Unification of the Physical Constants:
General Relativity joins Quantum Theory

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Abstract

Unification of the physical constants is announced, where gravity, quantum theory, and general relativity are linked via new physics. Unification involves a new, combined 'gravito-electromagnetic' constant, linked via Pi and Phi (the golden mean). All constants, most of which are found to run at high energies, are related via this expression. Energy, mass, and the gravitational constant are explained in those terms. The photon constant runs inversely to the gravitational constant, while both are united via a running fine-structure constant. Mass is not conserved, running with energy. Energy however is conserved. Space is a superconductor, where photons have mass. The Hubble constant is redefined, providing an alternative cause for red-shifting of photon wavelengths. A brief discussion of these findings offers an explanation via a new cosmological model that does not require inflation, singularities, dark energy, exotic dark matter, or supersymmetry. Anomalies in the Standard Model are explained. Suitable candidates are described for the cosmological constant, and mass density parameter. The Universe is found to be closed. Planck units run, and the Planck constant is calculated from theory, differing by 0.2%, as is the von Klitzing constant. Magnetic permeability, electric permittivity, and wave impedance are calculated from theory here, differing from accepted values (defined by convention) by just 0.2%. The fine structure, gravitational, and Hubble constants are defined, with accuracy for the latter two improved to 10 significant figures. These data described are all in excellent agreement with the Planck survey (2015) results. New, related constants are discussed. A novel explanation is introduced to explain the mass ratio between an electron and a proton. Predictions are made for future values of the principal running constants. These discoveries have substantial consequences for the Standard Model.

Key words: Quantum gravity; Unification of constants; running constants; Hubble Constant redefined; no singularities; no super-symmetry; no inflation; super-conductor; fine structure constant; gravitational constant; Pi; Phi; speed of light not constant; massive photons; new cosmology.

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1. Introduction

1.1 Background

General Relativity's success is attributed primarily to Einstein's[1] discovery of the equivalence principle for energy and mass within co-moving frames of reference. Current expectations are that the physical constants c, G, and α have always been, and will always be, constant. That is, invariant throughout space and time. There are however some anomalies that can not be explained by GR presently, including some experimental results involving superconductivity (discussed at ***4.8*** below).

Quantum Theory successfully describes particle interactions and forces at the micro level of physics. Gravity is too weak a force at this level to be important. However, gravity must have been a dominant force in the very early universe, and needs to be incorporated in any unifying theory.

Any such unifying theory ought to explain the superconductivity anomalies, as well as phenomena such as the Hubble constant and elementary charge. Such a theory ought to confirm or disprove super-symmetry, singularities, and inflation, as well as joining the major constants in a coherent manner.

The author announces discovery of the quantum gravity link, and provides a brief discussion regarding some unexpected consequences. These consequences are not insubstantial, and require us to re-think the model of the universe which we've come to accept as 'standard'.

1.2 Constants to choose from:

Primary physical constants that ought to be linked include -

- α – (alpha) the fine structure constant in QED, also denoted α_{em}
- c – speed of light in a vacuum (photon constant)
- G – the gravitational constant
- π – (pi)

Other parameters could include (for example) Rees[2] 'constants'; e.g. -

- $\Lambda \approx 0.7$ the ratio of the energy density of the universe, due to the cosmological constant, to the critical density of the universe (also called Ω_Λ);
- $D = 3$ the number of macroscopic spatial dimensions

1.3 Alpha

Alpha, α_{em} the fine structure constant for QED is well known quantitatively. The most precise value currently obtained is

α_{em} = 7.297 352 5698(24) x 10^{-3} (CODATA 2010)[3], or

α_{em} = 7.297 352 5664(17) x 10^{-3} (CODATA 2014)[4].

Feynman[5] on alpha said:-

> *'…all good theoretical physicists put this number up on their wall and worry about it.'*

Also as expressed by Pauli[6]

> *'But we are unable to understand or explain the above number.'*

It is essential that any unifying theory should complete our understanding of the contribution to cosmology, of the Fine Structure Constant.

1.4 Gravitational constant

Then there is the Gravitational Constant, G = 6.674 08(31) x 10^{-11} N.m^2/kg^2 (CODATA 2014), of which Wilczek[7] wrote:-

> *'When we come to seek a unified theory including all the forces of nature, the combination of gravity's universality and its (apparent) feebleness poses great difficulties.'*

This sentiment is echoed by Hawking and Mlodinow[8] –

> *'The standard model is very successful and agrees with all current observational evidence, but is ultimately unsatisfactory because, apart from not unifying the electro-weak and strong forces, it does not include gravity.'*

Thus any solutions for quantum gravity should actually include gravity, providing a better understanding of the constants themselves, and their fundamental interactions.

2. Methodology

2.1 Fine Structure Constant

Starting with alpha (all constants used are from CODATA 2014 except as specified): [all references to α_{em} in this paper are written as α for simplification] -

$$\alpha = \frac{e^2}{4\pi\varepsilon_o \hbar c} \qquad [1]$$

$$= \qquad 7.297\,352\,5664(17) \times 10^{-3}$$

where:

c is the speed of light (photon constant) = 299,792,458 m.s^{-1}

e is the elementary charge (proton) = 1.602 176 6208(98) x 10^{-19} C

ε_o is the electric constant or permittivity of free space; = 8.854 187 817… x 10^{-12} F.m^{-1}

$\hbar$ = h/2π, reduced Planck constant

from which we get

$$c = \frac{e^2}{4\pi\varepsilon_o \hbar\alpha} = \frac{e^2}{2\varepsilon_o h\alpha} \qquad [2]$$

and

$$\alpha = \frac{\mu_o e^2 c}{2h} \qquad [3]$$

(μ_o = magnetic permeability of space: defined by convention = 4π x 10^{-7} H.m)

and
$$\frac{\mu_o e^2}{2h} = \frac{\alpha}{c} = \; 2.434134806 \times 10^{-11} \qquad [4]$$

2.2 Phi: the overlooked constant

The 'Golden Ratio' appears almost everywhere in the universe. An elegant summary is provided by Frost and Prechter[9] -

> *'While Euclidean geometric forms (except perhaps for the ellipse) typically imply stasis, a spiral implies motion: growth and decay, expansion and contraction, progress and regress. The logarithmic spiral is the quintessential expression of natural growth phenomena found throughout the universe. It covers scales as small as the motion of atomic particles and as large as galaxies.'*

Phi ought to be regarded as a scaling ratio, which does appear (from our perspective) to hold true throughout the universe. Boeyens and Thackeray[10] anticipated its prominence also:-

> *'Apart from the Golden Ratio, a second common factor among this variety of structures is that they all represent spontaneous growth patterns. The argument that this amazing consilience ('self-similarity') arises from a response to a common environmental constraint, which can only be an intrinsic feature of curved space-time, is compelling.'*

[Interestingly, in reference [8] there are no less than 8 colour plates depicting the golden ratio in various natural forms.]

It seems logical then for the principal constants to be united via Phi. Using ϕ = 1.618 033 988…, we can postulate that Phi cubed per three macroscopic dimensions ought to express the scale ratio or growth factor for 3-dimensional space. In this sense Phi also functions as a 'time' component of space-time, or at least specifies the rate of change of time.

$$\frac{\phi^3}{3} = 1.412022657\ldots \quad [5]$$

Combining [4] & [5] we get

$$\frac{\phi^3 \alpha}{3c} = 3.437053497 \text{ x } 10^{-11} \quad [6]$$

Next we need to account for curvature of space, per growth rate (time); Pi divided by Phi

$$\frac{\pi}{\phi} = 1.94161104\ldots \quad [7]$$

Combining then equations [6] & [7] we get

$$\frac{\pi\phi^2\alpha}{3c} = \quad 6.673421013 \text{ x } 10^{-11} \quad [8]$$

This of course is our Gravitational constant G . And because of [4] and [8] we also get

$$G = \frac{\pi\phi^2\mu_o e^2}{6h} \quad [9]$$

2.3 Preliminary results

Using a common scientific calculator the author obtained a value for G of 6.673421015 x 10^{-11}. [The author originally used CODATA 2010 data, so this paper compares both year values.] CODATA 2014 values for the other constants were then used to obtain G via equations [8] and [9] above. An online calculator was also used for comparison, with Pi and Phi to 30 decimal places.

Differences in the various results are systemic errors due to uncertainties in the CODATA values, particularly alpha, the elementary charge, and the Planck constant h . Further systemic errors (small) are rounding errors between the two calculators used. A provisional value was assigned for G at 6.673421013(10) x 10^{-11} N.m^2/kg^2, which is well within the error range of the CODATA 2010 data, and in excellent agreement with CODATA 2014. But as we will presently discover, the value for G in this paper should be preferred.

However, due to the new relationships discovered here, it requires that the values for some constants need reinvestigation.

2.4 Alternative (new) definitions for ε, z and μ

Initially the discovery discussed in this paper showed how the gravitational constant interacted with other principal constants. Further analysis showed there are deeper relationships, requiring redefinition of the constants below.

