# Discovery of an interaction constant, variation of the principal constants, and consequences for cosmology

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## Abstract

An 'interaction constant' with the irrational number phi is discovered, unifying Nature's principal constants with gravity. This constant reveals an elegant symmetry permitting the universe to have change, while conserving principal parameter ratios. New relationships for principal constants are shown. Magnetic permeability and electric permittivity of free space, set by convention last century are found to have new values. This allows an exact value for the Planck constant, and a precise value for the elementary charge $e$ to be obtained. Errors in current Planck units are discussed. A reevaluation of dimensional analysis introduces new dimensional units for $G$, $\varepsilon$, $\mu$, gravity, the Coulomb constant and electric force. The fine-structure constant is found to have dimensions Hz. Pi and phi are found to have dimensions in some configurations. Energy variation causes most principal constants to run, while still adhering to this scale invariant, overall symmetry. Electromagnetic and gravitational forces also run, with gravity dominating at high energies as expected. Wavelength red-shifting occurs via dilation of space-time, attenuated by running of gravity and energy. Structural symmetry requires a new cosmic model where the universe has a constant form. Discussion of a toroidal cosmology introduces candidates for the Hubble and cosmological constants, and a mass-density parameter. These are found to have identical values to most recent Planck data. Standard Model anomalies become redundant. This study confirms and extends general relativity.

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# 1. Introduction

General relativity [1] breaks down at the highest energies, indicating the theory is incomplete. Any theory unifying quantum physics with general relativity must not only satisfy both simultaneously, but unite them in a manner explaining gravity. We show here the first stage of unification.

Nature's principal constants are often expressed as ratios with other parameters. Values for these constants are regularly published [2] for international use. Some are fixed by convention, e.g. the photon constant or speed of light (1983), and magnetic permeability of space was set to be exactly $4\pi \times 10^{-7}$ *Henries* per *metre* at the 9th Conférence Générale des Poids et Mesures (CGPM), 12–21 October 1948 [3].

Measurements for mass and wavelength rely on accuracy of other constants; for example, the electron rest mass is used to determine the Avogadro constant, yet it in turn relies upon the accuracy of the Rydberg constant, the Fine Structure constant, and the Planck constant. Much of the uncertainty of our fundamental physical constants depends upon the accuracy of the Planck constant.

Furthermore, recent studies [4-6] show the fine structure constant varies with energy, which implies that other constants must also vary, to preserve their respective constant ratios.

# 2. Discovery of an 'Interaction constant'

We observe 3 macroscopic dimensions of space, and measure one of time. Within these dimensions, the irrational number phi appears in various forms at every known scale. Commonly appearing as an expanding spiral form, it is observed in the motion of atomic particles, phyllotaxis in plants, and whorls of sea shells. On larger scales it is seen in cyclones, and spiral galaxies. All manner of life-forms exhibit phi-ratios with respect to proportion, including their DNA. One study [7] found variable stars that pulsate with two principal frequencies, separated by a ratio close to phi.

Phi ought to be regarded as a scale-invariant structural-growth constant, which must surely be embedded within the physical laws of Nature.

We find, using pi and phi ($\phi$ = 1.618 033 988…) in the following relationships (3 spatial dimensions) produces our gravitational constant[1] $G$ -

$$G = \frac{F_g r^2}{m} = \frac{\pi\phi^2\alpha}{3c} = \frac{\pi\phi^2\mu e^2}{6h} = 6.673421013\ldots \times 10^{-11} \qquad \mathrm{N/C^2.s}\ (\text{units}^2) \qquad (1)$$

where $F_g$ is the gravitational force, $\alpha$ is the fine structure constant, $c$ is the photon constant, $\mu$ is permeability of space (magnetic constant), $m$ is mass, $h$ is Planck's constant, and $e$ is the elementary charge.
From (1) we see that the physical constants $c$, $G$, $\mu$, $e$, $h$, and $\alpha$ (and actually all of the principal constants) are related through this equivalence, which we notate $K_I$ which is -

[1] This is about 0.005% smaller than the CODATA 2014 value, but within the error range of the CODATA 2010 value.
[2] See discussion below (page 4) regarding dimensional analysis.

$$K_I = \frac{\pi\phi^2}{3} = \frac{Gc}{\alpha} = \frac{2Gh}{\mu e^2} = \frac{F_g r^2 c}{m\alpha} = \frac{G\lambda}{t\alpha} = c\alpha\mu = 2.741598779\ldots\ \Omega/s^2 = 1/F.s \quad (2)$$

It unifies gravity with electromagnetism and evidences interactions of all constants and forces, providing many answers in our quest for a unified theory. As such, perhaps it should be known as the 'interaction constant' to convey that function. (See Appendix B chart also.)

Interestingly the units are found to be ohms per second squared ($\Omega/s^2 = \Omega/H.F = 1/F.s = N.m/C^2.s = V/C.s = H/s^3$), thus measuring electrical resistance through space-time. This is entirely consistent with similar expressions measuring electric permittivity and magnetic permeability.

# 3. Variation from conventional values

Electric permittivity $\varepsilon$ and magnetic permeability $\mu$ were set by convention in 1948 from the definition of the ampere. As such they are human values set for convenience. Two other constants are used to obtain values for electrical resistance: the Josephson and von Klitzing constants. These in turn rely solely on values of *h* and *e,* which are presently incorrect (discussed below, and notwithstanding that small errors were/are inherent during the measurement process [8]). If we continue using the set values $\mu$, $\varepsilon$, it will require revision of the fine structure constant, the elementary charge and other constants including $\pi$.

From (2) we can use a constant that has known absolute values, and the best empirically measured parameter. A Harvard study [9] found a highly accurate value for alpha from the electron *g* value and QED, which is the accepted value today [2]. Rearranging (2) and using our accepted value for $\alpha$ we find a new value for vacuum impedance –

$$z = \frac{2\alpha h}{e^2} = \frac{\pi\phi^2}{3\alpha} = 375.697728\ldots\ \Omega/s \quad (3)$$

This also sets new values for the von Klitzing constant $R_K = h/e^2 = 2.574205677 \times 10^4\ \Omega$, and Josephson constant $K_J = h/2e = 2.062814897 \times 10^{-15}$ Wb.

Although the speed of light *c* was also set by convention, this parameter has been repeatedly tested to high accuracy (e.g [10]). Using CODATA accepted values for $\alpha$ and *c,* plus our interaction constant we then find –

$$\mu = \frac{1}{\varepsilon c^2} = \frac{G}{\alpha^2} = \frac{2\alpha h}{ce^2} = \frac{\pi\phi^2}{3\alpha c} = \frac{6Gh}{\pi\phi^2 e^2} = \frac{F_g r^2}{\alpha^2 m} = \frac{6G\lambda cm}{\pi\phi^2 e^2} = \frac{\pi^4}{18c^3 e} = 1.253192727 \times 10^{-6}\ \text{H/m.s} \quad (4)$$

and -

$$\varepsilon = \frac{1}{\mu c^2} = \frac{\alpha^2}{Gc^2} = \frac{3\alpha}{\pi\phi^2 c} = \frac{e^2}{2\alpha hc} = \frac{9G}{\pi^2\phi^4} = \frac{m\alpha^2}{GE} = \frac{\alpha^2 m}{F_g r^2 c^2} = \frac{18ce}{\pi^4} = 8.878523088 \times 10^{-12}\ \text{F.s/m} \quad (5)$$

so that these become exact values obtained by theory here, connected via *c* and $K_l$. Values above for *ε*, *μ*, and *z* differ from convention by 0.275%. (*ε* is electric permittivity, *E* is energy, and *λ* is wavelength.)

