

Some Thoughts on the Natural Scaling of Physical Phenomena

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Current attempts at a unification of theoretical physics rest in part on the dimensional analysis of Newton's gravitational constant, G_N , by Max Planck and its applicability at a theoretically smallest limiting scale, where we have displacement, r_0 , mass, m_0 , and time, t_0 , and τ_0 is a fundamental unit of a presumed body force, the subscript naught indicating a fundamental unit, i.e. equal to one in some natural scale:

$$G_N = \frac{r_0^2}{m_0^2}(\tau_0) = \frac{r_0^2}{m_0^2} \left(m_0 \frac{r_0}{t_0^2} \right) = \frac{r_0^3}{m_0 t_0^2} \quad (1.1)$$

It bears emphasizing that if we are to anticipate a quantum theory of gravity, then the function of Newton's constant in the context of Newton's gravitational law is to produce the force between two massive bodies by converting their respective masses and the distance of separation of their centers of mass to some fundamental units of each property and multiplying this by a fundamental unit or quantum of force as in the second term above.

Since c , the speed of light, and $\hbar$, Planck's quantum of action, are assumed to be invariant at any scale, their expression in terms of the units of some as yet undefined natural length scale, r_0 , commensurate with τ_0 is

$$c = \frac{r_0}{t_0} \quad \therefore t_0 = \frac{r_0}{c}, \text{ and} \quad (1.2)$$

$$\hbar = \frac{m_0 r_0^2}{t_0} \quad \therefore m_0 = \frac{\hbar}{c r_0} \quad (1.3)$$

Substituting these conclusions for time and mass back into (1.1), and assuming the same natural units for the length scale, we have the following expression for G_N ,

$$G_N = \frac{r_0^3}{m_0 t_0^2} = \frac{c^3}{\hbar} r_0^2 = \frac{c^3}{\hbar} A_0 \quad (1.4)$$

Since G_N , c , and $\hbar$ have reasonably well determined values, we can rearrange and solve to evaluate the Planck scale, here in SI units, via the Planck area, A_P ,

$$A_0 = r_0^2 = \frac{G_N \hbar}{c^3} = 2.6116... \times 10^{-70} \text{ meter}^2 = A_P \quad (1.5)$$

and its square root, the Planck length, l_P , where

$$r_0 = 1.616... \times 10^{-35} \text{ meter} = l_P. \quad (1.6)$$

The remainder of the Planck scale values are easily determined using (1.2) and (1.3). A_P is generally deemed to be a low end cutoff scale for definable physical phenomena, but this shows that if it had any other value, lesser or greater, the invariance of one or more of the three familiar constants would be challenged.

In (1.1), τ_0 is presumed to be a body force, of units mass times acceleration, but in keeping with the analysis of general relativity, it can, and in this writers opinion should,

be considered a surface or stress force, or the product of a fundamental cross sectional area, A_0 , and a fundamental unit of tension stress, f_0 , as

$$\tau_0 = A_0 f_0. \quad (1.7)$$

A differential change in that force as a function of a change in the tension stress is then

$$d\tau_0 = A_0 df_0, \quad (1.8)$$

a change in the cross section being,

$$dA_0 = -\frac{\tau_0}{f_0^2} df_0 = -A_0 \frac{df_0}{f_0} = -A_0 d \ln f \quad (1.9)$$

With respect to an underlying inertial density/total stress, T_0 , commensurate with such a tension stress, we have the relationship to the sum of the tension stresses on a fundamental cubic unit,

$$T_0 = \sum_{i=1}^6 \frac{\tau_0 r_{0i}}{A_0 r_{0i}} = \sum_{i=1}^6 f_{0i} = |6f_0|. \quad (1.10)$$

