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Universal Constants:

A New Look

Building on the Standard Model by linking Gravitational Attraction and Hubble Expansion with Quantum Spin and Free Space Permitivity / Permeability

Section 1

Constants

The Fundamental "Constants": Constant ?

If a system scales synchronously during the evaluation of a system in a given reference frame, constancy is a natural, yet errant, assumption. The ramifications of not questioning the possibility of linked "fundamental constants" that scale directly with time are studied.

Fundamental Constants

The fundamental constants commonly used to drive the definition of units-of-measure are investigated. These are the Planck Constant ($\hbar$), Speed of Light (c), Gravity (G_{Newton}), and its General Relativity (GR) tensor $8pT_{uv}$. Additional relationships are found involving the Hubble Constant $H_0 = \frac{\dot{a}}{a}$, and Fine Structure:

$$a = \frac{\Omega_0}{4p\hbar} e^2 \quad (1)$$

where the Impedance of free space is $\Omega_0 = \sqrt{m_0 / e_0}$, derived from the Permitivity (e_0), and Permeability (m_0) of free space. These, of course, define $c = 1/\sqrt{e_0 \cdot m_0}$.

Section 2 Units

Units-of-Measure: An Indicator of "Nature" ?

An analysis of assumptions resulting from traditional "Natural" and "Planck" units-of-measure leads to a new "more Natural" definition.

Natural and Planck Units

New relationships were found from the study of the "Planck" and "Natural" units-of-measure. The definition of Natural* Units is obtained from a less than minimally constrained equation:

$$c = \frac{\hbar}{UnitLength}\frac{1}{UnitMass} = 1 DimensionlessUnit \quad (2)$$

The definition of Planck* Units are minimally constrained given:

$$c = \frac{\hbar}{UnitLength}\frac{1}{UnitMass} = \frac{1}{G_{Newton}} = \frac{1}{8pT_{uv}} = 1 DimensionlessUnit \quad (3)$$

The first part of (2) and (3) remain free, such that the experimentally derived inter-relationships of the magnitudes of the fundamental constants can not be in conflict. Any arbitrary reference point can be chosen. Unity is chosen for its ability to simplify and link the dimensional relationships between time, length and mass.

Dimensional Aspects of "Natural" Units

Dimensional consistency for both (2) and (3) are achieved setting length=time=1/mass. This is a natural conclusion from the Compton Effect. It is also necessary in (3) to redefine the dimensionality of the traditional $G_{Newton} = 8pT_{uv}$. This, of course, finds its roots in GR. The "more Natural" units-of-measure being proposed in this paper begins with (3) and adds constraints and dimensional considerations without resorting to the redefinition of the dimensionality of G_{Newton}. Considering GR, the choice of unity in (3), which defines Planck Units, is a conceptually powerful, elegant, and yet arbitrary choice. Unit mass or "Planck Mass" in this units-of-measure has been the "Indicator of Nature", which has been the basis for Grand Unification Theories (GUTs). Nevertheless, a minimally constrained dimensionless-unity driven solution is less informative than an over-constrained time driven "more Natural" units-of-measure.

"More Natural" Units

Defining a units-of-measure by linking the fundamental universal constants to time has its foundation in the attempt to unify the fundamental forces. When the relationship between over-constrained constants is established, the unification of forces may be determined.

Dimensional Aspects of "More Natural" Units

These "More Natural" units-of-measure are derived with the following dimensional relationships, chosen such that the dimensionality of the "Fundamentals" are equivalent to time. Instead of equating length and time (or l=t) in order to drive c to dimensionless unity, we equate:

$$UnitLength = UnitTime^2 \quad (4)$$

This can be visualized as the relationship between time and the expansion of space.

$$UnitMass = UnitVolume / UnitTime \quad (5)$$

* These are slightly modified in form from the traditional definition of Natural and Planck Units in order to maintain the consistency in the format of new "more Natural" units. Given the definitions of Natural and Planck Unit dimensions, these modifications do not change their results.

This is visualized as the transformation (via compression or deceleration) of space per UnitTime. A properly normalized mass represents the difference between a normally expanding volume of free space and its compressed volume divided by the time required for compression through the elimination of normal expansion. This is not inconsistent with GR.

(6) $$M_{Normalized} = \frac{V_{Normal} - V_{Compressed}}{\Delta t_{Compression}}$$

A photon is to be visualized as the momentary transformation via universal expansion or inflation (i.e. quantum decay) of a fixed volume of previously contracted space (normalized mass) back into a normally expanding volume of free space. Charge is the indicator or measure of this quantum transformation mechanism.

(7) $$UnitCharge = UnitMass / UnitTime$$

Charge is then visualized as a measure of the quantum change in normalized particle mass per UnitTime.