Electrical permittivity and magnetic permeability of the vacuum were set by convention (1948), where permeability μ_o has been set to 4π x 10^{-7} H. m^{-1}, from the definition of the ampere. Permittivity ε_o was thus as a consequence set to be 8.854187817.. x 10^{-12} F. m^{-1}, since $\varepsilon_o \mu_o = \frac{1}{c^2}$. Wave impedance (impedance of vacuum) is $z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}}$ and has the CODATA 2014 value of 376.730 313 461 ohms. From equations [10], [11] below, values can be derived here from theory, which are close to the present (accepted by convention) values.

[Using $\alpha = 7.297352566$ x 10^{-3}; CODATA 2014]

Using $\mu_o \varepsilon_o = \frac{1}{c^2} = \left(\frac{3G}{\pi\phi^2\alpha}\right)^2$, and from [9] we obtain $\frac{G}{\mu_o} = \frac{\pi\phi^2 e^2}{6h} = 0.000053251 = \alpha^2$, so

$$\mu_o = \frac{G}{\alpha^2} = \frac{\pi\phi^2}{3\alpha c}\text{, which has the value } 1.253192727 \text{ x } 10^{-6} \qquad [10]$$

$$\text{and } \varepsilon_o = \frac{9G}{\pi^2\phi^4} = \frac{3\alpha}{\pi\phi^2 c}\text{, which has the value } 8.878523088 \text{ x } 10^{-12} \qquad [11]$$

$$\text{Since } \mu_o c = z_o \text{ this means } z_o = \frac{Gc}{\alpha^2} = \frac{\pi\phi^2}{3\alpha} = 375.697728 \qquad [12]$$

The values obtained for $\mu_o, \varepsilon_o, z_o$ above differ from their current SI definitions today by 0.274%.

From [10] we see of course that $G = \alpha^2 \mu_o = \frac{\alpha^2}{\varepsilon_o c^2}$ (more on this below). [13]

2.5 Elementary charge and Planck constant

The elementary charge is given as

$e = 1.602\ 176\ 6208(98)$ x 10^{-19} C (CODATA 2014); $U_r = 6.1$ x 10^{-9}

And the Planck constant as

$h = 6.626\ 070\ 040(81)$ x 10^{-34} J.s (CODATA 2014); $U_r = 1.2$ x 10^{-8}

From [1], [2], [3], & [9] we can see that

$$e^2 = 2\varepsilon_o h\alpha c = \frac{2\alpha h}{\mu_o c} = \frac{6Gc^2\varepsilon_o h}{\pi\phi^2} = \frac{6Gh}{\pi\phi^2\mu_o} = \frac{6\alpha^2 h}{\pi\phi^2} \qquad [14]$$

which combines to form the Elementary charge-Planck constant ratio (von Klitzing constant), which is

$$\frac{h}{e^2} = \frac{\mu_o c}{2\alpha} = \frac{1}{2c\alpha\varepsilon_o} = \frac{\pi\phi^2}{6\alpha^2} = \frac{\pi\phi^2\mu_o}{6G} = 2.574205677 \text{ x } 10^4 \qquad [15]$$

The von Klitzing constant is best measured using one variable, alpha, as in $\frac{\pi\phi^2}{6\alpha^2}$ which gives the above result. This differs from CODATA 2014 recommended value by about 0.274%. [Using CODATA 2014 values produces alpha to be 7.287344995 x 10^{-3}.]

Using the CODATA 2014 value for α, h and values obtained from theory here for $\varepsilon_o, \mu_o, G,$ we find $e =$ 1.604 376 859 x 10^{-19} C, which is 0.137% larger than the CODATA 2014 recommended value.

Conversely, since e has a lower relative uncertainty, using that value and alpha from CODATA 2014 yields $h =$ 6.607908552 x 10^{-34} J.s, which is about 0.274% smaller than the CODATA 2014 value.

It is likely both values need adjustment. Interestingly e is close to $(6G)^2 =$ 1.603243729 x 10^{-19}, and also very close to $\frac{\pi^2 G}{2c\phi^4} =$ 1.602680715 x 10^{-19}. However, it can not be either of these due to running (see below). In any event, from the calculation of c via [8] & [9] above it can be seen that the ratio $\frac{\alpha}{G} = \frac{1}{\alpha\mu_o} =$ 1.093495008 x 10^8, which, if alpha is correct for CODATA 2014, means $\mu_o =$ 1.253192727 x 10^{-6}. [If μ_o is to remain set by convention at 4π x 10^{-7} then alpha becomes 7.277351151 x 10^{-3}, which is 0.2748% smaller than accepted presently.]

Proof of concept

Alpha can also be found using Coulomb's constant $k = \frac{1}{4\pi\varepsilon}$ then using this constant to find alpha via $\alpha = \frac{ke^2}{\hbar c}$. Using the CODATA 2014 value for the elementary charge and other values from this paper for ε, h, G we find

$$\alpha = \frac{\pi^2\phi^4 e^2}{18Ghc} = 7.297352566 \text{ x } 10^{-3}, \qquad [16]$$

which is identical to CODATA 2014 for alpha.

Note: These small changes to μ_o, ε_o mean that a number of constants need to be re-evaluated, including the Josephson constant, conductance quantum, Bohr magneton, Bohr radius, Rydberg constant, and Hartree energy. For example, the Rydberg constant will be about 0.2748% larger.

In this present paper we will use the CODATA 2014 value for the elementary charge, resulting in the lower value for the Planck term via the von Klitzing constant as stated above. These are still in excellent agreement with the CODATA values.

3. Results

3.1 The Constants

We now have our first equations for quantum gravity. Rearranging for each constant, we get

$$G = \alpha^2 \mu_o = \frac{\alpha^2}{\varepsilon_o c^2} = \frac{\pi\phi^2 \mu_o e^2}{6h} = \frac{\pi\phi^2\alpha}{3c} = \frac{2\alpha^3 h}{ce^2} = \frac{\pi^2\phi^4\varepsilon_o}{9} \qquad [17]$$

$$c = \frac{2\alpha h}{\mu_o e^2} = \frac{\pi\phi^2\alpha}{3G} = \frac{e^2}{2\varepsilon_o h\alpha} = \frac{z_o\alpha^2}{G} = \frac{2\alpha^3 h}{Ge^2} \qquad [18]$$

$$\alpha = \frac{e^2\mu_o c}{2h} = \frac{3Gc}{\pi\phi^2} = \frac{e^2}{2\varepsilon_o ch} = \sqrt{G\varepsilon_o c^2} = \sqrt{\frac{G}{\mu_o}} = \frac{\pi\phi^2 c\varepsilon_o}{3} = \frac{\pi^2\phi^4 e^2}{18Ghc} \qquad [19]$$

$$\pi = \frac{6Gh}{\phi^2 e^2 \mu_o} = \frac{3Gc}{\alpha\phi^2} = \frac{6\alpha^2 h}{\phi^2 e^2} \qquad [20]$$

$$\phi = \sqrt{\frac{6Gh}{\pi e^2 \mu_o}} = \sqrt{\frac{3Gc}{\pi\alpha}} = \sqrt{\frac{6\alpha^2 h}{\pi e^2}} \qquad [21]$$

[Further expressions for all these constants and others appears below in Appendix 1]

3.2 Gravitational constant

Our Gravitational constant is the square of the fine structure constant per permittivity of space at the photon constant squared. The last expression in [16] above shows its relationship with the Hubble constant. (See below in Discussion, and Consequences.) It also joins the photon constant to form the gravito-electromagnetic constant (see [32] to [34] below.)

So using $G = \dfrac{\pi\phi^2\alpha}{3c}$, and recalculating, we get as follows –

Method for calculation	Device used	CODATA value used for alpha (year)	G x 10^{-11} $N.m^2/kg^2$
Equation 8	Sharp EL-531WH	2010	6.673421016
Equation 9	Sharp EL-531WH	2010	6.673421014
Equation 8	Sharp EL-531WH	2014	6.673421013
Equation 9	Sharp EL-531WH	2014	6.673421011
Equation 8	Web 2.0 online calc	2010	6.673421022805
Equation 9	Web 2.0 online calc	2010	6.673421020586
Equation 8	Web 2.0 online calc	2014	6.673421019696
Equation 9	Web 2.0 online calc	2014	6.673421017476

Table 1. Values recalculated for *G* using two methods. Equation 9 modified as described for other constants.

Mean results for 2010 are 6.67342101835 x 10^{-11} and for 2014 are 6.67342101529 x 10^{-11}. The results are very tight within each device grouping, showing the inherent systemic errors of calculation. Differences between 2010 and 2014 simply reflect the adjustment of alpha by CODATA over this time. Our earlier result is confirmed and tightened for 2014 at $G =$ 6.673421013(+7, –2) x 10^{-11} $N.m^2/kg^2$.

This result is in excellent agreement with CODATA 2014 value, and differs, on either device by only 3.5 x 10^{-15} (0.005%). Tightening of the data confirms the alternative values for $\mu_o, \varepsilon_o, z_o$ above, and therefore also for e, h at [14] above.

