A More Natural Reference Model Integrating Relativity, Quantum Mechanics, and M-Theory

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Abstract. M-Theory holds the promise of resolving the conflict between General Relativity and Quantum Mechanics but lacks experimental connections to predictability in physics. This paper will suggest a process through which this connection could be made. The basis for this process begins by questioning the value of the traditional Planck unit reference point for the scales at which M-Theory operates. It accommodates a cosmological model of the universe which has acceleration as being fundamental. It provides for an intuitive understanding of the Standard Model and its relationship to particle masses and the structure of the atom. The ability for any theory to predict particle masses should be a good indicator for its validity. This model seems to indicate an intuitive mass prescription capability.

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INTRODUCTION

This paper will present a new "more natural" reference model for integrating General Relativity (GR) and Quantum Mechanics (QM) by contrasting it with the development of a reference model based on the more traditional Planck units. The new Unit-Of-Measure (UoM) is based on the non-linear expansion or acceleration of the universe [1]. It provides a testable framework for particle mass prediction in support of the Standard Model as well as M-Theory.

The fact that the universe is found to be accelerating indicates that an exponential model which accommodates this acceleration could be more natural than the traditional linear model. The key to defining this new model relies on deriving "unity" as the center of scales of length, time, mass and charge that are exponentially expanding.

Grand Unified Theories (GUTs) hold in high regard the Planck scale for its natural proximity to the unification energies. This scale is set by simply setting the fundamental parameters of the velocity of light (c), Planck's constant ($\hbar$), and Newton's constant (G) to unity. Planck units are derived by combining powers of these constants into their dimensions of length (L), time (T), mass (M), and charge (Q). In terms of space-time, it seems to identify a possible lower limit to the length scale at one unit Planck length (L_P). Cosmological models logically define an upper limit based on the age and extent of the universe. In addition to an upper and lower limit (e.g. infinity (∞) and zero=$1/\infty$ respectively), an exponential model should identify a center (unity) in order to be well defined. In physics the upper limit is naturally thought to be indicated by the macro world of G and GR. The lower limit is the micro world of $\hbar$ and QM. Fortunately c is at home in both the micro and macro worlds. In the Planck unit model, the expanse between unity and zero is where GR and QM require the 'new physics' beyond the Standard Model (SM). As a reference model for scaling the universe, it offers no direct prescription for phenomena associated with atomic scales; therefore, using Planck units as a reference frame for the 'center' of an exponentially scaling model seems counter-intuitive.

A new model is offered that uses this same general approach in defining natural dimensions but with interesting results achieved by associating with it two more fundamental parameters - the macro Hubble (H) and the micro fine structure (α). This approach does not detract from the significance of the Planck scale and its associated theoretical frameworks; however, it adds a point of view that puts it properly at the micro edge of an accelerating universal expansion.

DEFINING THE NEW MODEL

Except for the so called "Hubble constant", these parameters are typically thought to be truly constant. A new model based on an accelerating universe is achieved by considering that all of these fundamental parameters vary with time.[1] It is also necessary to redefine the relationships between the measurable aspects or dimensions of our reality; namely those of L, T, M, and Q.

Relating Length to Time

In Planck units, c sets up the relationship between space and time by being driven to an effective dimensionless unity. This is done by setting L_P to be traversed by a photon in one unit Planck time (T_P) or ($L_P = cT_P$).

This concept of using c to drive the relationship of space and time is also used in the new model with the difference focusing on the fact that the universe is found to be accelerating. The new model normalizes c and the other fundamental parameters to that acceleration by defining their magnitudes to be varying with it. It also modifies the traditional understanding of the relationship between the dimensionality of L and T.