(8) $$Q = \frac{\Delta M_{Particle\_Normalized}}{\Delta t_{Particle\_Photon}}$$

These descriptions of time, length, mass and charge do not alter the Standard Model of physics. They help define, in more physical terms, the underlying relationship between a charge, mass and the wavelength of emitted photons, which of course describes the fundamental nature of the Compton Effect:

(9) $$\lambda_{Photon} = \frac{\hbar}{c}\frac{1}{m}$$

The Magnitude of "More Natural" Units

Similar to Natural and Planck Units, for the aesthetic considerations of symmetry, Free Space Impedance is set to:

(10) $$\Omega_0 = 1 DimensionlessUnit$$

implying for Free Space Permitivity and Permeability $e_0 = m_0 = 1/c$. Setting $m_0 = e_0$ equates the natural rates of destruction and creation of mass and charge. It shows the natural linkage between charge, the magnitudes of UnitMass, and UnitLength, with the concept of a spin-angular momentum:

(11) $$\hbar = c \cdot UnitMass \cdot UnitLength$$

This is understood as an interchange of charge (quantum spin) continuously emitting and re-absorbing a UnitMass in the form of light (photons) with a wavelength of UnitLength. Notice that, as in Natural and Planck units, the Compton Effect (9) equates mass and emitted photon wavelength as direct inverses of each other.

This quantization of charge in this new "more natural" model is understood in terms of the selection of the "period (dt)" used to measure charge. Proper (i.e. "more natural") selection of the magnitude of this "period (dt)" allows for successful mass prediction rules. This is accomplished by defining the magnitudes of the "more natural" units-of-measure.

As is traditionally done using Planck Units, which define an intuitively small and fixed "period (dt)" in Planck Time (along with its correspondingly small Planck Length), in order to define the quantum magnitude of charge, a naturally simple mass prediction model is not apparent. Also, Planck Mass is extraordinarily large.

The new "more natural" model will be shown to help confirm the above relationships and conjectures by giving a UnitLength of approximately the diameter of the Bohr atom (~2a_0). It also allows for the definition of mass, charge, length and time, in such a way as to easily predict mass. Using this relationship, the Higgs Mass can be simply and directly linked to the electron charge. These effects will be described in detail in the next section.

"More Natural" Units Defined

Defining "more Natural" units by linking Hubble and Fine Structure to the minimally constrained constants in (3), we have a beautifully over-constrained equality, which is the foundation for a new universal model:

(12) $$\begin{aligned} c &= \frac{\hbar}{UnitLength}\frac{1}{UnitMass} \\ &= \frac{1}{G_{Newton}} = \frac{1}{8pT_{uv}} \\ &= \frac{1}{4pH_0} = a^{-8} UnitTime = t_{Universe} \end{aligned}$$

where the:

(13) $$AgeOfUniverse = \frac{2}{3}\frac{1}{H_0} = \frac{8p}{3} \cdot t_{Universe}$$

Section 3 Relationships

Linking the Constants: Ramifications

Several direct results from the adoption of the "more Natural" units are found. These results may explain the "new physics" required for understanding gravity beyond black hole singularities, the recent experimentally driven changes to cosmological models, as well as the paradoxical interpretations of quantum de-coherence.

Fundamental Constant Relationships

The following results are directly derived from the definition of more Natural units.

Acceleration of the Velocity of Light

Light velocity is accelerating with time. Consistent with an accelerating universe the strength of gravity decreases over time as a result of this universal inflation. It is an inverse relationship of universal proportions not unlike that found in the duality of string theory[1]. Given a simple tensor-like geometric translation ($1/4p$), we find an intuitively consistent relationship between gravitational attraction and Hubble expansion. They are equivalent in both magnitude and dimension. Hubble expansion and gravitational attraction can be considered a result of the acceleration of c.

In terms of length and time, where $l=t^2$, the current velocity of light, being also the current velocity of the expansion of the universe, would be the radial length of the universe ($l_{Universe} = t_{Universe}{}^2$) divided by time of its expansion $t_{Universe}$, giving $t_{Universe}$.

Our current representation of the velocity of light is thus not merely the current velocity of light that is undergoing acceleration; it is a representation of the current $t_{Universe}$, which is by (13) a tensor-like geometric translation ($8p/3$) of the age of the universe.

The previously presumed "short inflationary period" soon after the big bang is now shown to be a natural and ongoing part of the process of the normal accelerating expansion of the universe. It is also interesting to note:

(14) $$c \cdot H_0 = UnitAcceleration = 1 DimensionlessUnit$$

That is:

(15) $$\dot{c} = \dot{\hbar} = -\dot{G}_{Newton} = -\dot{H}_0 = -\frac{\ddot{a}}{a} = \frac{d(a^{-8})}{dt} = 1 DimensionlessUnit$$

The Hubble Constant Today

Using the commonly accepted values of the fundamental constants, (12) predicts:

(16) $$H_0 = 67.1330 \frac{km/s}{MegaParsec}$$

Fortunately, this lies near the center of a rather significant experimental error[2].