3.3 Other expressions for G

The speed of light c can also be expressed in this form –

$$c^2 = \frac{1}{\mu_o \varepsilon_o} \tag{22}$$

From [2], [8] and [21] we can also see that

$$G = \frac{\pi\phi^2\alpha.\sqrt{\mu_o\varepsilon_o}}{3} = \frac{\pi\phi^2 e^2 \mu_o}{6h} \quad \text{also} \tag{23}$$

Newton's equation for the gravitational force is

$$F_g = G\frac{m_1 m_2}{r^2} \tag{24}$$

So combining [8] & [23] and using m = total mass for the system under investigation, we can see that if

$$G = \frac{F_g r^2}{m} \quad \text{then} \quad \frac{F_g r^2}{m} = \frac{\pi\phi^2\alpha}{3c} \quad \text{so} \quad c = \frac{\pi\phi^2 m\alpha}{3F_g r^2} \tag{25}$$

3.4 Einstein's energy-mass equation

Bringing in the shortened form of Einstein’s equation with [8], we have

$$E = m\left(\frac{\pi\phi^2\alpha}{3G}\right)^2 = \frac{m\pi^2\phi^4\alpha^2}{9G^2} \qquad [26]$$

And solving for *m* gives us

$$m = \frac{9G^2E}{\pi^2\phi^4\alpha^2} \qquad [27]$$

Using [8] & [24] and solving for *E* we have

$$E = \left(\frac{\pi\phi^2\alpha}{3F_g r^2}\right)^2 m^3 \qquad [28]$$

The full form of Einstein’s equation, for moving particles is

$$E = \frac{mc^2}{\left(\sqrt{1-\frac{v^2}{c^2}}\right)} \qquad [29]$$

From equations [8], [21] & [28] we see G is thus -

$$G^2 = \frac{m\left(\pi\phi^2\alpha\right)^2}{9E\left(\sqrt{1-v^2\mu_o\varepsilon_o}\right)} \qquad [30]$$

And of course $$E = \frac{m}{\sqrt{1-\frac{v^2}{c^2}}}\left(\frac{\pi\phi^2\alpha}{3G}\right)^2 \qquad [31]$$

3.5 Dimensionless quantities

From [32] and [34] (below) it is obvious that the principal constants c, G, α form a constant ratio, provided the same system of units is used (e.g. SI) to measure each variable. The fine structure constant is dimensionless when $\alpha = \frac{e^2}{2\varepsilon_o hc}$, but not so using other expressions.

Consider the following dimensional qualities –

[c] = LT^{-1} but using $c = \frac{\pi\phi^2\alpha}{3G}$ gives $MT^2 L^{-3}$

[G] = $L^3 M^{-1} T^{-2}$ but using $\alpha^2\mu_o$ is $MLT^{-2}I^{-2}$ or using $\frac{\pi\phi^2\alpha}{3c}$ gives TL^{-1}

So, each expression changes the dimension units. These are ratios however, simply being used as conversion factors between constants. Duff[11] stated –

> *'Any theory of gravitation and elementary particles can be characterized by a set of dimensionless parameters such as coupling constants α_i (of which the fine-structure constant, $\alpha = e^2/\hbar c$, is an example), mixing angles θ_i and mass ratios μ_i.'*

Duff again –

> *'In summary, it is operationally meaningless and confusing to talk about time variation of arbitrary unit-dependent constants whose only role is to act as conversion factors.'*

Matsas[12] *et al* concluded that -

> *'…the number of dimensional fundamental constants is two.'*

And –

> *'…eventually, all we can directly measure are space and time intervals. In particular, this implies that one only needs two units to express all measurements.'*

They later conclude that one could adopt certain protocols to eliminate the mass unit and any remaining fundamental constants, such that all quantities would be dimensionless numbers. In this present work, we have two units that are proxies at least for some measurement of space and time, namely pi and phi. As such, they can be used together to describe the other constants (from [8], [9] earlier):-

$\pi\phi^2 = \dfrac{6Gh}{\mu e^2} = \dfrac{3Gc}{\alpha} = \dfrac{3\alpha}{c\varepsilon}$ which render the constants, as ratios, to be dimensionless. This becomes obvious, as in ***3.1*** above, also Appendix 3, and throughout this paper, all the constants are related via the photon constant, and (mostly) alpha, which itself is dimensionless. We suggest then that the principal constants, when used as conversion factors or ratios, can be regarded as dimensionless for this purpose.

3.6 The inconstant constants

On the speed of light, Hamilton[13] said

> *'What is there about the value of this constant that warrants such absolute authority, especially since we are now seeing evidence that the speed of light has been marginally increasing as we look into the distant past of the cosmos?'*

And also,

> *'The constancy of c and G appear to be at the heart of the inconsistencies in the standard model of cosmology and far from disposed of in inflation scenarios.'*

Why would the speed of light not be variable, in a varying density universe? From [2] and [3] we can see that if α is variable, then one or more of $\varepsilon_o, \mu_o, e^2, G,$ and c must also be variable at high energies/short distances. If α 'runs' larger at high energy there must be proportional running of ε_o (or the latter runs at the square rate) and inversely proportional to the running of c.

Also in [8], [16] with $\pi\phi^2 / 3 = Gc/\alpha$ it can be seen that if the former is invariant then Gc must be proportional to α. Thus if α runs, then G, or c or both must likewise vary. It follows then, that Gc/α must be a new constant.

$$\frac{Gc}{\alpha} = \frac{\pi\phi^2}{3} = 2.741598779\ldots \qquad [32]$$

Recent findings at CERN e.g. the L3 Collaboration[14], the TOPAZ Collaboration[15], and, from other sources eg Burkhardt & Pietrzyk[16] show that the fine structure constant for QED increases at high energies. In Reference 16 the authors found that at the energy of the *Z*-boson (m_z^2) the corresponding value for $1/\alpha_{em}$ = 128.936 ± 0.046.

Perhaps this increase in alpha can be better understood as a combination of [21] & [32] above –

$$\frac{\pi\phi^2}{3} = \frac{Gc}{\alpha} = \frac{G}{\alpha\left(\sqrt{\mu_o\varepsilon_o}\right)} \qquad [33]$$

or as $$\pi\phi^2 = \frac{6Gh}{e^2\mu_o} = \frac{3G}{\alpha\left(\sqrt{\mu_o\varepsilon_o}\right)} = \frac{3Gc}{\alpha} = 3c\alpha\mu_o = 8.224796339\ldots \qquad [34]$$

These expressions in [32] to [34] are constant, and for convenience we could call them: [32], [33] the 3-dimensional interaction constant, or gravito-electromagnetic constant; and [34] could be called the scalar-curvature constant. These expressions permit the individual 'constants' to run, without altering the overall interaction ratios. In each of these simple expressions, Nature's fundamental parameters, change, and motion are encapsulated within an elegant equivalence. The significance of these constants will be seen when we discuss the Hubble constant and other measured data below.

We should find (on a look-back into the earlier universe) that as electric permittivity increases, G should also increase (greater energy density), and likewise α. Since the inverse root product of $\mu_o\varepsilon_o = c$, it means c must *decrease*, and since α and c are inversely proportional we find an increase in α will -

1. be attended by a proportional decrease in c, and

2. G will strengthen by the square of the rate of increase of α (see also [10], [13])

4. Discussion

4.1 Running of the 'constants'

From the various research mentioned earlier, and as explained by Tobar[17] –

> *'…the running of the fine structure constant is due to equal components of electric screening (polarization of vacuum) and magnetic anti-screening (magnetization of vacuum), which cause the perceived quanta of electric charge to increase at small distances, while the magnetic flux quanta decreases.'*

As discussed, the photon constant c ought *not* to be 'constant' over time or higher energy gradients. From [2], [3], [33], and [34] we can see that as c runs, permittivity must run also, at the inverse square to the photon constant. From $E = h\nu$ we know that energy will change with frequency, and from $c = \lambda\nu$ combined with $h = \frac{E\lambda}{c}$ we see that as wavelengths increase, c must increase proportionally. And since $c^2 = \frac{1}{\mu_o\varepsilon_o}$ and $\mu_o c = \sqrt{\frac{\mu_o}{\varepsilon_o}} = z_o$ it follows that electric permittivity must run inversely proportional to c^2, and $z_o^{\ 2}$. Thus $\mu_o c$ and its' inverse, $c\varepsilon_o = \frac{1}{z_o}$ are also running constants. (Assuming permeability does not run.)

This means space is a superconductor, increasing in superconductivity as we look further back into the past. Photons have mass (very small now but much larger in the past), and all particles were increasingly massive in the earlier universe. Wilczek[7] had already predicted this –

> *'We live inside an exotic superconductor that hides the symmetry of the world.'*

And as shown by Tajmar[18]

> *'In quantum field theory, superconductivity is explained by a massive photon, which acquired mass due to gauge symmetry breaking and the Higgs mechanism. The wavelength of the photon is interpreted as the London penetration depth.'*

The author investigated several models, 4 of which interact such that the various equations used will hold true. Two models have the photon constant not running, and in the further two it does. The former two models essentially produce the status quo, i.e. they do not explain the anomalies of the standard model. One of the 'running' c models is discussed here. This is perhaps the only 'running' model where energy is conserved. [Running of the constants is further supported in the wider 'discussion' below, where it is an inevitable consequence of the new cosmic model we ought now to consider.]

Figure 1 shows the relative strength on running of G, c, and α at the inverse strength of alpha as energy increases.