From (4) and (5) and expressions for $c^2$ we find also that –

$$G = \alpha^2 \mu \quad \text{H/m.s}^3 = \text{N/C}^2\text{.s} = \Omega\text{/m.s}^2 = 1\text{/F.s.m} \tag{6}$$

$$\pi = \frac{3Gc}{\phi^2\alpha} = \frac{3GE}{\phi^2 c\alpha m} = \frac{6\alpha^2 c\lambda m}{\phi^2 e^2} = \frac{3F_g r^2 c}{\phi^2 m\alpha} = \frac{3c\alpha\mu}{\phi^2} = \frac{F_g ch}{2F_e\alpha\mu m} = \frac{F_g\lambda c^2}{2F_e\alpha\mu} = 3.1415926538\ldots \ \Omega/\text{s}^2 \tag{7}$$

$$\phi^2 = \frac{3Gc}{\pi\alpha} = \frac{3GE}{\pi\alpha mc} = \frac{6F_e\mu r^2}{h} = \frac{6F_e G\mu}{F_g\lambda c} = \frac{\pi^7}{216hc^4} = \frac{3F_g hc^2}{2F_e m\pi^2} = 2.618033988\ldots \tag{8}$$

From the above we find the following are constants (among many others) -

$$m\lambda = \frac{\mu e^2}{2\alpha} = \frac{e^2}{2\varepsilon\alpha c^2} = \frac{3Gh}{\pi\phi^2\alpha} = \frac{\pi\phi^2 e^2}{6\alpha^2 c} = \frac{F_g r^2\lambda}{G} = \frac{h}{c} = 2.205548249\ldots \times 10^{-42} \text{ kg.m} \tag{9}$$

$$E\lambda = \frac{h^2}{m\lambda} = hc = \frac{\pi^2\phi^4 e^2}{18\alpha^3\mu} = \frac{\pi^2\phi^4 e^2}{18G\alpha} = \frac{F_g r^2\lambda c^2}{G} = k_B T\lambda = 1.982247911 \times 10^{-25} \text{ J.m} \tag{10}$$

$$e\mu = \frac{6Gh}{\pi\phi^2 e} = \frac{\pi^4}{18c^3} = 2.008467816\ldots \times 10^{-25} \ \text{V.s/m = J/A.m = Wb/m} \tag{11}$$

$$\frac{G}{\alpha} = \alpha\mu = \frac{z\alpha}{c} = \frac{\pi\phi^2}{3c} = \frac{\alpha}{\varepsilon c^2} = \frac{\mu e^2}{2\varepsilon ch} = \frac{2\alpha^2 h}{ce^2} = 9.144989163\ldots \times 10^{-9} \text{ H/m.s}^2 \tag{12}$$

$$\frac{e}{\varepsilon} = \frac{\pi^4}{18c} = \frac{\pi^2 G\mu c}{2\phi^4} = 1.805120851\ldots \times 10^{-8} \text{ V.m/s} \tag{13}$$

$$\frac{G}{\varepsilon} = \frac{\pi^2\phi^4}{9} = Gzc = \frac{2Gch\alpha}{e^2} = \frac{G^2 E}{m\alpha^2} = \frac{E\alpha^2\mu^2}{m} = \frac{F_g r^2 E\mu}{m^2} = \frac{Gc\mu h}{m\lambda} = 7.516363867\ldots \ \Omega^2/\text{s}^4 \tag{14}$$

$$c = \frac{z\alpha^2}{G} = \frac{2\alpha^3 h}{Ge^2} = \frac{\pi\phi^2}{3\alpha\mu} = \frac{\pi\phi^2\alpha}{3G} = \frac{e^2}{2\varepsilon h\alpha} = \frac{2h\alpha}{\mu e^2} = \frac{h}{m\lambda} = \frac{\pi^2 G}{2\phi^4 e} = 299792458 \quad \text{m/s} \tag{15}$$

$$\frac{G}{e} = \frac{2\phi^4 c}{\pi^2} = 416391172 \ \ \Omega\text{/C.m.s}^2 = \text{N/C}^3\text{.s} = \text{V/C}^2\text{.m.s} \tag{16}$$

$$\frac{\alpha}{\varepsilon} = \frac{\pi\phi^2 c}{3} = \alpha\mu c^2 = \frac{Gc^2}{\alpha} = \frac{\mu^2 e^2 h\nu}{2m^2\lambda} = 8.219106369\ldots \times 10^8 \quad \text{m/F.s}^2 = \text{V.m/C.s}^2 = \Omega\text{.m/s}^3 \tag{17}$$

$$\frac{\alpha}{e} = \frac{2\phi^4 c\alpha}{\pi^2 G} = \frac{6\phi^2 c^2}{\pi^3} = 4.553216681... \times 10^{16}\ C^{-1}.s^{-1} \qquad (18)$$

## 3.1 Dimensional Analysis

Two approaches were considered for dimensional analysis. Firstly, that when these constants are used as conversion factors, they simply become dimensionless ratios [11]. All constants are related via the photon constant and three apparently dimensionless numbers: the fine structure constant, pi, and phi. However, this approach is problematic and cannot be correct.

The second approach requires guidance from the new expressions above, while using existing and 'accepted' dimensions. We form the view that –

- Dimensional analysis forms *part* of the total characterization of a given parameter; and
- A further system of analysis is required for parameters that vary with time, or run; and
- Values set by convention need to be corrected prior to dimensional reevaluation; and
- Parameters should be invariant under at least 3 methods of analysis.

We introduce a Vector analysis system for time-varying parameters, such that the direction and magnitude express running contingent upon increasing energy. This is shown below in Table 1. The vector notation is a useful tool for checking calculations, much like dimensional analysis. Dimensional and vector analyses are qualitative in terms of parameter-characterization, while mathematical analysis is quantitative. Further and more detailed discussion appears in Appendix C.

We see from (1) to (18) that $G$ cannot have dimensions $m^3\ kg^{-1}\ s^{-2}$ as presently assigned. Likewise, the gravitational force must be corrected, for although the Newton runs in the correct direction, no account is made of properties newly disclosed. We use the self-gravity expression for classical gravity which fits our requirements for invariance (and omits the extra mass term).

The term for radius or distance, $r$ (or $r^2$) does not form part of the force itself – it simply shows that the force is proportional to distance. This term indicates a gradient, and as such, cannot run and ought not to be included in the analysis. Radius or distance is part of the quantitative, rather than qualitative assessment.

The fine-structure constant is stated to be dimensionless due to dimensions of its constituent parts cancelling out to unity. If that number varies when subordinate inputs change however, it can no longer be regarded as a 'constant'. Also, a ratio cannot run or vary over time without assuming some dimension(s) of the subordinate parts. We find that the fine-structure constant has units Hz, or $s^{-1}$, in order that it can run with energy. This is consistent with dimensions for permittivity and permeability, both of which are dependent upon frequency [12]. Some other units are affected, but frequency cancels out for $c^2$ using $1/\mu\varepsilon$.