A differential change in tension stress, df_0 , resulting from an isotropic change of the inertial density, dT_0 , due to a cosmic expansion will operate orthogonally to any given 3 axes of the cube, or by a factor of $\sqrt{3}$, so that

$$dT_0 = 6\sqrt{3}df_0, \text{ and} \quad (1.11)$$

$$d\tau_0 = \frac{1}{6\sqrt{3}} A_0 dT_0 = \frac{1}{\gamma_3} A_0 dT_0 \quad (1.12)$$

and instead of (1.1), recognizing $d\tau_0$ as a quantum differential, we have

$$G_N = \frac{r_0^2}{m_0^2} (d\tau_0) = \frac{r_0^4}{\hbar^2/c^2} \left(\frac{r_0^2 dT_0}{6\sqrt{3}} \right) = \frac{c^2}{\gamma_3 \hbar^2} r_0^6 dT_0. \quad (1.13)$$

Since with respect to (1.12) and (1.13) dT_0 evaluates to 1, and as we know the values of the invariants, we can rearrange and solve for r_0 as an alternative fundamental length scale, appropriate for the current expansion extent of the cosmos, and get

$$r_0 = \left(\gamma_3 \frac{G_N \hbar^2}{c^2} \frac{1}{dT_0} \right)^{\frac{1}{6}} = 2.1002... \times 10^{-16} \text{ meter} \quad (1.14)$$

This happens to be the reduced Compton wavelength of the neutron, $\lambda_{C,n}$. Applying this to (1.3), (1.9) and (1.11) and solving we find that

$$dA_0 = A_P, \quad (1.15)$$

the Planck area, and a gravitational quantum, G_0 , for use in (1.13) and in Newton's Law is

$$G_0 = d\tau_0 = \gamma_3^{-1} r_0^2 dT_0 = \gamma_3^{-1} \lambda_{C,n}^2 dT_0 = 4.2443... \times 10^{-33} \text{ Newton} \quad (1.16)$$

Evaluation of the tension stress force at the boundary of a unit space based on this scale is

$$\tau_n = \tau_0 = \frac{\hbar}{c} \frac{c^2}{\lambda_{C,n}^2} = \frac{\hbar}{c} \omega_n^2 = \frac{m_n c^2}{\lambda_{C,n}} = 7.1676... \times 10^5 \text{ Newton} \quad (1.17)$$

The ratio of tension stress force to differential force or gravitational quantum, which is also the ratio of the tension stress to the differential stress is

$$\frac{\tau_0}{d\tau_0} = \frac{\tau_0}{G_0} = \frac{T_0}{dT_0} = 1.6887... \times 10^{38} . \quad (1.18)$$

Inverting this gives the differential of the natural log of the expansion stress

$$d \ln T_0 = \frac{dT_0}{T_0} = 5.9214... \times 10^{-39} \quad (1.19)$$

This is also the general scale of the ratio of the gravitational force to the strong force, this latter interaction being what τ_0 represents. It will prove of interest that the square root of (1.18) is equal to the ratio of the neutron reduced Compton wavelength and the Planck length as

$$\frac{r_0}{l_p} = \sqrt{\frac{T_0}{dT_0}} = \sqrt{d \ln T_0^{-1}} = 1.29952... \times 10^{19} . \quad (1.20)$$

The above analysis points to the wave properties of rest mass quanta in the neutron Compton wavelength as the basis for a fundamental physical scale. It bears noting that quantum theory is in essence a comment on the fact that “matter” and “energy” appear always to be observed on a fundamental level in discrete units of some property such as mass or spin or charge. This, at least in popular accounts, is depicted as matter or energy particles of a discrete and invariant quantity of such property, in the case of mass, subject to the transformational dictates of relativity. More specifically, such a particle, rest mass or messenger, is treated as the maximum concentration in space and time of a corresponding quantum field of the appropriate property, subject to the Heisenberg uncertainty principle. If treated as a point, i.e. as an entity without internal structure, it is as a point of maximum probable location in space and time. All such points, therefore, are conceptually in constant, generally oscillatory, motion against a backdrop of space and time; the quantum particles are deemed to be of a distinctly separate ontology from that space and time.