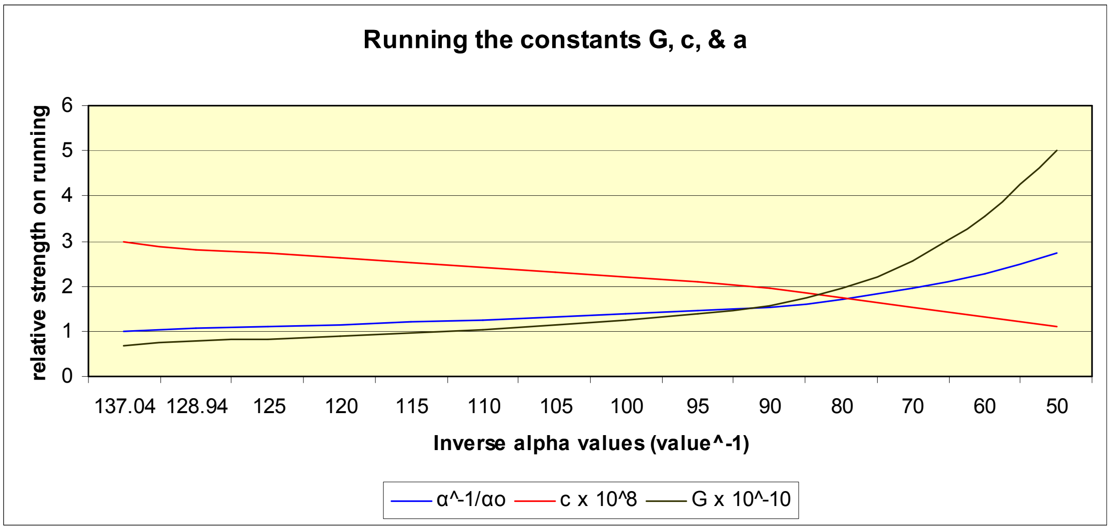


Figure 1: Running of the 'constants' G, c, and α where values are plotted against the inverse of alpha at increasingly greater energies. The speed of light decreases in the same proportion as the increase in α but G increases at the *square* of the increase in α.

A small increase in the fine structure constant is accompanied by a similar increase in mass. This is observed in particle accelerators. This occurs in a higher G, lower c environment. Since $m = \frac{h}{\lambda^2 \nu}$, mass increases as wavelength decreases, and the Planck constant runs inversely to mass. Looking back in time G becomes stronger than all other forces, while c continues towards zero without arriving there. [An alternative model allows h to remain constant.]

Figure 2 shows the running of the constants towards their limits.

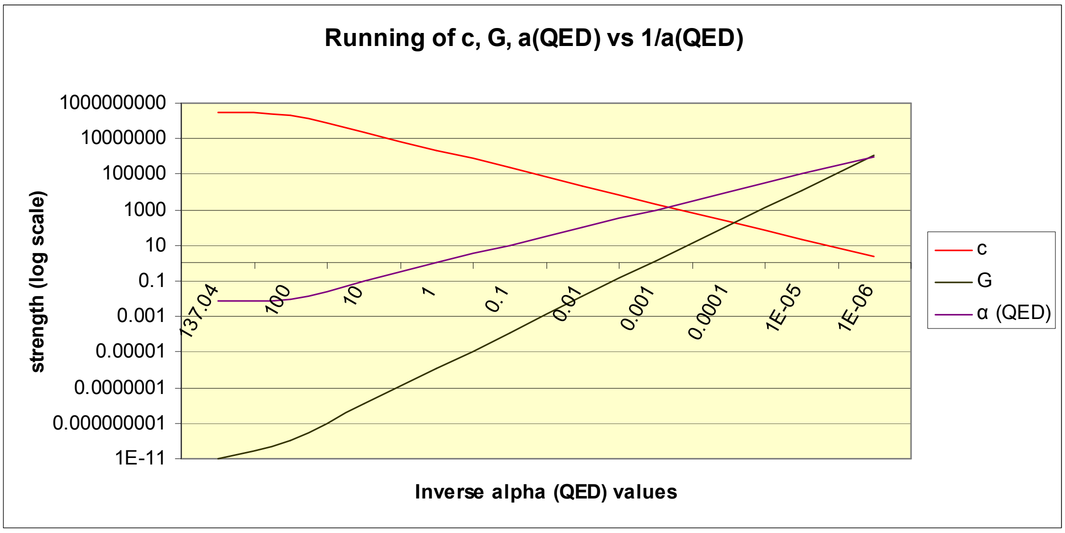


Figure 2: Running the constants on towards infinity.

4.2 Rules on running

1. α runs, and we know its rate[14],[15],[16] and from [13], [32] G runs at the square, in same direction (stronger in the past);
2. c may or may not run; if it does it will be slower in the past. It is most likely that $c\alpha$ is a constant, thus consigning the photon constant to run inversely proportional to alpha;
3. z runs proportionally with c;
4. G runs proportionally to ε (see ***5.1 Hubble constant***);
5. If $m\lambda$ is constant, h and c run proportionally or are constant; but probably run;
6. the von Klitzing constant $\frac{h}{e^2} = \frac{\pi\phi^2}{6\alpha^2}$ runs at the square of alpha, so if h runs, e^2 must run proportionally with alpha, and inversely to the Planck term;
7. if ε or μ run, the two must total 0, or 2 in running terms, and together run inversely to c^2;
8. if energy does not run, mass runs proportionally with G; otherwise mass runs proportionally with alpha, and energy runs proportionally with c;
9. if mass runs proportionally with G, then wavelengths run at the square of c ,and frequency runs proportionally with alpha. Alternatively, if energy runs proportionally with c, mass runs proportionally with alpha, frequency does not run, and wavelengths run proportionally with c;
10. due to 1, 4, and 9 above, radii will be inversely proportional to mass on running, whichever alternative is used.

In order to test the running of the constants (and confirm their relationships) a simple directional strength vector system can be used. Constants are found to have the following relative magnitudes and directions on running, on a time-reversed basis (looking back towards the earlier universe) –

Single constant					
constant	vector	constant	vector	constant	vector
α	↑	c	↓	π	0
e^2	↑	h	↓	$Φ^2$	0
Composite constant					
constant	vector	components	constant	vector	components
G	↑↑	$α^2μ$	z	↓	cμ
ε	↑↑	$9G/π^2Φ^4$	μ	0	$G/α^2$

Table 2: time-reversed vector on running of the constants. ↑ means increasing in strength, ↓ is decreasing in strength, 0 means no change.

As an example, consider equation [32] above. It would appear, using running vectors as –

$$\frac{\pi\phi^2}{3} = \frac{--}{-} \equiv \frac{Gc}{\alpha} = \frac{\Uparrow\downarrow}{\uparrow} = \text{ no overall running; stable}$$

4.3 Other Constants

If permittivity and wave impedance run, then so does e the elementary charge.

The following relationships are found to be constant (but individual terms are not, except for π, ϕ, μ_o):-

$$\frac{3}{\pi\phi^2} = \frac{e^2\mu_o}{2Gh} = \frac{\alpha}{Gc} = 0.364750673\ldots \text{ (inverse of [29])} \qquad [35]$$

and $$c\alpha = \frac{3G}{\pi\phi^2\varepsilon_o\mu_o} = \frac{e^2}{2h\varepsilon_o} = 2{,}187{,}691.263; \text{ inverse} = 4.571\ 028\ 906 \times 10^{-7} \qquad [36]$$

and $$ce^2 = \frac{2h\alpha}{\mu_o} = 7.716733132 \times 10^{-30}; \text{ inverse} = 1.295885167 \times 10^{29} \qquad [37]$$

and $$2h\varepsilon_o c = \frac{e^2}{\alpha} = \frac{2h}{z_o} = 3.527341021 \times 10^{-36}; \text{ inverse} = 2.834996656 \times 10^{35} \qquad [38]$$

and $$Gc^2 = 5{,}997{,}771.697 = \frac{GE}{m} = \frac{G}{\mu_o\varepsilon_o}; \text{ inverse} = 1.66728587 \times 10^{-7} \qquad [39]$$

and $$\frac{G}{\alpha^2} = \frac{\pi\phi^2}{3\alpha c} = \mu_o = 1.253192727 \times 10^{-6}; \text{ inverse} = 7.979618602 \times 10^{5} \qquad [40]$$

So we suggest then, that α, e^2, run inversely to c, h, z_o proportionately, and μ_o doesn't run. ε_o runs proportionally with G, which is at the square of the increase to the first terms (the running due to being the square of the fine structure constant). We find the various Planck units derived from h, c, G also run.

Because $\frac{\alpha}{c} = \frac{3G}{\pi\phi^2} = \frac{\mu_o e^2}{2h}$ we get $h = \frac{\mu_o e^2 c}{2\alpha}$ and $h = \frac{\pi\phi^2 \mu_o e^2}{6G}$ which runs. [41]

Similar to Table 2 above, a test for other entities including mass and energy shows their responses upon running, in this model.

Components and other entities					
entity	vector	components	entity	vector	components
λ	↓↓	c/v	m	↑↑	$h/\lambda^2 v$
v	↑	c/λ	E	0	hv
F_g	↑↑↑↑↑↑	Gm/r^2	r^2	↓↓	Gm/F_g

Table 3: time-reversed vector on running for other entities and components.