Support comes from $\pi^4/c^2 = 36ah/e$ which has dimensions V = J/C = eV/$e$. So $ah$ is joules, which means $a$ is Hz. From (6) and since alpha must have dimensions Hz, $\mu$ has dimensions H/m.s, $\varepsilon$ has dimensions F.s/m, $G$ must have dimensions $H/m.s^3$, and therefore the gravitational force $F_g$ now has units $N.kg/C^2.s$. We find that $K_l$ and $\pi$ have dimensions of $\Omega/s^2$. $\phi^2$ is dimensionless, but $\phi^4$ and $\phi^6$ have complex dimensions (see Appendix C). $\pi^2$ has dimensions $\Omega^2/s^4$, but $\pi^3$ has dimensions $A.m^2$

and $\pi^4$ is V.m$^2$/s$^2$ and $\pi^5$ is V$^2$.m$^2$/A.s$^4$. Interestingly, $\frac{\phi^4}{\pi^2}=$ N/C$^3$.m = 1/F.C.m$^2$, as does $\frac{\phi^2}{\pi^2}$ where these expressions occur, whether they be actual, assumed, transferred, or virtual dimensions. It appears that pi and phi are dimension-sharing in some combinations. When tested against other known and proven expressions, the dimensional analysis shows the ratios must be correct.

Despite these anomalies or apparent departures from current expectations, the expressions shown in this study are exact numerically, and also exact through vector analysis as shown below. (See Table 1).

## 3.2 New value for Planck's constant

We can now establish the exact value for the Planck constant –

$$h=\frac{c\mu e^2}{2\alpha}=\frac{e^2}{2\varepsilon c\alpha}=\frac{\pi\phi^2\mu e^2}{6G}=\frac{\pi\phi^2 e^2}{6\alpha^2}=\lambda p=\frac{F_g r^2 c^2 t}{G}=\frac{\pi^7}{216\phi^2 c^4}=6.612067309\ldots \times 10^{-34}\ \text{J.s} \quad (19)$$

This differs from the accepted value today [2] by 0.212%.

## 3.3 New value for elementary charge

Uncertainty in the value for the elementary charge *e* is almost entirely due to the uncertainty of the Planck constant. From (19) above we now find that *e* is presently –

$$e=\sqrt{2\alpha h\varepsilon c}=\frac{\pi^2 G}{2c\phi^4}=\frac{\pi^4\varepsilon}{18c}=1.602680715\ldots \times 10^{-19}\ \text{C} \quad (20)$$

This differs from the accepted value today [2] by 0.0315%.

Consequentially many constants in common use today will require adjustment, including particle masses obtained from theory. For example: using the electron Compton-wavelength [2] yields an electron mass 0.212% smaller than the most accurate Penning trap results, [13] due entirely to the present (incorrect) Planck constant. Likewise the proton mass, recently measured to high accuracy, [14] is still subject to errors when using formulae involving *h*, *e*, and *ε*.

A recent value [15] for the Avogadro constant obtained from a $^{28}$Si-enriched crystal was found to be $N_A$=6.02214076(12) x 10$^{23}$ mol$^{-1}$, with relative uncertainty at 2 x 10$^{-8}$. Using this number and *e* from (20) gives us 96515.68859 for the Faraday constant, *F*. The Boltzmann constant was measured at 1.380655 x 10$^{23}$ JK$^{-1}$ with relative uncertainty of 7.9 ppm [16]. These two results yield a gas constant at 8.314498751 Jmol$^{-1}$K$^{-1}$, slightly larger than the present CODATA value.

# 4. Running of the constants

While it is well known [3-5] that the fine structure constant varies with energy, debate surrounds which, if any, of the other constants also vary. Our fine structure constant is –

$$\alpha = \frac{e^2}{2\varepsilon hc} = \frac{3Gc}{\pi\phi^2} = \frac{\pi\phi^2 c\varepsilon}{3} = \frac{3GE\lambda}{\pi\phi^2 h} = \frac{3F_g r^2 c}{\pi\phi^2 m} = \frac{\pi\phi^2 m\lambda}{3\mu h} = \frac{k_e e^2}{\hbar c} = 7.297352566 \times 10^{-3}\ \mathrm{s}^{-1} \qquad (21)$$

among many other expressions. ($k_e$ is the Coulomb constant.)

We can see that the ratios in (7) to (18) above are constant, which implies that most of the principal constants must vary or 'run' with energy. All constants are related by $K_I$. The relationships above show that *m, G, ε, α, e, v,* and *E* must run proportionately[3], as do momentum *p* and the electric force $F_e$. Conversely *λ, μ, z,* and time *t* run inversely proportional to the previous terms, as does the Coulomb constant $k_e$. Gravity varies or runs at the square of the variation in the fine structure constant.

The following table shows how the principal constants vary with energy.

**Table 1: Time/energy variation of some principal parameters**

| Time/energy variation of some principal constants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 'Constant' | Symbol | Running vector | 'Constant' | Symbol | Running vector | 'Constant' | Symbol | Running vector |
| *Fine structure* | *α* | ↑ | *Magnetic permeability* | *μ* | ↓ | *Planck constant* | *h* | 0 |
| *gravitational* | *G* | ↑ | *Vacuum impedance* | *z* | ↓ | *photon constant* | *c* | 0 |
| *Electric permittivity* | *ε* | ↑ | *wavelength* | *λ* | ↓ | *pi* | *π* | 0 |
| *elementary charge* | *e* | ↑ | *time* | *t* | ↓ | *phi* | *Φ* | 0 |
| *frequency* | *v* | ↑ | *Coulomb constant* | $k_e$ | ↓ | *Interaction constant* | $K_I$ | 0 |
| *mass* | *m* | ↑ | *magnetic flux* | $\Phi_o$ | ↓ | *volt* | V | 0 |
| *Energy* | *E* | ↑ | *gravity* | $F_g$ | ↑↑ | *Avogadro number* | $N_A$ | 0 |
| *electric force* | $F_e$ | ↑ | *Schwarzschild radius* | $r_s$ | ↑↑ | *ohm* | Ω | ↓↓ |
| *momentum* | *p* | ↑ | *conductance quantum* | $G_o$ | ↑↑ | *Bohr radius* | $\alpha_o$ | ↓↓ |
| *Temperature* | *T* | ↑ | *watt* | W | ↑↑ | *von Klitzing const* | $R_K$ | ↓↓ |
| *Farad* | F | ↑ | *ampere* | A | ↑↑ | *Rydberg const* | $R_\infty$ | ↑↑↑ |
| *Boltzmann const* | $K_B$ | 0 | *henry* | H | ↓↓↓ | *Hartree energy* | $E_h$ | ↑↑↑ |

Table 1: time-reversed vector on running of the constants (i.e. towards the early universe). ↑ means increasing in strength/size; ↓ means decreasing in strength/size; 0 means no variation over time.

We see that gravitational time-dilation and length-contraction are confirmed, and the running of these 'constants' is consistent with experimental observation (for *α* now, but the remainder by extension) during high-energy conditions. An explanation [17] is that the running of the fine structure constant is due to equal components of electric screening and magnetic anti-screening (i.e. *ε*↑ and *μ*↓) for example.

Our new interaction constant encapsulates the hidden symmetry of the universe, allowing for change without changing the fundamental ratios. Variation in energy throughout the universe and time causes the principal constants to run, while still adhering to this scale invariant, overall symmetry. We see that values for individual running constants are difficult to obtain from theory (because they run) and must be obtained empirically.

[3] Planck units are also affected by a running *G*, and discussed below.