Space and time then, in the absence of such quanta (which of course it is not, in reality) would be a true void or vacuum. In fact it is difficult to envision a concept of space, much less that of time, if all there is, is a void. Time denotes a change of or within space, and if that space has no boundary or internal features, then change, therefore time, would appear to be impossible.

The presence of quanta in space, however, alters it according to the descriptions of general relativity, causing it to flex, bend or curve in the locus around aggregates of quanta, and presumably around a single quantum. The flexing around such quantum aggregates is well described by the methods of general relativity, but how this coupling of a single quantum and spacetime is achieved, the subject of quantum gravity, is understood very little, if at all. The fact that spacetime interacts in such a manner, in fact in any manner with quanta, suggests that it has inertial properties apart from such quanta.

The line of thinking upon which the analysis of this writing is based is that:

1. Spacetime and quanta are of one ontology. Specifically, physical space can be modeled as a three dimensional manifold without boundary, analogous in two dimensions to a 2-sphere (the surface of a three dimensional ball) or more likely,

a 2-torus, that expands and contracts over time, such cosmic oscillation forming the basis of a cosmic time scale. Quanta are an emergent property of this space under the stress/energy gradient of expansion.

2. Such space, which is continuous, has a finite inertial density of a non-particulate nature that decreases with expansion and increases with contraction. It also increases and decreases microscopically with any quantum oscillation. In fact, it is the sustained local, by which is meant microscopic, simple harmonic oscillation of spacetime, that constitutes rest mass quanta. We can therefore think of spacetime as an inertial fabric (STF) or simply an inertial field.
3. It is the local oscillation of rest mass quanta that provides the coupling responsible for quantum gravity. Since quanta are loci of spacetime, there is no “coupling” necessary and there are no messenger particles or graviton needed to mediate the “coupling”. The stress/strain of rest mass oscillation responsible for gravity, in turn propagates through space and affects the trajectory of messenger particles.
4. Space is under internal stress with cosmic oscillation, which is isotropically tensional or divergent from any arbitrary point, but this in turn contributes to initial shearing or transverse, including torsional, stress due to interaction with adjacent loci under similar tension stress. Because it is comprised of a finite and at some point in time maximum density, the STF is not compressible beyond a finite point, and under torsion or shearing exhibits a “spring” response towards adjacent areas of lower density. With expansion, the shearing stress oscillates about each local center. Due to the non-commutative, three dimensional nature of the local stress, a simple torsional oscillation is not possible, and a second torsional oscillation normal to and superimposed on the first results in an emergent rotational oscillation of the local area of the STF about the arbitrary center, creating quantum spin. The emergence of this rotational oscillation at resonant frequency of the STF creates a rotating wave boundary that prevents dispersion of the wave energy. As long as the STF expands, such dispersion, other than in the case of beta decay, is impossible. Thus expansion creates an energy gradient, initially isotropic about each locus, that optimizes the tendency toward equilibrium through the development of rotationally oscillating cells. Geometrically determined interstitial areas about the cells develop wherein the shear stress is effectively neutralized, leaving tension to predominate.

There is a well-studied, two dimensional corollary of this spontaneous phenomena in Rayleigh-Bénard convection cells. While that phenomenon is due to the emergence of regular molecular convection patterns in a thin liquid resulting from an applied temperature/gravity gradient, it is essentially an example of the geometrically determined development of sustained transverse stress in response to a tension gradient.

5. With expansion stress, the interstitial areas respond primarily to tension, and tension strain results with a decrease in inertial density. Over time, with sufficient density decrease, the mechanical impedance of the interstitial area decreases as well, and a portion of the energy of the quantum oscillation is transmitted in the process of beta decay. Therefore, we would expect the expansion rate, i.e. the

Hubble rate, to be linearly coupled with the decrease in linear density and mechanical impedance and thereby beta decay. Photonic messenger particles, in turn, are generated by the activity of the emitted electron.