4.4 Energy and mass

Note that energy E is conserved and does not run (in this model), even in higher gravity. At first this appears counterintuitive. However, we see that since

$E = mc^2$ and $m = \frac{E}{c^2} = E\mu_o\varepsilon_o$, and we now know that $\mu_o = \frac{G}{\alpha^2}$, then $m = \frac{GE\varepsilon_o}{\alpha^2}$. [42]

This shows that the gravitational influence is *hidden* from first consideration in Einstein's equation. When rearranged we then get $GE = \frac{m\alpha^2}{\varepsilon_o}$ and the fuller expression $G^2 E = \frac{m\pi^2\phi^4\alpha^2}{9}$. (See [27]).

The running gravitational contribution to total energy coincides with mass running proportionally, while E is conserved. When we use $\frac{\pi^2\phi^4}{E} = \frac{9G^2}{m\alpha^2}$ (rearrangement of [26]) we see that energy is conserved, but mass is *not.* It is suggested that this is what is seen routinely in particle accelerator collisions, where the constants run at high energies.

4.5 Momentum 'runs'

Momentum $p = mv$ (where *v* is velocity in 3-dimensions) appears to be conserved in local frames, but runs due to the running of *m.* For massless particles (eg the photon apparently), $p = mc$. We rearrange with [17] to find that -

$$p = mc = \frac{m\pi\phi^2\alpha}{3G} = \frac{3GE}{\pi\phi^2\alpha} = \frac{h}{\lambda}$$, which then runs. [43]

In this particular example the equation is only valid if photons are massless. From [27], [32], and [53] photons must have mass. The equation [43] is thus redundant. The equation then ought to be –

$$p = \frac{mv}{\sqrt{1 - v^2\mu_o\varepsilon_o}} \quad \text{or} \quad p = \frac{9vG^2E}{\pi^2\phi^4\alpha^2} = \frac{3vGh}{\pi\phi^2\alpha\lambda} = \frac{v\mu e^2}{2\alpha\lambda}$$ which then runs as before [44]

(only when the other constants run). This occurs due to the photon constant running.
This occurs in all reference frames. [Note: running only occurs when the other constants run.]

4.6 Gravity

Gravity appears to operate via the fine structure constant, alpha. We can see from [13] why G runs at the squared rate for alpha. As gravity increases, a particles' cross-section must diminish, including the spatial component. Since space has been likened to a foamy structure[7] it appears that space itself must diminish (or is squeezed) in a higher gravitational environment. A convenient way to mentally picture this is the act of squeezing a sponge.

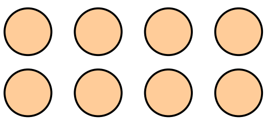
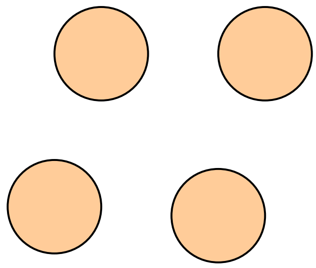


Figure 3. On the left, atoms in the early universe. Today they are larger (more space between, and within) as gravity relaxes its hold.



From [23] & [24] and rearranging to $r^2 = \frac{Gm}{F_g} = \frac{\pi\phi^2 m\alpha}{3F_g c}$ [45]

and from Table 3 above we can see that in higher gravitational environments (the 'core', black holes, and other dense stellar objects, and likely in superconductive states), spatial distances between particles must reduce. This confirms that the universe was smaller – in our 'Standard Model' understanding of it – in the past.

If gravity operates via the fine structure constant, which operates on quantized 'particles', which themselves are disturbances in their fields of operation, then gravity itself must also be quantized. Perhaps gravity controls the 'graininess' of space, allowing it to expand as gravity relaxes. It seems natural to conclude that continued research in the direction of Loop Quantum Gravity ought to be fruitful.

4.7 Dark energy, dark matter

We see from Table 3, ***4.3***, and ***4.5*** above that the accelerating universe is an illusory artifact based on the assumption that the photon constant is actually constant. Table 3 shows that as G increases, mass increases proportionally but radii *decrease*. It appears as though gravity may control expansion and contraction of the 'graininess' of space. This further evidences, on a time-reversed basis, the increased superconductance of space-time (indicating a greater superconductive state may be the preferred state for the system). From [27], [28] we can see that this occurs due to $E = \frac{m\pi^2\phi^4\alpha^2}{9G^2}$, where the gravitational component of a body or system is masked by gravity's feebleness at the present time. In the core – from running values in this paper – G would be 5.997771695 x 10^6 when the photon constant = 1 m/s. The gravitational contribution at this point is very high. In the 'standard model', as the universe appears to expand, energy apparently is introduced into the system via *dark energy.* Apparently this energy is provided by *dark matter.* What occurs, we suggest, is that the 'graininess' of space dilates at the expense of gravity and mass. Although this present model (Tables 2, 3) is speculative, it provides an alternative explanation that makes sense. Also there appears to be little evidence thus far for *dark energy* and *dark matter.* (That is, matter other than neutrinos, brown dwarfs, exoplanets, and other natural 'dark' objects).

4.8 Further Support

1. Experimenters using gravity superconductors claim to have produced momentum transfers of a strong gravity-like nature, in a 'recoil' when the superconductive condition is released. Modanese[19] discusses these results, and states the effect produced can not be explained by general relativity. They found a transfer of momentum where $\frac{hf}{P} = 1m/s$, which is equivalent to reducing c to this value. Such effects are predicted in this present (unification) paper, and reducing c will produce a high G moment. We assume that during the brief superconductive phase particles become more massive under high G , then the 'recoil' upon release is likely an energetic gravitational wave.

2. Tajmar and de Matos[20][21] reported on repeated superconductor experiments producing large gravitomagnetic moments which they describe as caused by non-zero graviton mass. They also report that the photon mass increases, and that these phenomena produce a higher mass for the Cooper-pair electrons, that is not explained by general relativity. They further discuss at[22] local photon and graviton mass causes. Such results are predicted by theory in our present paper.

5. Quantum Forces and Other Constants

5.1 Hubble Constant

The Hubble Constant or Hubble Parameter is apparently the expansion rate for space since the big bang. If the universe is expanding, we measure that expansion rate by the rate of red-shifting of spectral wavelengths. Apparently space stretches the wavelengths before they are observed. However the overall structure of the universe is still not well understood.

The author suggests the universe may be a toroidal structure (eg. horned torus), where boundary conditions are an as yet undefined continuum within the confines of stated space-time constants. This view is supported in part because the universe appears to be expanding at an accelerating rate[23][24], combined with running of the constants, yet the best candidate for the Hubble constant, as stated below, is a static number. A non-running Hubble constant implies that expansion of the universe is fixed.

If the universe is a torus, the Hubble constant will need to be redefined. We suggest it is actually the roll-out constant (about the minor axis of the torus), formed by the product of the scalar-curvature constant $\pi\phi^2$ with the (equivalent) 3-dimensional force-interaction or gravito-electromagnetic constant

$$\pi\phi^2 \times \frac{3Gc}{\alpha} = 67.64727481\ldots$$

Alternatively it can be viewed as the density constant multiplied by the spatial curvature constant (from (9), 'Consequences' below);

$$\pi^2\phi^4 = \left(\frac{3Gc}{\alpha}\right)^2 = 67.64727481\ldots.. \qquad [46]$$

or the square of the von Klitzing constant x 36 alpha to the fourth power; and since $\varepsilon_o = \frac{\alpha^2}{Gc^2}$ then the Hubble constant is also

$$\pi^2\phi^4 = \frac{36\alpha^4 h^2}{e^4} = \frac{9G}{\varepsilon_o} \qquad [47]$$

Another view (as expressed below also) is that both the pi and phi terms relate to the radius of space as a ratio of mass and curvature (or perhaps gravity and curvature). However it arises, the Hubble term in this paper is intrinsically related to the physical constants (see Appendix 1), and is impossible to ignore. Also, and significantly, it is in excellent agreement with the 2015 Planck[25] survey data for the Hubble constant of 67.8 ± 0.9 (km.s^{-1} per Mpc). [In our expression the Hubble constant is a dimensionless ratio.]

It also pins down the age of the universe at $\frac{1}{\pi^2\phi^4} = 0.014782561$, which translates to 14.454 Gyr. In our model, this would be the age from last exit from the core.

5.2 Mass Density Parameter

A suitable candidate for mass density appears to be the following expression, per phi (scale factor) –

$$\Omega_m = \frac{\varepsilon_o hc\alpha}{e^2} \div \phi = \frac{\varepsilon_o hc\alpha}{e^2\phi} = \frac{3Gc}{2\pi\phi^3\alpha} = \frac{1}{2\phi} = 0.309016994\ldots \qquad [48]$$

If correct, it provides a parameter that is constant throughout the history of the universe (running constants cancel out). Rather than a volumetric density, it would have to be an expression of the density by mass times the radius of space at a given time; i.e. something like $\Omega_m = m_t r_t^2 = \frac{1}{2\phi}$, [49]

where the subscript $_t$ refers to total mass and total radius. This keeps the term constant (see Table 3) throughout time.

This is in excellent agreement with the Planck[25] survey finding of 0.308 ± 0.012. If correct, it likely provides further evidence for a toroidal universe.