Acceleration becomes the new "dimensionless unity" in this reference frame and this requires setting each space dimension (L) to be equivalent to the square of the time dimension.[2]

$$L=T^2 \qquad (1)$$

Since c is the indicator for the expansion of space-time through its integral relationship with the impedance of free space (Ω_0), which is also derived from the permittivity (ε_0) and permeability (μ_0) of free space, it should be defined as a naturally accelerating parameter with an equivalence to time in terms of both magnitude and dimension. Since $LT^{-1}=T$, it can be directly associated with the age of the universe instead of dimensionless unity.

[1] Based on principle, the ability to measure a synchronous time variation of multiple fundamental constants is problematic, if not impossible. It can be shown that the time variation per unit time would be 1 part in $\alpha^{-8} = 1.2436x10^{17}$.

[2] Procedural note: in terms of the traditional dimensionality of length, time, mass and charge, the extra time dimensions found (e.g. in length) are associated with the complex plane by suggesting that they are imaginary.

Of course, since H is already directly related to the age of the universe, it can be incorporated into the new model as well, with:[3]

$$\begin{aligned} 4p \cdot c \cdot H &= UnitAcceleration \\ &= 1 DimensionlessUnit \\ &= 81.9618\, Angstroms/s^2 \end{aligned} \qquad (2)$$

where:

$$\dot{c} = -\dot{H} = -\frac{\ddot{a}}{a} = 1 DimensionlessUnit \qquad (3)$$

Relating Length to Mass

Typically, equating dimensions of mass to length in Planck units uses the QM based Compton Effect. Setting $\hbar$ (or h) and c to dimensionless unity effectively associates a Compton (wave) length to be the inverse of mass ($L=M^{-1}$). The association of length to mass could also be accomplished in GR by associating mass to its gravitational radius, although this method establishes (L=M) at odds with the Compton method. While this GR approach removes the dimensionality of G, it leaves a dimensionality to $\hbar$ of L^2, which is used by Veneziano [2] to link GR to M-Theory by setting $\hbar$ to the square of Planck (string) Length ($\hbar = \lambda_P^2$).

The new model also uses Compton in setting the magnitude of $\hbar$ equal to c, while giving significantly different results due to c being associated with time and not dimensionless unity. This begs the question of whether to simply take the Compton Effect as nature's indicator of the dimensional relationship between length and mass. Compton relates mass to a 1D wavelength. In 4D GR space-time, the inter-relationship between mass and gravity is spherically symmetric. The ability to link GR and QM in an intuitive way becomes problematic.

A more natural alternative to rationalizing this problem is offered. The Compton Effect is the indicator of the interdependence between a particle's rest mass and the corresponding quantized wavelength and angle of its emissions. It is merely one aspect of how mass relates to length given the wave-particle duality of nature. *It is reasonable to understand a particle's rest mass in terms of both its linear wave-like property and a spherically symmetric compression (deceleration) of space for some period of time*. That is:

[3] This is an explicit acceleration in terms of dimension and does not rely on the modified relationship between length and time.

$$M=L^3T^{-1}=T^5 \qquad (4)$$

This implies that the transformation of GR space-time into a particle's rest mass is a separate transformation from that of QM transformations to the massless photon. This idea is the key to particle mass prediction of the new model.

Since $\hbar$ is a quantized angular momentum (mvr or spin), its particle dimensionality in the new model is:

$$ML^2T^{-1}=T^8 \qquad (5)$$

This seems to indicate a strong linkage between QM and an 11D M-Theory space-time with 3 real dimensions of space and 8 dimensions associated with time allocated to complex imaginary space.

Locking in Magnitude

Completing the minimally constrained definition of Planck units is easily accomplished by locking in a specific unit of mass by the free selection of the magnitude for G=1. For the most part this affords a pleasing result. Unfortunately, it also results in a unit mass that is significantly larger than the particles of the SM. This large unit mass is rationalized with the hope that it will be the harbinger of particles in a GUT. This indeed may be the case and is not precluded in the definition of the new model.