## 4.1 Time

As shown above, time also runs, slowing in high-energy environments. Some relationships are -

$$t = \frac{h}{E} = \frac{\lambda}{c} = \frac{1}{v} = \frac{Gh}{F_g r^2 c^2} = \frac{3G\lambda}{\pi\phi^2\alpha} = \frac{6F_e G\mu}{\phi^2 F_g c^2} = \frac{h}{Tk_B} = \frac{Gh}{K_I \alpha p} \quad \text{s} \tag{22}$$

Where $k_B$ is the Boltzmann constant. This allows us to find a time-mass constant –

$$mt = \frac{3F_g r^2 \lambda}{\pi\phi^2\alpha} = \frac{3Gh}{\pi\phi^2\alpha c} = \frac{\mu e^2}{2\alpha c} = \frac{m}{v} = \frac{h}{c^2} = 7.356917062 \times 10^{-51} \text{ kg.s} \tag{23}$$

and a frequency per mass constant (inverse of above) -

$$\frac{v}{m} = \frac{6c^2\alpha^2}{\pi\phi^2 e^2} = \frac{c^2}{h} = 1.359265018 \times 10^{50} \text{ kg}^{-1}.\text{s}^{-1} \tag{24}$$

## 4.2 Temperature and Planck units

Temperature is $E/k_B$ which leads us to the following expressions -

$$T = \frac{E}{k_B} = \frac{3GEc}{\pi\phi^2 k_B \alpha} = \frac{hc}{k_B \lambda} = \frac{3F_g r^2 Ec}{\pi\phi^2 k_B \alpha m} = \frac{3\alpha\mu mc^3}{\pi\phi^2 k_B} = \frac{h}{tk_B} \quad \text{K} \tag{25}$$

From the above (and using the most recent value for $k_B$) we can find new constants such as temperature-wavelength, -

$$T\lambda = \frac{hc}{k_B} = 0.0143573 \text{ K.m} \tag{26}$$

And temperature per mass constant –

$$\frac{T}{m} = \frac{c^2}{k_B} = \frac{3c^3 G}{\pi\phi^2 k_B \alpha} = 6.509628971\ldots \times 10^{39} \text{ K/kg} \tag{27}$$

And temperature per momentum –

$$\frac{T}{p} = \frac{c}{k_B} = 2.171378498\ldots \times 10^{31} \text{ K/N.s} \tag{28}$$

This highlights a problem with accepted Planck units. The Planck mass is shown to be $m_P = \sqrt{\frac{\hbar c}{G}} \approx 2.17647 \times 10^{-8}$ kg, however, when we peruse expressions for mass as shown here –

$$m=\frac{E}{c^2}=\frac{GE\varepsilon}{\alpha^2}=\frac{9G^2E}{\pi^2\phi^4\alpha^2}=\frac{h}{\lambda c}=\frac{3Gh}{\pi\phi^2\alpha\lambda}=\frac{h}{tc^2}=\frac{k_BT}{c^2}\quad \text{kg} \tag{29}$$

the 'vector' analysis shows the Planck mass to be incorrect $\left(m_P \uparrow\neq\sqrt{\frac{\hbar c}{G\uparrow}}\right)$ both in direction and magnitude. Plank units work only when the product of 2 units cancels out *G*, which means the fault lies in the interpretation of *G.* Dimensional analysis for *G* as per (1) with $\frac{\pi\phi^2\alpha}{3c}$ shows the new dimensions are henries per metre per second-cubed, among other equivalent expressions. Our length expressions, using *λ* are –

$$\lambda=\frac{h}{p}=\frac{Gh}{F_gr^2c}=\frac{\pi\phi^2\alpha h}{3GE}=\frac{3\alpha\mu h}{\pi\phi^2 m}=\frac{\mu e^2}{2m\alpha}=\frac{24F_e\phi^2\alpha h}{F_g\pi^2ce}=\frac{\pi\phi^2\alpha t}{3G}=\frac{\pi\phi^2 t}{3\alpha\mu}=tc\quad \text{m} \tag{30}$$

We know that *mλ = h/c* (see (9) above), which is equivalent to Planck mass times Planck length. Using another example, from (25) for Planck temperature, the error becomes obvious. First, we show some expressions for energy –

$$E=mc^2=\frac{hc}{\lambda}=\frac{m\pi^2\phi^4\alpha^2}{9G^2}=\frac{m\alpha^2}{G\varepsilon}=\left(\frac{\pi\phi^2\alpha}{3F_gr^2}\right)^2m^3=\frac{\pi\phi^2\alpha h}{3G\lambda}=Tk_B=\frac{h}{t}=hv=pc\quad \text{J} \tag{31}$$

From (25) and (31) we see that $T_P\neq\sqrt{\frac{\hbar c^5}{Gk_B^2}}$ because $E\neq\sqrt{\frac{\hbar c^5}{G}}$. However, due to running of the constants, and as discussed below in 'new cosmology', the idea of primary Planck units becomes redundant.

# 5. Gravity

The gravitational property of a particle can be ascertained if we know either the wavelength or the mass (because mass = *h/cλ,* and *mλ* is constant). One observes also, through the mass-wavelength relation at (9) that if photons are quantized, gravitons, if they exist, must likewise be quantized.

As a consequence, it would appear that space-time is a superconductor [18] and photons have mass. Running of the constants and mass, whereby the universe maintains symmetry through the principal ratios, negates any requirement for super-symmetry. $K_l$ also removes the need for singularities, and supergravity.

We now have new expressions for the force or interaction of gravity –

$$F_g=\frac{Gm}{r^2}=\frac{\alpha^2\mu m}{r^2}=\frac{\pi\phi^2\alpha m}{3cr^2}=\frac{r_sc^2}{2r^2}=\frac{\pi\phi^2\mu e^2}{6c\lambda r^2}=\frac{Gh}{c\lambda r^2}=\frac{GE}{r^2c^2}=\frac{2\phi^4 eh}{\pi^2\lambda r^2}=\frac{\pi\phi^2k_B\alpha T}{3r^2c^3}\quad \text{N.kg/C}^2\text{.s} \tag{32}$$

Alternative units are H.kg/m.s$^3$ = Ω.kg/m.s$^2$ = kg/F.s.m, (and $r_s$ is the Schwarzschild radius, itself in doubt due to dimensional analysis).

We see that an increase in energy results in a squared increase in the gravitational force from running of *G, m,* and *E.* Rearranged for gravitational energy –

$$GE = F_g r^2 c^2 = \frac{r_s c^4}{2} = \frac{\pi\phi^2 m\alpha c}{3} = \frac{\pi^2\phi^4 e^2}{18\alpha\lambda} = \frac{\pi\phi^2 c\mu e^2}{6\lambda} = \frac{Ghc}{\lambda} = \frac{\pi\phi^2 h\alpha}{3\lambda} = \frac{Gh}{t} = \frac{2\phi^4 ehc^2}{\pi^2\lambda} \qquad (33)$$

(Units are N.J/C$^2$.s = H.J/m.s$^3$ = Ω.J/m.s$^2$ = V$^2$/m.s = J/F.s.m).

Gravity dominated the early universe and remains the dominant feature of dense objects (e.g neutron stars, black holes). High-energy experiments in particle accelerators cause an increase in particle mass and gravity.

A revelation emerges here with respect to 'dark matter' and 'dark energy'. According to the 'standard model' the present era is dominated by dark forces. We suggest instead that running of *G* and *E* eliminates the need for a Modified Newtonian Dynamics (MOND) theory for the much discussed 'missing mass problem', e.g. as per here [19]. Mass is simply hidden within the symmetry of running parameters, as well as within all forms of radiation. This explains why galaxies and clusters are surrounded by a halo of extra mass/energy, as seen in ROSAT pictures for example [18].