5.3 Cosmological Constant

Cosmological constant: From [19] and [32] we suggest that squaring ϕ^2 will give a density constant (scaling constant for reducing density of space during roll-out), and dividing this by Pi squared would give a density rate per spatial curvature constant. It is identical to dividing the Hubble constant by pi to the fourth power. This number is then

$$\Omega_\Lambda = \frac{36\alpha^4 h^2}{\pi^4 e^4} = \frac{9G^2c^2}{\pi^4\alpha^2} = \frac{9G}{\pi^4\varepsilon_o} = \frac{\phi^4}{\pi^2} = 0.694465722\ldots \qquad [50]$$

which ought to be a suitable candidate for the cosmological constant. If so, it is in excellent agreement with the Planck[25] survey finding of 0.6911 ± 0.0062. If correct, this likely provides further evidence for a toroidal universe.

As mentioned above, phi may relate to the inverse mass-radius ratio as $\phi = \frac{1}{2m_t r_t^2}$, so that the

cosmological term may be $$\Omega_\Lambda = \frac{\phi^4}{\pi^2} = \frac{1}{16\pi^2 m_t^4 r_t^8} \qquad [51]$$

As a consequence of the above terms, we see that the Universe is just closed, thus-

$$\Omega_k = 1 - \Omega_\Lambda - \Omega_m = -0.003482716 \qquad [52]$$

which is to state that the universe can not be expanding at an accelerated rate.

5.4 Mass-wavelength constant

Since $E = h\nu$ and $c = \lambda\nu$ then $m = \dfrac{h}{\lambda^2 \nu}$, and so it follows that $m\lambda = \dfrac{h}{c}$ which must [53]

be a constant throughout the universe and time (each component's running cancels out). This value, taken from the Planck constant in this paper, is then 2.204161037…x 10^{-42} kg.m. (See other expressions in Appendix 2). So even photons have mass, and gravitons likewise should have a low mass.

5.5 Quantum Forces

If the principal constants of nature run, then it is surmised that the quantum forces must also. The strong and weak forces are short-ranged, and gravity and the electro-magnetic force are long-ranged. Under conditions of increased density (e.g. the early universe) we have shown that gravity increases, and space effectively shrinks. The range of short-ranged forces ought to diminish under such conditions. Further work is required in this area. A possible view on this is $\dfrac{\alpha_w}{G} \times \dfrac{\pi\phi^2}{3} = \dfrac{\alpha_s}{\alpha_{em}}$, where the subscripts identify each coupling constant as *strong, weak,* or *electromagnetic.* [Further work to follow at later date.]

5.6 The constants on running – chart

The principal constants were calculated on running (this model), based on their movement against the Hubble constant per megaparsec. The photon constant slows to 1 m/s at 4431.700432 Mpc. Figure 4 shows these constants on running. The last 3 positions were stretched to better illustrate the relatively rapid changes in this era, looking remarkably like an inflation event. [In another model h is constant, only. The remaining constants run exactly as in this model.]

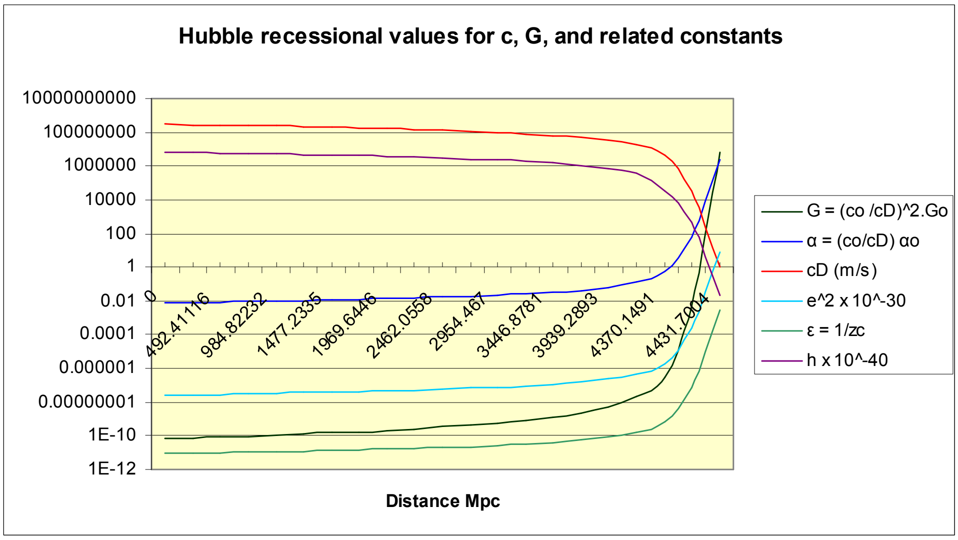


Figure 4: Primary constants on running, per Mpc. The photon constant slows to 1 m/s at 4431.700432 Mpc.

This is what one would expect to measure from the core of a torus rotating outwards from high density towards lower density.

6. Consequences (and supporting data)

Running of the constants as shown in Figure 1 imply that –

1. For any one known value of $c, G,$ or α at any time, we can calculate the other two values via equations [32[, [36], and [39]. From these we can then calculate the values of all the other running constants at any given time or distance from the core.

2. At the 'core' (earliest, very dense universe), c was many magnitudes smaller than what we measure today, yet G was many orders of magnitude stronger. Photons were massive (much more massive than today). Photon mass has since dissipated, as c has increased due to the axial roll-out rate. Phenomenologically this has the same appearance as the universe continually expanding, when there is a constant speed for c throughout time. This running is an ongoing process, and we predict the following changes via the Hubble constant at ***5.1*** above, and at (9) below:-

    - c should increase by ≥ 4.68 μm/s per year (i.e. about 1 m/s faster every 213,671 years); and
    - α should decrease by $\geq 1.139 \times 10^{-16}$ per year; and
    - G should decrease by $\geq 1.626 \times 10^{-38}$ m^3 kg^{-1} s^{-2} per year

3. Due to (1), (2) above, super-symmetry is not required. As the principal constants adjust continuously, they maintain equilibrium (on large scale) for the mass-density of the universe (equations [32], [33]). Particle masses and forces are adjusting constantly, but maintain a constant interactional ratio overall. This must be occurring everywhere, including localised areas such as black-holes. Super particles are therefore not required.

4. The minimum condition for the universe is an existence in 3 dimensions, via $\frac{\pi\phi^2\alpha}{Gc} = 3$ where the running constants change in a constant synergy. A 'big bang' is not required. Singularities are not required.

5. The gravito-electromagnetic constant [32] suggests there is a natural limit to particle interactions, such as the photon decay rate during the recombination era. That rate [32] is 8.224796338… which is in excellent agreement with the Planck[25] survey data for the 2s-1s two-photon decay rate of 8.2206 s^{-1}.

6. From ***4.7*** above, there is no requirement for dark energy or exotic (as yet unknown) dark matter. Ordinary dark matter is not affected.

7. Consequentially to (2), (3), (4), and (6) above, a dense plasma 'crush zone' at the core would ensure homogeneity under extreme G during 'roll-out'. Thus there is no need for any 'inflationary' epoch.

8. Phi relationships are found throughout the universe. An obvious observation is the spirals in galaxies. Also, a recent example was found by Lindner *et al*[26] who found stars that pulsate at ratios near the golden mean.

9. If the Hubble constant (see ***5.1***) is 'fixed' as discussed above, then the universe can not be expanding. Photon wavelength red-shifts can not be caused by expansion of the universe. Rather, it is suggested they are caused by the running of c (the photon 'constant') during the 'roll-out' of space-time from the core of the torus (minor axis roll-out), accompanied by a decline in G at the inverse square of Δc . This is shown in equation [32]. The observable effect in this scenario is identical to that of an expanding universe. Moreover, this effect will be observed in all directions (past or future times). Toroidal models have been considered in the past, eg Luminet *et al* [27] and some (low correlation) evidence favouring such a model was described by the Planck[28] analysis. However such an analysis does not account for running of the constants used in this paper.

10. The Planck constant h runs, and other values derived from it also run – Planck mass, Planck length, Planck time, and Planck temperature. (However the Planck charge is constant.) Calculations for Schwarzchild radii will need to take this running of c, G, h into consideration. This means, using the values in this paper, and taking the running values back in time to when the photon constant was 1 ms^{-1} we get the following -

    - Planck length $L_p = \sqrt{\frac{\hbar G}{c^3}}$ = 1.45052992 x 10^{-18} m, which looks like approaching a limit for photon wavelength compression;
    - Planck mass $M_p = \sqrt{\frac{\hbar c}{G}}$ = 2.418448041 x 10^{-25} kg, which looks like approaching a maximum mass limit for a photon;
    - Planck temperature $T_p = \sqrt{\frac{\hbar c^5}{G K_B^2}}$ = 0.017516753 K, (which is interestingly close to zero). This temperature, if correct, suggests the 'core' is strongly superconductive, and supports the theory here: i.e. – no 'big bang'.

This raises at least two interesting points. Firstly, if we multiply Planck length by Planck mass we get a constant that holds true despite running of $c, G, h,$ which ought to be identical to the expression from ***5.4*** above, i.e. $m\lambda = \frac{h}{c}$. However we end up with $L_p M_p = \frac{h}{2\pi c}$. The equation at left is correct. Secondly, how could the universe be cooler at the core and yet stars have very high temperatures? This needs much further investigation, however stars can not form in conditions at the core of the universe. Perhaps the best evidence comes from black holes, which are predicted to be very cold at their cores, and superheated at the event horizon. [Is the universe a black hole?]