The Gravitational Constant Today

The theoretical to experimental difference in G_{Newton} from (12) is also within standard error limits[3,4]:

(17) $$G_{Newton} = 6.67893x10^{-11} \frac{m^3}{kg \cdot s^2}$$

The new "more Natural" definition of a unit-of-measure based on a multiply over-constrained relationship will naturally produce deviations from experimental results. Given the current limits on experimental accuracy, this is not yet the case for this new theoretical foundation for "Fundamentals" referenced in (12).

The Mass Creation Process

Given the definition of mass in (5), a conjecture is proposed: the process for increasing the mass density of a compressed volume (mass) is limited to the non-expansion of the space that volume occupies. Relative to the macro (expanding universe) point of view, this is seen as a compressive force.

If a given mass experiences no compression relative to free space $\dot{c}_{mass} = \dot{c}_{space}$, it is seen as expanding with space. There is no change to its mass density. Therefore, the lower limit of compressibility in terms of a change in mass density per unit time is $\dot{c}_{space} - \dot{c}_{mass} = 0$. The given mass experiences no change in mass density. This is of course a particle traveling at the speed of light (which is the rate of universal expansion as defined above).

Implications for the Planck Constant

In this new model, $\hbar$, which still represents quantum spin, can also be viewed as a representation of the continuous acceleration of space over time. This is easily converted to $t_{Universe}$ by dividing out UnitMass and UnitLength. From (11), this operation leaves c, which again represents the accumulated time over which the universe has expanded.

This means $\hbar$ is a measure of the spin angular momentum tied up in a UnitMass (~ $\frac{m_e}{m_p} m_e$) from a UnitVolume (~$8a_0^3$) of space compressed for a UnitTime (~1/3 Second). It is a measure of the increasing tension of the continuum of space, which is also be represented by Gravity, Hubble, and the Permeability and Permitivity of space, as indicated by c= a^{-8} UnitTime.

This description is key to the linkage between $\hbar$, a quantum of charge, and the Higgs Mass described below.

The New Physics of the Black Hole Singularity

If a given mass experiences maximum compressibility relative to free space, the space it occupies has stopped expanding $\dot{c}_{mass} = 0$. Its mass density changes at the same rate as the universe expands $\dot{r}_{space} = \dot{c}_{space}$. The upper limit of compressibility in terms of a change in mass density per unit time is $\dot{c}_{space} - \dot{c}_{mass} = \dot{r}_{space} - 0 = 1$. The given mass is seen as a black hole singularity at the limit of GR physics.

The Cosmological Constant and Models

With respect to the Cosmological Constant and the assumption of a flat universe, a conjecture is made that the energy density ratio of the cosmological constant is the cumulative effect of the changing of the constants with time. This is presented in the form of the integral:

(18) $$\Omega_\Lambda = \int_0^1 \frac{1}{\sqrt{G_{Newton}}} dt = 2/3$$

The total energy density ratio of a flat universe is:

(19) $$\begin{aligned}\Omega_{Total} &= (\Omega_{Energy}) + (\Omega_{Matter}) + \Omega_\Lambda \\ &= \left(\Omega_{CMB} + \Omega_{Neutrinos}\right) \\ &+ \left(\Omega_{Stars} + \Omega_{Baryons} + \Omega_{CDM}\right) + \Omega_\Lambda \\ &= 1\end{aligned}$$

Since the current estimates for $\Omega_{Matter} \cong \frac{1}{5}$, this leaves a reasonable $\Omega_{Energy} \cong \frac{2}{15}$.

This resolves recent experimental results[5] implying the need for new cosmological models, as well as providing a rationale for "fine tuning" problems in cosmology.

New Mass and Charge Relationships

New relationships involving electron mass and charge are found based on a predicted Higgs mass (m_{Higgs}). m_{Higgs} is directly related to $\hbar$ and an "ElectroWeak Ratio ($4p a$)".

The Electron Charge

Using (1), (4)-(10), we can now define:

(20) $$e = m_{Higgs} \cdot \sqrt{\frac{4p a}{UnitLength}}$$

The Higgs Mass

This predicts:

(21) $$m_{Higgs} = \sqrt{\hbar \cdot UnitLength} = 98.1372 \text{ GeV}$$

This is a very intriguing, intuitive, and testable prediction implying that the Higgs mechanism is fundamentally related to the source of quantum spin, gravitational attraction, the expansion and age of the universe.

References

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