Running of the constants explains why quark-gluon plasma (QGP) has the highest vorticity of any fluid, and higher than expected electro-magnetic strength [20]. From (25) and (32) we find –

$$\frac{\pi\phi^2 K_B}{3c^3} = \frac{F_g r^2}{\alpha T} = 1.404833723\ldots \times 10^{-48} \text{ kg/F.m.K} \qquad (34)$$

Thus, gravity is also *temperature*-dependent. It is probable that the solar-limb red-shift anomaly may be solved via this new understanding, as the corona has a much higher temperature than the solar surface.

Boltzmann's constant now has new equivalent expressions also –

$$k_B = \frac{PV}{NT} = \frac{R}{N_A} = \frac{3GEc}{\pi\phi^2 T\alpha} = \frac{hc}{T\lambda} = \frac{E}{T} = \frac{3F_g r^2 c^3}{\pi\phi^2 T\alpha} = \frac{h}{Tt} = \frac{K_I \alpha p}{GT} = 1.380648529(79) \times 10^{-23} \text{ J/K} \qquad (35)$$

## 5.1 Schwarzschild radius and entropy

The Schwarzschild radius $r_s$ relies on dimensions for *G* and *m*, as $r_s = \frac{2Gm}{c^2}$. However, dimensions are now Ω.kg/m$^3$ which is mass-resistance per volume and not a radius at all. The Bekenstein-Hawking formula for entropy of a black-hole is $S_{BH} = \frac{k\,A}{4L_P^2}$ where *k* is the Boltzmann constant, $L_P$ is Planck length, and *A* is $4\pi R^2$ which is the area of the event horizon, i.e. the Schwarzschild radius. Multiple issues arise here: -

- Planck length is incorrect, as discussed; and
- $r_S$ is not a radius, so *A* is not 'area'; and

- running with energy-increase produces a vector ↑↑↑↑↑↑ which means entropy increases at $10^6$ per any increase in energy.

Using corrected units gives us dimensions for $S_{BH}$ of $V^2.\Omega.kg^2/K.F.m^8$ which isn't entropy.

## 5.2 Coulomb constant and electrostatic force

The Coulomb constant $K_e$ is $1/4\pi\varepsilon$ which currently has units $N.m^2/C^2$. Due to pi having dimensions $\Omega/s^2$ the Coulomb constant now has a dimension, meters.

$$k_e = \frac{1}{4\pi\varepsilon} = \frac{\mu c^2}{4\pi} = \frac{\phi^2 c}{12\alpha} = \frac{F_e r^2}{e^2} = \frac{\phi^2 h}{6r^2 \mu e^2} = \frac{\pi\phi^4}{36G} = 8.962917679 \times 10^9 \text{ m} \quad (36)$$

Since $F_e = K_e e^2/r^2$ we have new dimensions for $F_e$ of $C^2m$. The $r$ term again represents a gradient, and is not counted in dimensional analysis. Our electrostatic force is -

$$F_e = \frac{k_e e^2}{r^2} = \frac{\phi^2 ce^2}{12r^2\alpha} = \frac{F_g ch}{2\pi\alpha\mu m} = \frac{\phi^2 h}{6r^2\mu} = \frac{Gch}{2\pi\alpha\mu r^2} = \frac{F_g \pi^2 h}{12\phi^2 me\mu c} = \frac{F_g \pi^2 \lambda ce}{24\phi^2 \alpha h} \quad C^2.m \quad (37)$$

Figure 1 shows some of these constants upon running, using the example of a high-energy cosmic photon from the early universe, losing energy and observed at 510 nm (visible green) today.

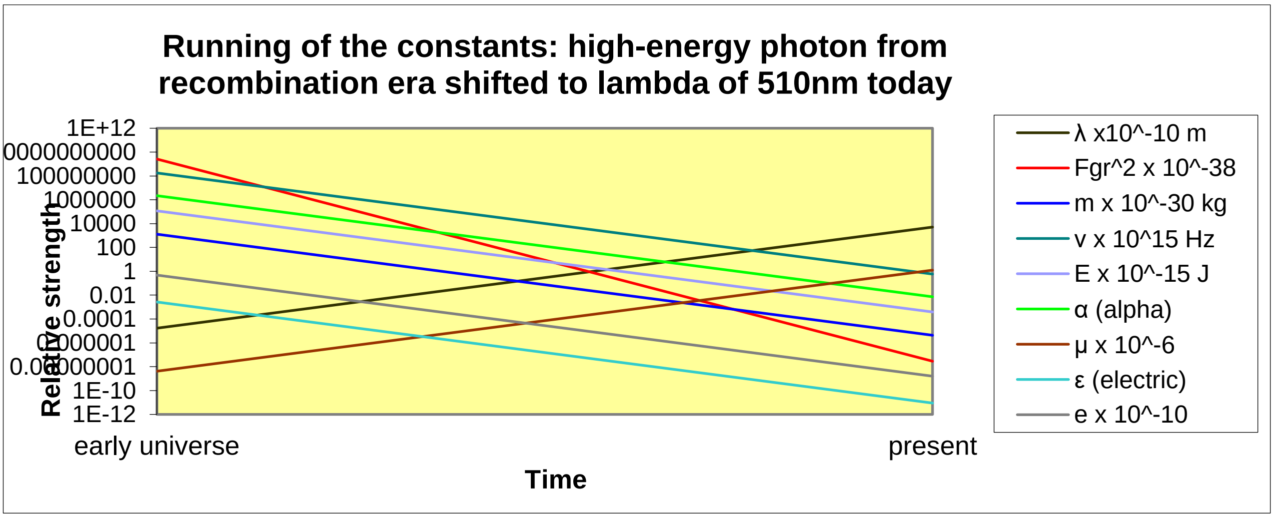


Figure 1: Running effects: some principal constants, plus gravity, energy, and mass plotted against time, for a high-energy cosmic photon originating from the early universe. The rate of change is per the Hubble metric, $H_o$. Today the photon appears in the visible range at 510 nm (green). $\lambda$ = wavelength, $v$ = frequency, $F_g r^2$ = gravitational force times distance squared. (Early universe is synonymous with high-energy environments such as black holes.)

In the example above our gravitational force $F_g$ loses about 17 orders of magnitude from a theoretical value in the early universe to the present, calculated in conjunction with other 'constants'. As gravitational strength (energy) diminishes, space-time dilates. Photon wavelengths in the early universe were shorter, irrespective of the cosmological model employed.

Symmetry is maintained through constant ratios, strongly suggesting an alternative cosmology[4], where we exist in a universe that has some defined shape. Equally, a run-away, expanding universe does not support the constant ratios we observe.

We ought to also see common ratios for the forces. Using the following we find a constant ratio –

$$\frac{F_e}{F_g\lambda}=\frac{\pi^2 ce}{24\phi^2\alpha h}=\frac{c^2}{2\pi\alpha\mu}=\frac{\phi^2 c}{6G\mu}=\frac{3c^3}{2\pi^2\phi^2}= 1.564149796 \times 10^{24}\ \text{F.m}^3/\Omega \qquad (38)$$

for the electric and gravitational forces (interactions). This is distance independent.

We predict that the weak and strong interactions will also share a ratio of symmetry, and furthermore, they will be related by the interaction constant.