11. Time is relevant for humans, measured in seconds. We receive information at the photon-constant speed which is actually increasing. Time, then, in a human sense, is accelerating (extremely slowly, imperceptible over a human lifetime). Absolute time, via the Hubble constant, is still constant. Equation [32] shows despite each of α, c, G continuously changing, the gravito-electromagnetic constant remains so.

12. An interesting argument that fits well with the overall theory in this paper is that of the mass ratio between a proton and an electron $\frac{m_p}{m_e} = 1836.15267389$ (CODATA 2014). If we use the following terms from this paper we get very close -

$$\frac{m_p}{m_e} \approx \frac{3\pi^2\phi^4}{\Omega_\Lambda \Omega_m} \times \frac{\pi}{\phi} = 6\pi^5 = 1836.118109\ldots \qquad [54]$$

This number is within 0.0019% of the CODATA 2014 value. It could well be found that in the process of measuring the proton mass that a very small energy is introduced, altering the mass value in the process. This may account for the slightly higher ratio measured.

13. A further interesting feature is that of the QCD charges on quarks, where up, charm and top have positive 2/3, and down, strange, and bottom have minus 1/3. This can be expressed as –

$$\textit{up, charm, top} = +\frac{2Gc}{\pi\phi^2\alpha} = +\frac{2}{3} \quad \textit{and down, strange, bottom} = -\frac{Gc}{\pi\phi^2\alpha} = -\frac{1}{3} \qquad [55]$$

These partial charges hold true throughout time, despite the running of G, c, α.

14. We predict that further research should prove fruitful in explaining particle mass ratios, quark masses, and the quantum forces.

6. Summary

We produce equations linking general relativity with quantum theory, and define those principal constants involved. Most of the constants are found to run with variable energy density of the universe. This is consistent with several large-group, multi-year surveys that have shown that α *-strong* and α *-QED* are running constants. Space is a superconductor where photons are massive.

We improve accuracy of G and H_o to 10 significant figures. New, related constants are described. $\varepsilon_o, \mu_o, z_o, h$ are calculated from theory, differing from their conventional values by just over 0.2%.

These findings imply that the Hubble Constant needs to be re-interpreted, as it is likely the roll-out rate about the minor axis of a torus. This would explain why the current value is preferred. We also suggest this discovery explains several other data measured by the Planck surveys, including the two-photon decay rate during the recombination era, mass density parameter, and the cosmological constant. Superconductor anomalies are explained briefly. While the model to demonstrate the running of the constants shown here is speculative, it does provide a working explanation covering the interaction of all the physical constants, while keeping all parameters in excellent agreement with the Planck survey data.

Our 'Standard Model' of the universe will need to be reviewed. It is suggested an alternative model will better explain the physical properties we actually observe, where super-symmetry, singularities, dark energy, exotic dark matter and inflationary scenarios are not required.

References

[1] H M Schwartz. "Einstein's Comprehensive 1907 Essay on Relativity", Parts I, II & III, (1976) Department of Physics, University of Arkansas, Fayettsville, Arkansas, 72701 http://hermes.ffn.ub.es/luisnavarro/nuevo_maletin/Einstein_1907_Jahrbuch.pdf

[2] M Rees. *Just Six Numbers: The Deep Forces that Shape the Universe*. Basic Books, 2008. ISBN 0786723580, 9780786723584. pp 2-4

[3] P J Mohr, B N Taylor, D B Newell. CODATA Recommended Values of the Fundamental Physical Constants: 2010. *National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8420, USA.* March 15, 2012.

[4] P J Mohr, D B Newell, B N Taylor. CODATA Recommended Values of the Fundamental Physical Constants: 2014. *National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8420, USA.* July 30, 2015. arXiv:1507.07956v1 [physics.atom-ph] 21 July 2015

[5] R P Feynman. "QED: The Strange Theory of Light and Matter". *Princeton University Press*, (1985), p 129. ISBN 0-691-08388-6

[6] W Pauli. "Phenomenon and Physical Reality, Dialectica". 11 (1957), pp 35 – 48. Introduction to a Symposium on the occasion of the International Congress of Philosophers, Zurich 1954.

[7] F Wilczek. *The Lightness of Being: Mass, Ether and the Unification of Forces*, pp 149, 211 & 212. Basic Books, 2008. ISBN 978-0-465-01895-6

[8] S W Hawking, L Mlodinow. *The Grand Design;* p 112. Transworld Publishers (Random House Group); ISBN 9780593058299

[9] A J Frost, R R Prechter. *Elliott Wave Principle*. Pp 114, 10th Ed, New Classics Library (2005), ISBN: 978-0-932750-75-4

[10] J C A Boeyens, J F Thackeray. Number theory and the unity of science. S Afr J Sci. 2014: 110(11/12), Art #a0084, 2 pages. http://dx.doi.org/10.1590/sajs.2014/a0084

[11] M J Duff. "Comment on time variation of fundamental constants". arXiv:hep-th/0208093v3, 11 Jul 2004; pp 2,3

[12] G E A Matsas, V Pleitez, A Saa, D A T Vanzella. "The number of diemsional fundamental constants." arXiv:0711.4276v2 [physics.class-ph] 4 Dec 2007. pp 1, 2, 4-5

[13] H J Hamilton. "Gravity in Relativistic Particle Theory: A Physical Foundation for the Life Sciences". Scipress Publishing Co (2013), pp 69. ISBN 978-0-9892572-4-4

[14] The L3 Collaboration. "Measurement of the Running of the Electromagnetic Coupling at Large Momentum-Transfer at LEP"; *CERN-PH-EP/2005-021*; arXiv:hep-ex/0507078v1 18 Jul 2005. pp 1, 5-6

[15] I Levine, *et al* (The TOPAZ Collaboration). "Measurement of the Electromagnetic Coupling at Large Momentum Transfer". (1997), *Physical Review Letters*, 0031-9007/97/78(3)/424(4). Pp 2-5

[16] H Burkhardt, B Pietrzyk. "Update of the Hadronic Contribution to the QED Vacuum Polarization". *Physics Letters B*, Elsevier, 2001, 513, pp.46-52. <in2p3-00009886> . pp 2-7

[17] M E Tobar. "Global Representation of the Fine Structure Constant and its Variation". 2003, revised 2005; arXiv:hep-ph/0306230v5. pp 1, 5-10.

[18] M Tajmar. Electrodynamics in Superconductors Explained by Proca Equations. *Space Propulsion and Advanced Concepts, Austrian Research Centers GmbH – ARC.* A-2444 Seibersdorf, Austria https://arxiv.org/ftp/arxiv/papers/0803/0803.3080.pdf p 2

[19] G Modanese. "Gravity-Superconductors Interactions as a Possible Means to Exchange Momentum with the Vacuum". Submitted to *Journal of Space Exploration, Special Issue "Spaceflight Perspectives from Novel Concepts of Spacetime, Gravitation and Symmetries"*, Ed. J. H. Hauser. Pp 1-17

[20] M Tajmar, C de Matos. "Gravitomagnetic Fields in Rotating Superconductors to Solve Tate's Cooper Pair Mass Anomaly". http://arxiv.org/ftp/gr-qc/papers/0607/0607086.pdf ; 2006. pp 1-5

[21] M Tajmar et al. "Experimental Detection of the Gravitomagnetic London Moment". http://arxiv.org/abs/gr-qc/0603033 9 Mar 2006; pp 1-17

[22] M Tajmar, C de Matos. "Local Photon and Graviton Mass and its Consequences". http://arxiv.org/abs/gr-qc/0603032v2 24 Mar 2006; pp 1-15

[23] S Perlmutter *et al.* The Supernova Cosmology Project. arXiv:astro-ph/9712212v1 16 Dec 1997.

[24] A G Reiss *et al.* "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant." *The Astronomical Journal,* 116:1009-1038, Sept 1998.

[25] Collaboration, Planck, PAR Ade, N Aghanim, C Armitage-Caplan, M Arnaud, *et al*., "Planck 2015 results". XIII. *Cosmological parameters*. arXiv preprint 1502.1589v2, 6 Feb 2015. pp 1, 6, 25, 31, 46, 52-54, 58.

[26] J Lindner, V Kohar, B Kia, M Hippke, J Learned, W Ditto. "Strange nonchaotic stars". arXiv:1501.01747v2 [nlin.CD] 4 Feb 2015

[27] J-P Luminet, J Weeks, A Riazuelo, R Lehoucq, J-P Uzan. "Dodecahedral space topology as an explanation for weak wide-angle temperature correlations in the cosmic microwave background." arXiv:astro-ph/0310253v1 9 Oct 2003

[28] Collaboration, Planck, PAR Ade, N Aghanim, C Armitage-Caplan, M Arnaud, *et al*., "Planck 2015 results". XVIII. *Background geometry and topology of the Universe*. arXiv:1502.01593v1, [astro-ph.CO] 5 Feb 2015.