6. With respect to gravity, the rotational oscillation of the quanta results in a centripetally directed tension stress force differential in response to expansion tension force that accounts for gravity, as found in (1.16) above. A quantum version of Newton's law can thus be shown from the above as

$$F_G = \frac{n_{M1}n_{M2}}{n_{r_0}^2} \left(\frac{A_0}{\gamma_3} dT_0 \right) = \frac{n_{M1}n_{M2}}{n_{r_0}^2} G_0 \quad (1.21)$$

where the mass and distance properties are expressed in units of the fundamental neutron scale. Substituting

$$n_{Ma} = \frac{M_a}{m_0} = M_a \frac{r_0}{\frac{\hbar}{c}} \quad (1.22)$$

$$n_{r_0} = \frac{d}{r_0} \quad (1.23)$$

gives Newton's law

$$F_G = \frac{M_1 M_2}{d^2} \left(\frac{r_0^4}{\left(\frac{\hbar}{c}\right)^2} \frac{A_0}{\gamma_3} dT_0 \right) = \frac{M_1 M_2}{d^2} G_N \quad (1.24)$$

Since the interaction depicted here is mediated directly by the STF and not by any messenger particles and since it has been operable with expansion since the initial generation of the rest mass particles, it is not a case of "action at a distance".

7. The quark structure of the standard model is, in this modeling, the oscillating nodes and antinodes of the above fundamental oscillation, which flips its spin as a result of transmission of the electron wave.

Now for a mathematical development of item 5 above, we review the following:

Classical wave mechanics, specifically the mechanisms of harmonic motion of an ideal inertial – elastic continuous medium, also give rise to discrete phenomena in the form of wave phasing, θ , expressed as a wave period, semi or quarter period, or here as radian. Such discreteness can be quantized in terms of distance as the angular wave number, κ , and in terms of time as the angular frequency, ω , of the motion. The speed of the motion, c , in either standing or traveling form, is then given as the ratio of the frequency to wave number as

$$c = \frac{\omega}{\kappa} = \frac{\frac{\partial \theta}{\partial t}}{\frac{\partial \theta}{\partial r}} = \frac{\partial r}{\partial t}. \quad (1.25)$$

Such ideal wave bearing continuum will typically have a resonant frequency, ω_0 , and hence a corresponding resonant wave number, κ_0 , and we can thereby designate natural distance and time units based upon these resonance values as

$$r_0 = \kappa_0^{-1} \quad (1.26)$$

and

$$t_0 = \omega_0^{-1} \quad (1.27)$$

and (1.25) can be restated variously as

$$c = \frac{\omega_0}{\kappa_0} = \frac{\frac{\partial \theta}{\partial r_0}}{\frac{\partial \theta}{\partial t_0}} = \frac{\partial r_0}{\partial t_0} = \frac{r_0}{t_0} = r_0 \omega_0 \quad (1.28)$$

Note the correspondence of (1.25) with (1.2) and that as long as the distance and time variables remain coupled by the phase variable, they are co-variant with respect to any change in θ .

While the relationship given by (1.25) is descriptive of the phenomena of quantization, the dynamics of the wave is explained by the properties of the underlying continuum substrate. According to classical wave mechanics, in this case of an ideal stretched string, the wave speed squared is directly related to the tension force through the string and indirectly related to its inertial or mass density as

$$c^2 = \frac{\tau_0}{\lambda_0}. \quad (1.29)$$

Thus an increase in the tension force or a decrease in inertial density necessarily results in an increase in the wave speed. Coupling (1.28) and (1.29) gives the basic wave equation

$$-\kappa_0^2 = \frac{\partial^2 \theta}{\partial r_0^2} = \frac{1}{c^2} \frac{\partial^2 \theta}{\partial t_0^2} = \frac{1}{\frac{\tau_0}{\lambda_0}} \frac{\partial^2 \theta}{\partial t_0^2} = -\frac{1}{\frac{\tau_0}{\lambda_0}} \omega_0^2 \quad (1.30)$$