# 6. New Cosmology

Latest analyses from surveys of the CMB surface of last scattering [21] contain critical parameters that constrain cosmic models. Our interaction constant $K_I$ ought to appear within some of these parameters if an alternative cosmology is anticipated from the constant ratios shown earlier. In fact it does: pi times phi-squared produces a number that looks extremely close to the 2s-to-1s two-photon decay rate from the recombination era. The accepted value [21] for $A_{2s\rightarrow 1s}$ is 8.2206 $s^{-1}$, and from our theory here we see $\pi\phi^2$ is the constant below. From (2) we observe that it can be expressed as a 'rate'. This suggests there is a natural limit to particle interactions.

$$\pi\phi^2=\frac{3Gc}{\alpha}=\frac{6\alpha^2 h}{e^2}=\frac{3\alpha}{c\varepsilon}=\frac{3GE\lambda}{\alpha h}=\frac{3F_g r^2 c}{m\alpha}=\frac{3Gh}{\alpha m\lambda}=\frac{3G\lambda}{t\alpha}=3c\alpha\mu=8.224796338\ldots\ \Omega/\text{s}^2 \qquad (39)$$

Furthermore, squaring $\pi\phi^2$ yields a value in excellent agreement with our Hubble constant $H_o$, well within the error range of the latest measurement [21].

$$H_o=\pi^2\phi^4=\frac{9G}{\varepsilon}=\frac{9G^2E}{m\alpha^2}=\frac{9F_g r^2\mu h}{m^2 t}=\frac{9G\mu\lambda c}{t}=3\pi\phi^2 c\alpha\mu=67.64727481\ldots\ \Omega^2/\text{s}^4 \qquad (40)$$

An interesting theory emerges from these discoveries. Our expressions above suggest the universe has some invariant form, rather than run-away acceleration [22-23] from a big-bang. Suitable cosmologies include a rolling torus, where the Hubble constant describes a radial (poloidal) 'roll-out' rate (or ratio). The Hubble term above appears inextricably related to the running constants, suggesting a cyclic action. Consequentially, photon wavelength red-shifts are not caused by expansion of the *universe*. It is suggested instead this occurs through cyclic variation of the constants during poloidal 'roll-out' from the torus core. As gravity and energy relax, space-time expands. Tori have been previously considered [24, 25].

This constant may be related to the volume of a torus ($2\pi^2Rr^2$) where $\phi^4$ corresponds to an expansion rate or factor for volume.

---

[4] Alternative to the Standard Model, or ΛCDM model

A torus cosmology requires a closed universe. If the mass-density parameter shown here is correct, we find a perfect match:[5]

$$\Omega_m = \frac{\varepsilon hc\alpha}{e^2\phi} = \frac{\pi\phi}{6c\alpha\mu} = \frac{\alpha h}{c\mu e^2\phi} = \frac{m\lambda\alpha}{\phi\mu e^2} = \sqrt{\frac{\pi\alpha m\lambda}{12Gh}} = \frac{3Gc}{2\pi\phi^3\alpha} = \frac{1}{2\phi} = 0.309016994\ldots \qquad (41)$$

This and (2) imply a limit for all entities such that singularities are avoided. Rearranging (32) reveals an ideal candidate for the cosmological constant. This also points toward our torus model, and is probably a curvature-density ratio. The last expression shows how gravity, mass and the electrostatic force are related: -

$$\Omega_\Lambda = \frac{G}{2ec} = \frac{GE\lambda}{2ehc^2} = \frac{\pi\phi^2\alpha}{6ec^2} = \frac{Ge\mu}{4\alpha h} = \frac{9G}{\pi^4\varepsilon} = \frac{\phi^4}{\pi^2} = \frac{F_g\phi^2 e}{24F_e\alpha m} = 0.6944657227\ldots \ \Omega/\text{C.s.m}^2 \qquad (42)$$

This constant appears above at (13), (16), (18), (20-22), (32) and (33).

Table 2 compares these results to the Planck 2015 values.

| **Comparison with Planck 2015 data** | | | |
|---|---|---|---|
| Parameter | Symbol | Planck data | This study |
| Hubble constant | $H_o$ | 67.8±0.9 | 67.64727481… |
| 2s-1s two photon decay | $A_{2s\to 1s}$ | 8.2206 | 8.224796338… |
| Mass density parameter | $\Omega_m$ | 0.3089±0.012 | 0.309016994… |
| Cosmological constant | $\Omega_\Lambda$ | 0.6911±0.0062 | 0.694465722… |
| Cosmological curvature | $\Omega_k$ | $\lvert\Omega_k\rvert$<0.005 | -0.003482716… |

Table 2: Planck parameters from CMB radiation compared to theoretical values from this present study. Dimensional units are omitted. $A_{2s\to 1s}$ has an error range of ±0.5.

Note: our values here are within the error range of the Planck survey findings. Such close correlations are not likely to be coincidental.

The Sloan Digital survey [26] found the Hubble constant to be $67.6\pm^{0.7}_{0.6}$ which is identical to the value found in this present study.

We now show that from our theory above, the universe is closed, just;

$$\Omega_k = 1 - \Omega_\Lambda - \Omega_m = -0.003482716 \qquad (43)$$

In one method, the Planck team [27] showed $\Omega_k = -0.003\pm^{0.012}_{0.014}$ which is identical.

## 6.2 Proton-electron mass ratio

[5] $\Omega_m$ is the mass-density parameter; $\Omega_\Lambda$ is the cosmological constant; and $\Omega_k$ is the cosmological curvature parameter, where zero means a flat universe. A positive value = open universe, negative = closed.

At present the official [2] proton to electron mass ratio is 1836.15267389(17). The number $6\pi^5$ is very close to $m_p/m_e$, but could it be the *actual* ratio? It fits out theory thus –

$$6\pi^5 = \frac{108\pi ce}{\varepsilon} = \frac{36\pi^2\phi^2c^2e}{\alpha} = \frac{288\pi\phi^6F_e\alpha h}{F_g\lambda G} = \frac{288\pi\phi^6F_e p}{F_g\alpha\mu} = 1836.118109\ldots \text{ V}^2.\text{m}^2/\text{A.s}^4 \quad (44)$$

This constant includes ratios between electromagnetic and gravitational forces, includes the interaction constant, momentum, fine-structure constant, and is independent of distance. This finding differs from the current value by 0.0019%. However it ought to be dimensionless, so this is not probably not it.

<u>Discussion</u>

Probably the most precise experimental value for $h/m_u$ (the Planck/unified atomic mass constant ratio) was obtained by photon-recoil momentum [28]. This produces[6] a unified atomic mass unit of 1.657029856 x $10^{-27}$ kg, which is smaller than the recommended value [2] by 0.211% due almost entirely to the new value for *h* found here. Irrespective of the $m_p/m_e$ ratio, a smaller value for the electron mass will result.

## 6.3 Age of the universe

The radiation component should be included in the mass parameter (because of the *mλ* constant). Using $F = \Omega_m + \Omega_\Lambda$ (values as above) and as a consequence of (40) we find the age of the universe to be slightly older, at 14.404 Gyr. In a torus universe this would represent the age back to the core.

# 7. General discussion

Regardless of the cosmology, we ought to be able to observe small differences in *G* as a gradient along some plane through the cosmos. The larger value will point towards the core[7] (or big-bang). Perhaps the *G* gradient might best be observed as a gradient in alpha, since $G = \alpha^2\mu$.