Appendix 1: Expressions for the Principal Constants

Fine Structure Constant $\alpha = \frac{e^2 \mu c}{2h} = \frac{3Gc}{\pi\phi^2} = \frac{e^2}{2\varepsilon ch} = \sqrt{G\varepsilon c^2} = \sqrt{\frac{G}{\mu}} = \frac{\pi\phi^2 c\varepsilon}{3} = \frac{\mu e^2}{2m\lambda} = \frac{\pi^2\phi^4 e^2}{18Ghc}$

Speed of Light $c = \frac{2\alpha h}{\mu e^2} = \frac{\pi\phi^2\alpha}{3G} = \frac{e^2}{2\varepsilon h\alpha} = \frac{z\alpha^2}{G} = \frac{2\alpha^3 h}{Ge^2} = \frac{h}{m\lambda}$

Elementary charge[2] $e^2 = 2\varepsilon h\alpha c = \frac{2\alpha h}{\mu c} = \frac{6Gc^2\varepsilon h}{\pi\phi^2} = \frac{6Gh}{\pi\phi^2\mu} = \frac{6\alpha^2 h}{\pi\phi^2}$

Electric Permittivity $\varepsilon = \frac{1}{\mu c^2} = \frac{\alpha^2}{Gc^2} = \frac{3\alpha}{\pi\phi^2 c} = \frac{e^2}{2\alpha hc} = \frac{9G}{\pi^2\phi^4} = \frac{m\alpha^2}{GE} = \frac{m}{\mu E} = \frac{m}{\mu hv}$

Gravitational constant $G = \alpha^2\mu = \frac{\alpha^2}{\varepsilon c^2} = \frac{\pi\phi^2\mu e^2}{6h} = \frac{\pi\phi^2\alpha}{3c} = \frac{2\alpha^3 h}{ce^2} = \frac{\pi^2\phi^4\varepsilon}{9} = \frac{\pi^2\phi^4 e^2}{18\alpha hc} = \frac{F_g r^2}{m_1 m_2}$

Planck Constant $h = \frac{c\mu e^2}{2\alpha} = \frac{e^2}{2\varepsilon c\alpha} = \frac{\pi\phi^2\mu e^2}{6G} = \frac{\pi\phi^2 e^2}{6\alpha^2} = \frac{mc^2}{v} = m\lambda^2 v$

Hubble Constant

$$H_o = \pi^2\phi^4 = \frac{9G}{\varepsilon} = 9Gc^2\mu = \frac{9G^2c^2}{\alpha^2} = \frac{9\alpha^2\mu}{\varepsilon} = \frac{9\alpha^2}{\varepsilon^2 c^2} = 9\alpha^2 z^2 = \frac{36\alpha^4 h^2}{e^4} = \frac{3\pi\phi^2 Gc}{\alpha} = \frac{9G^2 E}{m\alpha^2}$$

2s-1s Two Photon decay rate $\pi\phi^2 = \frac{3Gc}{\alpha} = \frac{6Gh}{\mu e^2} = \frac{6\alpha^2 h}{e^2} = \frac{3\alpha}{c\varepsilon} = 3z\alpha = \frac{3GE\lambda}{\alpha h}$

Mass $m = \frac{E}{c^2} = E\mu\varepsilon = \frac{GE\varepsilon}{\alpha^2} = \frac{9G^2 E}{\pi^2\phi^4\alpha^2} = \frac{9\alpha^2\mu^2 E}{\pi^2\phi^4} = \frac{h}{\lambda^2 v} = \frac{\mu e^2}{2\alpha\lambda} = \frac{F_g r^2}{G}$

Mass-Wavelength constant $m\lambda = \frac{\mu e^2}{2\alpha} = \frac{e^2}{2\varepsilon\alpha c^2} = \sqrt{\frac{3\mu^2 e^2 h}{2\pi\phi^2}} = \frac{\mu e}{\phi}\left(\sqrt{\frac{3h}{2\pi}}\right) = \frac{3Gh}{\pi\phi^2\alpha} = \frac{h}{c}$

Pi $\pi = \frac{6Gh}{\phi^2 e^2\mu} = \frac{3Gc}{\alpha\phi^2} = \frac{6\alpha^2 h}{\phi^2 e^2}$

Phi $\phi = \sqrt{\frac{6Gh}{\pi e^2\mu}} = \sqrt{\frac{3Gc}{\pi\alpha}} = \sqrt{\frac{6\alpha^2 h}{\pi e^2}}$

Magnetic Permeability $\mu = \frac{1}{\varepsilon c^2} = \frac{G}{\alpha^2} = \frac{2\alpha h}{ce^2} = \frac{4\alpha^2 h^2\varepsilon}{e^4} = \frac{3G}{\pi\phi^2 c\alpha\varepsilon} = \frac{\pi\phi^2}{3\alpha c} = \frac{z}{c}$

Frequency $v = \frac{6mc^2\alpha^2}{\pi\phi^2 e^2} = \frac{mc^2}{h}$

Wave Impedance $z = \mu c = \frac{1}{\varepsilon c} = \frac{2\alpha h}{e^2} = \sqrt{\frac{\mu}{\varepsilon}} = \frac{\pi\phi^2\alpha\mu}{3G} = \frac{\pi\phi^2}{3\alpha} = \frac{\pi^2\phi^4}{9Gc} = \frac{Gc}{\alpha^2}$

Appendix 2: Comparison CODATA/Planck Survey Data vs McMahon Data

Quantity	Symbol	**C**ODATA (2014)/**P**lanck (2015)		Number (McMahon)		Difference (%)
Photon *c*	c	299792458	C	299792458	C	0
Fine structure	α	$7.297352566 \times 10^{-3}$	C	$7.297352566 \times 10^{-3}$	C	0
Elementary charge	e	$1.6021766208(98) \times 10^{-19}$	C	$1.6021766208 \times 10^{-19}$	C	0
Planck *h*	h	$6.626070040(81) \times 10^{-34}$	C	$6.607908552 \times 10^{-34}$		0.274
Magnetic permeability	μ	$1.2566370614 \times 10^{-6}$	C	$1.253192727 \times 10^{-6}$		0.274
Electric permittivity	ε	$8.854187817 \times 10^{-12}$	C	$8.878523088 \times 10^{-12}$		0.2748
Wave impedance	z	376.730313461	C	375.697728		0.274
Gravitational	G	$6.67408(31) \times 10^{-11}$	C	$6.673421013 \times 10^{-11}$		0.003-0.009
2s-1s two photon decay	γ_d	8.2206	P	8.224796338		0.051
Hubble parameter	H_o	67.8 ± 0.9	P	67.64727481		0
Mass density	Ω_m	0.308 ± 0.012	P	0.309016994		0
Cosmological term	Ω_Λ	0.6911 ± 0.0062	P	0.694465722		0
Mass-wavelength	$m\lambda$	$2.210219058 \times 10^{-42}$	C	$2.204161037 \times 10^{-42}$		0.2748
Universe	Ω_k	0 (neither open or closed)	P	-0.003482716 (closed)		

Appendix 3: Relationships of the Principal Constants of Nature

$\pi\phi^2 \xrightarrow{\text{squared}} \pi^2\phi^4 \longrightarrow \div \pi^4 = \dfrac{\phi^4}{\pi^2} = \Omega_\Lambda$

2s-1s two-photon decay rate at recombination (-)

Hubble constant (-)

Cosmological constant (-)

$$\phi = \sqrt{\frac{3Gc}{\pi\alpha}}$$ (-)

Phi

$\times 3$

$\times 3\pi\phi^2$

$\times \dfrac{3\phi^2}{\pi^3}$

$$\div\,\alpha = \frac{\pi\phi^2}{3\alpha} = z$$

wave impedance (↓)

$$\frac{\pi\phi^2}{3\alpha c} = \frac{G}{\alpha^2} = \mu$$

magnetic permeability (-)

$$\pi = \frac{3Gc}{\alpha\phi^2}$$ Pi

(-)

$\div\ \alpha c$

$$\frac{\pi\phi^2}{3} = \frac{Gc}{\alpha} = \frac{\alpha}{\varepsilon c} = c\alpha\mu = z\alpha = \frac{2Gh}{e^2\mu}$$

Gravito-ElectroMagnetic constant

(-)

$$\div\ \alpha\mu = \frac{\pi\phi^2}{3\alpha\mu} = \frac{\pi\phi^2\alpha}{3G} = c$$

Photon constant (↓)

$$\times\frac{\alpha}{c} = \frac{\mu e^2}{2h} = \alpha^2\mu = G$$

Gravitational constant (↑↑)

$$\times\frac{e^2}{2\alpha^2} \text{ or } \times\frac{\mu e^2}{2G} = h$$

Planck constant (↓)

$$\times\frac{3}{2\pi\phi^3} = \frac{1}{2\phi} = \frac{\varepsilon hc\alpha}{e^2\phi} = \Omega_m$$

Mass density parameter (-)

$$\text{(inv.)} \times Gc = \frac{3Gc}{\pi\phi^2} = \alpha$$

Fine structure constant (↑)

$$\boxed{\Omega_k \equiv 1 - \Omega_\Lambda - \Omega_m}$$

$$\text{(inv.)} \times 2\alpha^2 h = \frac{6\alpha^2 h}{\pi\phi^2} = e^2$$

U = -0.003482716;

[closed universe]

$$\text{(inv.)} \times\frac{\alpha}{c} = \frac{3\alpha}{\pi\phi^2 c} = \varepsilon$$

Electric permittivity (↑↑)

Elementary charge (↑)

Running indication: (-) Does not run; (↑) larger in the past; (↓) smaller in the past