In the last term, the dynamic properties of the wave are found in the ratio of force to density, which determines the wave speed and thereby produces the observed quantization found in the displacement and time derivatives. An increase in the wave speed over time will result in a decrease in the wave number, i.e. in a red shift, if the time standard given by t_0 is held fixed. However, if time and displacement standards are co-variant, then the nominal wave speed will remain invariant, even though that speed in absolute terms, i.e. measured against some universal time scale, is increasing.

Note that if the medium, in this case the string, is extended, it indicates a decrease in inertial density throughout its extent, along with a possible net force increase. We can apply this same reasoning to an arbitrary one dimensional tension component of a three dimensional space under isotropic extension or expansion.

As expressed in (1.3), if the speed of light is invariant at any scale, then Planck's constant simply points to a more fundamental relationship in which the product of particle mass and length scale, as given by the particle's reduced Compton wavelength, is invariant. Particle mass, m_q then, is an inverse measure of the particle wavelength, and can also be expressed as the particle angular wave number, κ_q . Thus

$$\frac{\hbar}{c} = m_q r_q = m_q \tilde{\lambda}_{C,q} = \frac{1}{\tilde{\lambda}_{C,q}} \tilde{\lambda}_{C,q} = \kappa_q \tilde{\lambda}_{C,q} = \mathfrak{n} \quad (1.31)$$

where the final term is a constant of inertia, herein designated $\mathfrak{n}$, which is equal to 1 in a natural system as seen in the fourth term, and is simply a proportionality factor relating conventional measures of mass to distance in the second and third term. While there are cases in which the transverse wave speed of a medium may be different from its

longitudinal speed, in cases where they are the same, the greater the wave number, the greater will be the curvature of the wave form. If the wave medium is the spacetime fabric, the greater the curvature, the more particle mass, i.e. inertia, will be incorporated by the wave action. The value in breaking down Planck's constant into the inertial constant and the speed of light, is that it allows us to remove the time dimension from the fundamental invariant, giving us a dynamic component or moment that is invariant in any reference frame.

Combining (1.31) with (1.25) and (1.29) gives the quantum wave equation

$$\lambda_q = \hbar \kappa_q^2 = \frac{1}{c^2} \hbar \omega_q^2 = \frac{1}{c^2} \tau_q \quad (1.32)$$

where λ_q is the inertial density of the quantum waveform and τ_q is the wave force of that quantum.

Applying (1.31) to (1.4) with (1.5) gives

$$G_N = \frac{r_0^3}{m_0^2 t_0^2} = \frac{c^3}{\hbar} r_0^2 = \frac{c^2}{\hbar} A_P \quad (1.33)$$

and to (1.13) gives

$$G_N = \frac{r_0^2}{m_0^2} (d\tau_0) = \frac{r_0^4}{\hbar^2} \left(\frac{r_0^2 dT_0}{6\sqrt{3}} \right) = \frac{r_0^4}{\gamma_3 \hbar^2} A_0 dT_0 \quad (1.34)$$

Substituting (1.34) and (1.9) and (1.11) into (1.33) gives

$$\frac{r_0^4}{\gamma_3 \hbar^2} A_0 dT_0 = \frac{c^2}{\hbar} \left(-\frac{A_0}{\gamma_3} d \ln T_0 \right) \quad (1.35)$$

Here the difference in sense between the two terms indicates the centripetal direction of the left term and the counter centripetal of the right. Rearranging so that the space dimensions are on the left and the properties with time dimension, apart from the stress differential, on the right gives

$$\frac{A_0^2}{\hbar} dT_0 = c^2 (-d \ln T_0) \quad (1.36)$$

while some rearrangement

$$\frac{r_0^4}{\hbar} = c^2 \left(\frac{-d \ln T_0}{dT_0} \right) = -c^2 \frac{1}{T_0} \quad (1.37)$$

and inversion gives a three dimensional equivalent of the wave speed equation of (1.29)

$$\frac{\hbar}{r_0^4} = -\frac{1}{c^2} T_0. \quad (1.38)$$

This is descriptive of the spacetime substrate and not of any particular quantum wave.