One team [29] has found such a dipole, showing an increase in $\alpha$ in the direction right ascension 17.5±0.9 hours, declination −58±9 degrees. This followed earlier work [30] where a similar decrease was found in the opposite direction. We suggest this dipole represents the poloidal radian from core to outer universe from the period of emission, within our observable universe. If so, the plane will be rotated away from the actual core due to age of light measured, assuming a poloidal roll and toroidal spin (for the universe). Other research [31] showed a dark-energy dipole matching that of alpha. Again, we submit this must be due to running of gravity.

There ought to likewise be a CMB dipole in a different plane (more rotated) showing slightly warmer temperatures towards where the core once existed. This assumes our present observable universe is near the 'roll-out' pole of the torus, as opposed to the 'roll-in' pole.

[6] Using the revised Planck constant in this study.
[7] That is, where the core existed when the radiation was emitted.

Running of the parameters in Figure 1 above are consistent with a torus universe. Photon wavelengths red-shift uniformly while receding from gravitational hubs. Gravitational, and spatial-expansion red-shifting are two facets of the same mechanism, contributing to observed large scale homogeneity. Phenomenologically, this appears to us as though the universe is expanding at an accelerated rate, while initial expansion from the core may simulate an inflation event from our perspective. These are, however, illusory artifacts of poloidal roll-out.

A torus cosmology removes all the anomalies of the ‘standard model’. Such a universe does not require singularities, dark energy, exotic dark matter, super-symmetry, or inflation epochs. There is no horizon-problem, since a plasma core provides a connective flow to all regions continuously. Structural symmetry is maintained through variable (running) parameters. Space-time is a superconductive medium, where photons have mass. Rolling tori are highly stable and enduring.

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## Appendix A: comparison of parameter values

| Quantity | Symbol | Best value | (source[8]) | This study | Difference (%) |
|---|---|---|---|---|---|
| Photon constant | $c$ | 299792458 | A | 299792458 | 0 |
| Fine structure constant | $\alpha$ | $7.297352566 \times 10^{-3}$ | C | $7.297352566 \times 10^{-3}$ | 0 |
| Elementary charge | $e$ | $1.6021766208(98) \times 10^{-19}$ | A | $1.602680715 \times 10^{-19}$ | 0.031 |
| Planck constant | $h$ | $6.626070040(81) \times 10^{-34}$ | C | $6.612067309 \times 10^{-34}$ | 0.212 |
| Magnetic permeability | $\mu$ | $1.2566370614 \times 10^{-6}$ | A | $1.253192727 \times 10^{-6}$ | 0.275 |
| Electric permittivity | $\varepsilon$ | $8.854187817 \times 10^{-12}$ | A | $8.878523088 \times 10^{-12}$ | 0.275 |
| Wave impedance | $z$ | 376.730313461 | A | 375.697728 | 0.275 |
| Gravitational constant | $G$ | $6.67408(31) \times 10^{-11}$ | C | $6.673421013 \times 10^{-11}$ | 0.005-0.014 |
| 2s→1s two photon decay | $\gamma_d$ | 8.2206±0.5 | P | 8.224796338 | 0 |
| Hubble parameter | $H_o$ | 67.6 ± 0.6 | S | 67.64727481 | 0 |
| Mass density | $\Omega_m$ | 0.3089 ± 0.00062 | P | 0.309016994 | 0 |
| Cosmological term | $\Omega_\Lambda$ | 0.6911 ± 0.0062 | P | 0.694465722 | 0 |
| Universe | $\Omega_k$ | −0.003±0.013 (closed) | P | −0.003482716 (closed) | 0 |
| Proton-electron mass ratio | $m_p / m_e$ | 1836.15267389(17) | C | 1836.118109… | 0.0019 |
| Mass-wavelength *h/c* | $m\lambda$ | $2.210219058 \times 10^{-42}$ | C | $2.205548249 \times 10^{-42}$ | 0.212 |
| Temp-time constant | $Tt$ | | | $4.789080045 \times 10^{-11}$ | new |
| Temperature-mass constant | $\frac{T}{m}$ | | | $6.509628971 \times 10^{39}$ | new |
| Electrostatic-mass/gravity | $\frac{F_e m}{F_g}$ | | | $3.449807844 \times 10^{-18}$ | new |
| Temp-wavelength constant | $T\lambda$ | | | 0.0143573 | new |
| Interaction constant | $K_I$ | | | 2.741598779… | new |

[8] C = CODATA 2014; P = Planck 2015; S = Sloan (SDSS) 2016; A = agreed by convention

## Appendix B: Derivation of some Principal Constants of Nature

$\times 3 = \pi\phi^2$ → squared → $\pi^2\phi^4$ → $\div \pi^4 = \frac{\phi^4}{\pi^2} = \frac{G}{2ec} = \Omega_\Lambda$

$(inv)\times\frac{G\lambda}{\alpha} = t$

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

Hubble constant (-)

Cosmological constant (-)

Time (↓)

$\times 3\pi\phi^2$

$(inv)\times\frac{GhT}{\alpha p} = Tt$ Temp.-time (-)

$\times\frac{\alpha}{2ec^2}$

$(inv)\times\frac{GE}{\alpha c} = m$

mass (↑)

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

wave impedance (↓)

$\times\frac{m\alpha}{G} = p$

momentum (↑)

$\times\frac{ce^2}{4\pi r^2\alpha} = F_e$

electrostatic force (↑)

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

magnetic permeability (↓)

$\times\frac{\alpha h}{G\lambda} = E$

Energy (↑)

$(inv)\times\hbar c^2 = \frac{F_e m}{F_g}$

Electrostatic-mass per gravity (-)

$\times m\alpha c = GE$

gravitational energy (↑↑)

$(inv)\times\frac{GEc}{T\alpha} = k_B$

Boltzmann's (-)

$\times\frac{m\alpha}{cr^2} = F_g$

Gravitational force (↑↑)

$(inv)\times\frac{GEc}{k_B\alpha} = T$

Temperature (↑)

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

Interaction constant (-)

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

Photon constant (-)

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

Gravitational constant (↑)

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

Planck constant (-)

$T\times\lambda = \frac{hc}{k_B}$ (-)

Temperature-wavelength

$(inv)\times\frac{2mc^2\alpha^2}{e^2} = v$

frequency (↑)

$\times\frac{\alpha h}{GE} = \lambda$

wavelength (↓)

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

Mass density parameter (-)

$\times\frac{c}{4\pi\alpha} = k_e$

coulomb constant (↓)

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

Fine structure constant (↑)

$\times\frac{e^2}{2\alpha^2 c} = m\lambda$

mass-wavelength (-)

$(sq'd)\times\frac{e^2}{2G\alpha} = E\lambda = hc$

Planck-photon constant (-)

$\Omega_k \equiv 1 - \Omega_\Lambda - \Omega_m$

U = -0.003482716;

[closed universe]

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

Electric permittivity (↑)

$(inv)\times\frac{Gh}{\alpha c} = mt$

mass-time constant (-)

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

Elementary charge$^2$ (↑↑)

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

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# Appendix C: Dimensional Analysis supplement

## Fine-structure constant

Conventionally, dimensional analysis for units of a ratio of multiple parameters that cancel out to a dimensionless constant, imply the final 'dimensions' must equal 1. This unity is omitted when referring to the constant: it is simply a dimensionless number. If that number varies when subordinate inputs change however, it can no longer be regarded as a 'constant'. Change, in this respect is synonymous with the terms time-variation, drift, or running.