Since the new UoM-based model is already overconstrained, the ad hoc selection of the magnitude of G is not possible. Given the new relationships between L, T, and M it is found that:

$$G=4\pi H \qquad (6)$$

in terms of the magnitude *and* dimension. This requires specific values for G and H. Specifically:

$$G = 6.67889\,x10^{-11}\,\frac{m^3}{kg\cdot s^2} \qquad (7)$$

and:

$$H = 67.1328\,\frac{km/s}{MegaParsec} \qquad (8)$$

The error in prescription of G is outside the relative standard uncertainty of 150 ppm by a factor of 5 times [3]. Hubble is comfortably within a rather large standard uncertainty of 0.2 [4].

Defining Charge

The magnitude and dimensionality for a unit of charge still needs to be defined explicitly. It has implications for Quantum Field Theory (QFT) linking Quantum Electron Dynamics (QED) to Quantum Chromo Dynamics (QCD), particle mass prediction, as well as a more general linkage between GR, QM and M-Theory. Planck units effectively set up charge as a dimensionless parameter which seems to pale in comparison to the significant role just described. It sets e(Q) to the small fraction $\sqrt{a}$. Of course, it is also possible to set e(Q) comfortably to unity and use ε_0 and μ_0 to do the work of determining α while keeping c at unity. This procedure has less insightful implications for the role Ω_0 plays in modern QM and GR. Since the dimensionality of M has been redefined in terms of L and T, an alternate definition to the dimensionality of Q is offered with possible implications for Higgs mass prediction.

Holding Ω_0 to dimensionless unity and using the new model's dimensional definition for M forces the magnitude of $e^2(Q)=(4\pi\alpha)\hbar$ and:

$$Q=ML^{-1/2}=MT^{-1}=T^4 \qquad (9)$$

Charge can now be visualized as a measure of the quantum change in particle mass per unit time. The significance of an intuitive choice for the magnitude of the charge's mass gives a testable prediction for what may be the Higgs boson:

$$m_{Higgs} = \sqrt{\hbar\cdot UnitLength} = 98.1409\text{ GeV} \qquad (10)$$

and:

$$e = m_{Higgs}\sqrt{\frac{4pa}{UnitLength}} \qquad (11)$$

This leaves the possibility of a new interpretation for the parameter $(4\pi\alpha)$ traditionally equated in a Planck unit model to (e) where $\hbar$=1. This can be shown to have new more natural relationships in the definitions of the Fermi Constant (G_F), electro-weak mixing angle (θ_W), and the Vacuum Expectation Value (VEV or $<\phi^0>_0$).

Completing the Model

It is possible to extend the model even further by noting that the resulting number of time units is precisely α^{-8}. The exponent seems to support the 8D time construct previously noted in the dimensionality of $\hbar$. It implies that fine structure is a fractional dimension (fractal) of time. Combining the magnitude and dimension discussions above into a single equation, gives:

$$c = \hbar(T^8)\frac{1}{UnitLength \cdot UnitMass} = \frac{1}{G} = \frac{1}{4pH} \quad (12)$$
$$= a^{-8} UnitTime = (3/8p)\,AgeOfUniverse$$

Notice the inverse relationships between the fundamental parameters and a more natural connection between gravitational attraction and Hubble expansion. It may suggest the duality of M-Theory in its relating the micro and macro worlds defined above. The model identifies a very natural unit length which is very close to twice the circumference of the Bohr model of the atom ($4\pi a_0$). It offers a unit mass that may approximate the electron neutrino (η_e).

SPECULATIVE RELATIONSHIPS AND PREDICTIONS

This model also offers more speculative predictions for the electro-weak model, particle masses, as well as cosmological models.

Electro-weak Predictions

The electro-weak model predictions are found using (10)-(12), and Standard Model's parametric relationships.

