a local perspective as expansion is from the universal perspective a process of regional and local concentration of inertial density. With respect to our analogy of the fixed balloon above, the linear (and area) density of the balloon in the absence of a wave is invariant over the surface of the sphere, but a wave moving over its surface creates a density differential at the wave front, increasing as it approaches a pole and anti-pole and decreasing as it approaches an equator.

Citations

[1] National Institute of Standards and Technology, These are the **2002 CODATA recommended values** of the fundamental physical constants, the latest CODATA values available. For additional information, including the bibliographic citation of the source article for the 1998 CODATA values, see P. J. Mohr and B. N. Taylor, "The 2002 CODATA Recommended Values of the Fundamental Physical Constants, Web Version 4.0," available at physics.nist.gov/constants. This database was developed by J. Baker, M. Douma, and S. Kotochigova. (National Institute of Standards and Technology, Gaithersburg, MD 20899, 9 December 2003).

[2] a study by R. Eastman, B. Schmidt and R. P. Kirshner in 1994 quoted in The Extravagant Universe, R. P. Kirshner, Princeton University Press, Princeton, NJ (2002).

[3] W. L. Freedman, et al, Astrophysical Journal, 533, 47-72 (2001).

General References

The Feynman Lectures on Physics :Commemorative Issue, Feynman, Leighton, Sands, Volume I, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts 1963.

Fundamentals of Physics, Fifth Edition, Halliday, Resnick, Walker, John Wiley & Sons, Inc. New York, 1997.

Mathematical Methods for Physicists, Fifth Edition, Arfken and Weber, Harcourt Academic Press, New York, 2001.

Physics of Waves, Elmore and Heald, Dover Publications, Inc., New York, 1985.
This was the primary source for wave, elasticity and tensor equations.

Visual Complex Analysis, Needham, Oxford University Press, Oxford, 1997.