Returning to (1.36), assuming that the inertial and space parameters are invariant over time, and that the stress derivative remains at unity, so that the left hand term of the equation is invariant, if we assume that the log of the tension increases with expansion, that is, over cosmic time, then going back in time indicates an increase in the differential log of the expansion and a corresponding decrease in the square of the wave speed, if the

invariance of the left hand term is to be preserved. In other words, expansion results in a decrease in inertial density of the spacetime substrate and a corresponding increase in the wave speed. If the decrease in the differential is not balanced by the increase in wave speed with expansion, then the stress differential on the left must change accordingly, with a corresponding effect on the invariance of the gravitational quantum.

We are assuming that the speed of a traveling wave, i.e. of electromagnetic radiation, is the same as that of a discrete, standing oscillation, a rest mass waveform. Such oscillation is equivalent to an electromagnetic wave circling a center of spin at a distance of the quantum's reduced Compton wavelength. If we think of such wavelength as the arm of a quantum clock whose tip travels always at the speed of light, then extending the length of the arm results in a decrease in its angular velocity. By contrast, if we think of time as a measure of the clocks angular velocity as is customary, then time must slow down as the arm extends if the end speed is to remain invariant.

In general relativity, time is said to dilate, but in a different manner. Increased inertial density, as in a gravitational sink, causes our quantum clock to contract its arm instead of extend it, in keeping with the inertial constant, with a corresponding decrease in angular velocity. The end of the clock arm, then, slows down as measured from some global perspective. Rising out of that sink causes the clock arm to lengthen and the angular velocity to increase.

If the speed of the arm tip is to remain constant with decreasing density and an extension of the arm, either the angular velocity must decrease or the time unit must extend to t_{0e} , to account for an increase in circumferential travel per unit of initial time, t_{0i} . Inverting the usual expression for velocity, the time standard must vary with the length standard if c is to remain invariant as

$$c^{-1} = \frac{t_{0e}}{r_{0e}} = \frac{t_{0i}}{r_{0i}} \quad (1.39)$$

$$\therefore t_{0e} = \frac{r_{0e}}{r_{0i}} t_{0i}$$

Similarly in terms of angular frequency

$$c = r_{0e} \omega_{0e} = r_{0i} \omega_{0i} \quad (1.40)$$

$$\therefore \omega_{0e}^{-1} = \frac{r_{0e}}{r_{0i} \omega_{0i}}$$

We are now ready to tackle item 5. Expansion of the STF does not indicate an equal linear decrease in density either inside, locally outside or remotely outside the fundamental quantum oscillation. The region remotely outside any oscillation is primarily under tension stress and attendant strain, and with extension suffers a decrease in linear density and related mechanical impedance, Z , where impedance, which essentially relates units of time to units of mass of a wave bearing medium, is defined as follows, using the customary theoretical unit values

$$\lambda_0 c = \frac{\tau_0}{c} = Z_0 \quad (1.41)$$

The region about the periphery of the oscillation participates in the oscillation and exhibits a combination of tension and shear stress/strain and corresponding density fluctuations similar to what we might find in the ergosphere of an extreme Kerr quantum black hole, which is what the neutron is. The region between the nodes of the oscillation remains at the same density, unless a change of external impedance allows transmission of a small portion of its energy and therefore a change in inertial density.