$C_{Axial\text{-}Vector}$ ($C_{V\text{-}A}$)

From the evolved Fermi model of weak interactions [5], it has been found from unit magnitudes of the new UoM (12) given in Table I that the $C_{V\text{-}A}$ relationship can be defined within experimental error as:

$$C_{V-A} = UnitVolume \cdot UnitTime \cdot (UnitMass \cdot c^2) = 6.34818x10^{-44}\,cm^3 MeV \quad (13)$$

Weak Mixing Angle (q_W)

The Electro-weak Ratio ($4\pi\alpha$) from (11) is used to define a weak mixing angle of:

$$\theta_W = Sin^{-1/2}(x_w) = 28.3489^o \quad (14)$$

where:

$$x_W = \tfrac{1}{2}\sqrt[3]{4pa} = 0.225473 \quad (15)$$

and by the standard definition of $g = g_W Sin(q_W) = \sqrt{8}x_W$ [6]:

$$g_W = \sqrt{\frac{\sqrt{2}}{8}}g = \sqrt{\sqrt{2}}x_W = \sqrt[3]{2^{-9/4}4pa} = 0.268134 \quad (16)$$

This prescription for the input parameters of the electro-weak model is outside a large experimental standard error of 3400 ppm by a factor of 1.5 times. This could imply that the electro-weak mechanism is fundamentally related to fine structure scaling with the acceleration of universal expansion.

Fermi Constant (G_F)

The definition of Higgs Mass (10) could be used to define:

$$G_F = (3m_{Higgs})^{-2} = 1.15361x10^{-5}/GeV^2 \quad (17)$$

Unfortunately, this prescription is significantly outside the very small experimental standard error of 8.6 ppm by a factor of 1275 times.

Vacuum Expectation ($\langle f^0 \rangle_0$)

Using the electro-weak model, Higgs mass (10), electron charge (11) gives:

$$VacuumExpectation = 1/\sqrt{G_F\sqrt{2}} = \frac{3m_{Higgs}}{\sqrt{\sqrt{2}}} \quad (18)$$

and:

$$\langle f^0 \rangle_0 = VacuumExpectation/\sqrt{2} = \frac{3m_{Higgs}}{\sqrt{2\sqrt{2}}} \quad (19)$$

and:

$$G_{el} = m_{el}/\langle f^0 \rangle_0 \quad (20)$$

Weak Boson Masses (m_w & m_z)

Finally, this gives by standard definition of the electro-weak model, a weak boson mass:

$$m_w = g_w / \sqrt{G_F} = g_w 3m_{Higgs}$$
$$= 3 \cdot 2^{-3/4} (4pa)^{1/3} a^{-4} UnitMass \quad (21)$$
$$= 78.9448 GeV$$

and also:

$$m_Z = m_w / Cosq_w = 89.7027 GeV \quad (22)$$

This error in prescription of weak boson masses is outside the experimental standard error of 3400 ppm by a factor of 5 times.

The new definition of e (already related to G_F by m_{Higgs} and a non-unity $\hbar$) has created an opportunity to simplify the electroweak model. Keeping with the standard definition for g_w=e modifies (16) giving:

$$g = \sqrt{\frac{8}{\sqrt{2}}} g_W = 2^{5/4} m_{Higgs} \sqrt{\frac{4pa}{UnitLength}} \quad (23)$$

and solving for m_w:

$$m_w = \frac{3}{2^{5/4}} \sqrt{\frac{LengthUnit}{x_w}} g_w = \frac{3}{4} \sqrt{\frac{LengthUnit}{2x_w}} g \quad (24)$$

now shown solving for g in terms of m_w:

$$g = m_w \frac{4}{3} \sqrt{\frac{2x_w}{LengthUnit}} \quad (25)$$

Mass Predictions

The particle mass predictions of the proton, electron, and pion based on the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) quark-gluon momentum splitting structure functions (using a base of 2/α).

Unit Mass

UnitMass can be defined using an approximate relationship of:

$$UnitMass = \frac{m_e}{m_p} m_e \quad (26)$$

Electron Mass (m_e)

This gives for the electron:

$$m_e = \sqrt{m_p UnitMass} \quad (27)$$

which has also been found to be linked to the fine structure constant (α) by:

$$m_e = \left(\frac{a}{2}\right)^{-\frac{16}{9}} UnitMass \quad (28)$$

Unfortunately, this interesting prescription is significantly outside the very small experimental standard error of 170 ppb by a factor of 3470 times.