In order for the energy of beta decay, which we will quantify as the mass of the electron, to be transmitted from the neutron waveform, the density and impedance at its boundary must decrease sufficient to permit that mass-energy to pass. While beyond the scope of this presentation, but developed elsewhere, the electron mass, m_e , is determined according to geometric constraints of the neutron oscillation and is approximately 0.000543867 . . . of the neutron mass, m_0 . The reduced Compton wavelength of the electron resulting from beta-decay is

$$\lambda_{C,e} = r_e = \frac{\hbar}{m_e} = \frac{m_0 r_0}{m_e} \quad (1.42)$$

According to (1.32) the change in inertial density of the STF required for beta-decay is the loss of mass/energy equal to that of the electron from the region exterior to the neutron oscillation nodes over a distance r_e , to be replaced by beta-decay from the neutron energy or

$$d\lambda_0 = \frac{\hbar}{r_e^2} = \frac{1}{c^2} \hbar \omega_e^2 = \frac{1}{c^2} \tau_e \quad (1.43)$$

where ω_e is the rest mass frequency of the electron given by

$$\omega_e = \frac{c}{r_e} \quad (1.44)$$

and τ_e is the wave force of the electron rest mass. The differential density is the decrease in inertia over the distance of a wavelength required to generate a waveform of such mass.

With separation of one of the wave speed components in (1.43), a change in the linear inertial density over time is equal to a change in the impedance over distance as

$$\frac{d\lambda_0}{dt} = \frac{\tau_e}{c} \frac{1}{dr} = \frac{dZ_0}{dr} \quad (1.45)$$

Since the values of the inertial constant as Planck's constant over the speed of light and the electron reduced Compton are well determined, we can solve for $d\lambda_0$ and get

$$d\lambda_0 = 2.3589... \times 10^{-18} \text{ kg} / \text{m} \quad (1.46)$$

Since the change in linear inertial density is a linear change, we might expect this expression to reflect the Hubble rate, which instead of a velocity per megaparsec of recession of galaxies, can be viewed as a dimensionless linear strain of space and therefore of time, and in fact (1.46) is a very close approximation. Converting kilometers

per megaparsec to a dimensionless strain for a second, assuming a Hubble, H_0 , of 73^1 km per second per mps gives a spacetime strain of $2.3657... \times 10^{-18}$ per second. This indicates that the Hubble rate generates the force required for beta-decay. However, we would like something more precise and dimensionally correct.

Returning to (1.43), we can decompose the wave speed invariants

$$\frac{\eta}{r_e^2} = \frac{1}{(r_e \omega_e)(r_0 \omega_0)} \eta \omega_e^2 \quad (1.47)$$

then rearrange and multiply through by r_e to get

$$m_e = \frac{\eta}{r_e} = \frac{\eta \omega_e}{r_e} \frac{\omega_e}{\omega_0} \frac{r_e}{r_0 \omega_e} = dZ_0 \left(\frac{\omega_e}{\omega_0} \right) H_0 \quad (1.48)$$

where the change in impedance is stated as the quotient of the change in expansion force and the wave speed and the Hubble rate is shown as the spacetime length and simultaneous time strain for each second, as in (1.39) and (1.40),

$$H_0 = \frac{r_e}{r_0 \omega_e} = \frac{r_e}{r_0} \frac{t_0}{\theta_e} = \frac{\omega_0}{\omega_e} \frac{t_0}{\theta_e} = 2.36838922... \times 10^{-18} s. \quad (1.49)$$

Transferring the frequency ratios to the mass side of the equation and substituting from (1.40) the mass of the neutron as a function of the product of the expansion rate and the concurrent change in mechanical impedance is

$$m_0 = \frac{\eta}{r_0} = \frac{\eta}{r_e} \frac{r_e}{r_0} = dZ_0 H_0. \quad (1.50)$$

Evaluation of (1.49) in conventional astronomical terms is 73.082 kilometers per megaparsec for each second of current time. That is, a unit of space and co-variant time are currently extended/dilated at this rate. The implication is that space and time are currently expanding logarithmically, therefore at a continually accelerating pace.

Thus, if the Hubble rate of expansion is roughly 73 kilometers per second per mpc, this would indicate that every local section of space is moving away from every other at approximately 2.37×10^{-18} meters per second per meter of separation. However, we would expect this expansion to show up primarily in the large voids between galactic filaments and clusters and not in these galactic environs or filaments of baryonic matter due to the counter effects of gravity and electromagnetism. It follows conventionally that inversion of this number would give us the approximate time since all the matter was at the same locale and that the universe has been expanding, or 4.22×10^{17} seconds, which is roughly 13.4 billion years.

However, as this number represents an expansion via a compounded augmentation of the scale of spacetime itself, and not simply an extension of matter within that spacetime, the following equation for the doubling of spacetime applies, giving us the Hubble time, τ_H as

¹ A study by Ron Eastman, Brian Schmidt and Robert Kirshner in 1994 and quoted in Kirshner's book, *The Extravagant Universe*, found an H_0 of 73 km/s/mps +/- 8 km.

$$\tau_H = \frac{\ln 2}{H_0} = 2.92666... \times 10^{17} s, \quad (1.51)$$

This indicates that space is doubling at a current rate of every 9.280 billion years, measured in terms of today's seconds. If we assume that the wavelength of the cosmic background radiation at approximately 5mm embodies that augmentation, while harkening back to a period of primal beta decay as indicated by the Compton wavelength over 2π of an electron, this represents a doubling of some 30 times, or

$$\frac{\ln \left(\frac{\frac{.005}{2\pi}}{r_e} \right)}{\ln 2} = \frac{\ln 2.060... \times 10^9}{\ln 2} = 30.94... \text{doublings} \quad (1.52)$$

a lifetime in terms of today's measure of time of roughly 288 billion years. If we extrapolate back on the same basis for the expansion over the scale of r_0 to r_e , prior to beta-decay where it may or may not be applicable, we have an additional doubling of 10.84 times or

$$\frac{\ln(1830.6842...)}{\ln 2} = 10.84... \quad (1.53)$$

or a total doubling of the Hubble time of 41.78 or 393.47 billion years in current time as

$$(2.927... \times 10^{17})(41.78...) = 1.2227... \times 10^{19} s \quad (1.54)$$

Finally, if we envision that a current expansion factor can be derived by a comparison of the Planck length and the neutron Compton wavelength, keeping in mind that we can multiply both terms by the speed of light without affecting their ratio and express the quotient as a coefficient of expansion in light seconds, given as

$$\kappa_{\text{exp}} = \frac{r_0}{l_p} = \frac{2.10019... \times 10^{-16} m}{1.61612... \times 10^{-35} m} = 1.29952... \times 10^{19} ls \quad (1.55)$$

We have a close agreement with (1.54) at 412 billion years.

In another vein, we can multiply this figure as with (1.51) to get the extent of doubling in terms of current time standards over the most recent doubling period of 285 billion years as

$$C_x = \ln 2(\kappa_{\text{exp}}) = 9.00758... \times 10^{18} ls. \quad (1.56)$$

Dividing by (1.51) we get the number of doublings since the initial factor established by beta-decay and get

$$\frac{C_x}{\tau_H} = \frac{9.00758... \times 10^{18} ls}{2.92666... \times 10^{17} s} = 30.77... \text{doublings} \quad (1.57)$$

compared to (1.52).

With respect to the period before beta-decay or the last scattering of the standard model cosmology, it is not clear from this extant modeling that rest mass quanta emerged from an initial big bang. Rather it appears likely that such matter emerges from galactic inertial centers, i.e. black holes which can be gravitational field sources as well as sinks, and their connecting filaments in response to the tension stress of expansion of the surrounding,

relatively mass free voids, as evidenced by the observance of episodic gamma ray bursts of unknown origin.

As

$$\ln 2 = 0.693147181... \quad (1.58)$$

it is worth noting that this figure is effectively 70%, the factor of expansion attributed in current cosmological schemes to dark energy.