Proton Mass (m_p)

This obviously gives:

$$m_p = \left(\frac{a}{2}\right)^{-\frac{16}{9}2} UnitMass \quad (29)$$

Pion Mass ($m_{p\pm}$)

Speculating on the mass of the pion using the so-called "Weinberg relation" and discovered two more equivalent derivations using the mass relationships above. This gives:

$$m_{p\pm} = \sqrt[3]{\Re \frac{\hbar^2}{c}} = \sqrt[3]{UnitMass \cdot m_{Higgs}^{\;2}}$$
$$= \sqrt[3]{\frac{(m_e/3)^2}{m_p G_F}} = a^{-8/3} UnitMass \quad (30)$$

where:

$$\Re = \frac{4pH_0}{G_{Newton}} = \frac{UnitMass \cdot UnitTime}{UnitVolume} \quad (31)$$
$$= Dimensionless - Unity$$

This intriguing prescription for the mass of the pion is outside the experimental standard error of 5ppm by a factor of 940 times.

Cosmological Predictions

Cosmological Constant (L)

Further work suggests a natural dark energy component in terms of the cosmological constant (Λ) that fits very nicely with recent cosmological data [7]:

$$\Omega_\Lambda = \int_0^1 \sqrt{c}\,dt = \int_0^1 \frac{1}{\sqrt{G}} dt = 2/3 \quad (32)$$

CONCLUSION

To summarize, the new dimensionality relations from (1), (4), and (9):

$$L=T^2$$
$$M=L^3T^{-1}=T^5$$
$$Q=ML^{-1/2}=MT^{-1}=T^4$$

The new magnitude relations in Table I have been generated from (12).

TABLE I. NEW to MKS Conversion Table.

NEW Units	MKS Units
1 Unit Time =	0.294125 Seconds
1 Unit Length =	$7.09047\ 10^{-10}$ Meters
1 Unit Mass =	$4.96112\ 10^{-34}$ Kilograms
1 Unit Charge =	$1.50032\ 10^{-27}$ Coulombs

This model could be described using terms from [2] as a “one (not-so) constant (unit) party view”. In this context, “unit” of course refers to time from which c, $\hbar$, G, H, and α are derived. It seems to restore the idea of an absolute reference frame for time which is embedded in the very core of the fundamental parameters of physics. It helps in understanding “the arrow of time” and entropy. The micro and macro scales of the universe are limited in magnitude by time in such a way that infinity becomes only a mathematical concept not physically realized as the universe unfolds. The universe itself becomes the clock upon which time can be measured.

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REFERENCES

[1] A. Riess et al. “Observational evidence from supernovae for an accelerating universe and a cosmological constant”, *Astron. J.* 116 (1998) 1009, astro-ph/9805201

[2] M. Duff, L. Okun, G. Veneziano, “Trialogue on the number of fundamental constants”, physics/0110060.

[3] Edited by P. Mohr, B. Taylor, “*CODATA recommended values of the fundamental physical constants: 2002*”, National Institute of Standards and Technology, Gaithersburg, MD 20899-8401.

[4] B. Mason, S. Myers, A. Readhead, “A measurement of H_0 from the Sunyaev-Zeldovich Effect”, astro-ph/0101169

[5] J. Sakurai, “Advanced Quantum Mechanics”, Addison-Wesley Publishing, 1967, p. 167.

[6] C. Quigg, “Gauge Theories of the Strong, Weak, and Electromagnetic Interactions”, Addison-Wesley Publishing, 1983, p. 111.

[7] D. Eisenstein, W. Hu, M. Tegmark, “Cosmic complimentarity: probing the acceleration of the universe”, astro-ph/9805239