While a dimensionless ratio between parameters does not preclude the individual running of those parameters, a *running* ratio implies that the dimensional analysis must be incorrect. A ratio cannot run or vary over time without assuming some dimension(s) of the subordinate parts.

Fine-structure relates to the splitting of main spectral lines (emission or absorption) into two or more sub-lines, each with a slightly different wavelength and frequency. These lines are produced when an electron releases a photon on transition to a lower energy state. Originally, the fine-structure constant (FSC, alpha or just $\alpha$) was used to provide a ratio between the velocity of an electron compared to the speed of light. It is presently regarded generally as a measure of the strength of the electromagnetic coupling between an elementary particle and the electromagnetic field.

It has been demonstrated that alpha runs with energy [3, 4, 5] and at the energy of the *Z*-boson, $\alpha$ is nearly 8% larger. There is evidence further that alpha was larger in the past [29], implying that conditions earlier in the universe were more energetic. If alpha varies over time, so too will fine-structure frequencies. Particle mass and charge must likewise vary.

## Vector analysis

To test our hypothesis, we can conduct a series of 'on paper' tests based on established principles in physics. Using our well-known expressions for energy provides -

$$E = mc^2 = \frac{h}{t} = h\nu = pc = Tk_B \tag{A}$$

where $E$ is energy, $m$ = mass, $c$ = speed of light (photon constant), $h$ = Planck's constant, $t$ = time, $v$ = frequency, $p$ = momentum, $T$ = temperature, and $K_B$ = Boltzmann's constant;
and the fine-structure constant is –

$$\alpha = \frac{e^2}{2\varepsilon hc} = \frac{c\mu e^2}{2h} = \frac{k_e e^2}{\hbar c} \tag{B}$$

where $\alpha$ = FSC, $e$ = the absolute value of the elementary charge on a proton or electron, $\varepsilon$ = electric permittivity of free space, $\mu$ = magnetic permeability of free space, $k_e$ = Coulomb's constant, and $\hbar$ = Planck's constant/2 pi.

Next, we use a simple vector-system of arrows to show running direction and magnitude, where (↑) means 'increasing with higher energy', (↓) means 'decreasing with higher energy', and (-) means the parameter does not run with energy. We already know from general relativity that wavelength decreases with increasing energy (↓), but frequency increases (↑) which allows $c$ to remain constant. Lengths generally decrease (length contraction), and time dilates (↓) at speeds approaching *c* (i.e. in high energy states). Mass increases with energy. From $h = Et$ we see that *h* must be constant. Since *c* is constant, *m* must run (↑), as does *T*, and likewise *p*. Since $c/2h = \alpha/\mu e^2$ and alpha runs, then $\mu$ must run (↓) and *e* must run (↑). This means, from (B) we see $\varepsilon$ must run with alpha. This must be correct to satisfy $1/\mu\varepsilon = c^2$.

Mass, length, and time have already been discussed, and combinations which make up the more complex SI units are shown in Table 1 in the main text. All running vectors are relative to the energy-variation in the fine-structure constant.

## Dimensional anomalies

Magnetic permeability, and electrical permittivity have units henries per metre (H/m), and farads per metre (F/m) respectively. Their base units suggest that $\mu$ and $\varepsilon$ ought to run at the square of the rate determined by their mathematical and vector relationships, indicating that their dimensions need re-examination.

Both parameters are dependent upon frequency [12], and as such we find that permeability times frequency gives us $\mu$ = H/ms, and permittivity per frequency yields $\varepsilon$ = F.s/m. The photon constant *c* is not affected by this, since frequency terms cancel out when multiplying $\mu$ and $\varepsilon$. This *does* have a significance for alpha however, where this parameter now has units 1/s, allowing it to run (↑). Since alpha varies with energy and is related to frequency, it seems logical that it would have units, Hz.

Does this affect our dimensional analysis of gravity or the gravitational constant? It is helpful to use the self-gravity form of the classic expression, $F_g = Gm/r^2$ where *r* is the radial distance of a particle's cross section. The term for radius or distance, *r* (or $r^2$) does not form part of the force itself – it simply shows that the force is proportional to distance. The term indicates a gradient, and as such, cannot run and ought not to be included in the analysis. Radius or distance is part of the quantitative, rather than qualitative assessment. Also, we know that gravity is a squared-force, and if *r* runs with lengths generally we find, rearranging for mass, that *m* doesn't run or even runs (↓) if *G* runs. This clearly is not correct and is contrary to experimental data.

It is clear then, that $F_g$ runs (↑↑) and mass is (↑). If *r* doesn't run, *G* must run (↑). SI units for gravity are Newtons (N), which run (↑↑), and appear to be correct at first. However, all is not well on the 'big *G*' front.

## Gravity units

Classically the dimensions for *G* are N.m$^2$/kg$^2$ or alternatively m$^3$/kg.s$^2$. We see this gives the constant a vector on running of (↓↓) in both cases. This is clearly counter to experiment and expectation, and occurs due to inclusion of $r^2$ in the force dimensions. Our self-gravity formula doesn't assist either, as in both cases running is at (↓) as discussed above. Worse still, *G* looks like an acceleration, which it isn't.

How do we cure this conundrum? The question is partly answered above, where we leave *r* out of the dimensional analysis for force, and it doesn't run. Since $G = \pi\varnothing^2\alpha/3c$ or $\alpha^2\mu$ we get units for *G* of

N/C$^2$.s = H/m.s$^3$ = Ω/m.s$^2$ = 1/F.s.m which runs (↑). Our gravitational force $F_g$ redacts to *Gm*, which gives units N.kg/C$^2$.s = H.kg/m.s$^3$ = Ω.kg/m.s$^2$ = kg/F.s.m and which runs (↑↑) as expected.

## Electrostatic force

The Coulomb constant $K_e$ is $1/4\pi\varepsilon$ which currently has units N.m$^2$/C$^2$. Due to pi having dimensions Ω/s$^2$ the Coulomb constant now has the dimension, meters. Since $F_e = K_e e^2/r^2$ we have new dimensions for $F_e$ of C$^2$m. The *r* term again represents a gradient, and is not counted in dimensional analysis.

## Pi and phi dimensions

Cross-checking of dimensions using all expressions shows consistently the following -

| **Expression** | **Dimensions** | **Equivalent units** |
|---|---|---|
| $\pi, \pi\phi^2, \pi\phi^4$ | Ω/s$^2$ | H/s$^3$ = 1/F.s |
| $\pi^2, \pi^2\phi^2, \pi^2\phi^4$ | Ω$^2$/s$^4$ | H$^2$/s$^6$ = 1/F$^2$.s$^2$ |
| $\pi^3$ | A.m$^2$ | C.m$^2$/s |
| $\pi^4$ | V.m$^2$/s$^2$ | |
| $\pi^5$ | V$^2$.m$^2$/A.s$^4$ | Ω.V.m$^2$/s$^4$ |
| $\pi^7$ | W.m$^4$/s$^2$ | |
| $\phi$ | nil | |
| $\phi^2$ | nil | |
| $\phi^3$ | nil | |
| $\phi^4$ | Ω$^3$/C.m$^2$.s$^5$ | |
| $\phi^6$ | Ω$^2$.V/C$^2$.m$^2$.s$^4$ | |
| $\frac{\pi}{\phi}, \frac{\pi}{\phi^2}, \frac{\pi}{\phi^3}$ | Ω/s$^2$ | H/s$^3$ = 1/F.s |
| $\frac{\pi^2}{\phi^2}, \frac{\pi^2}{\phi^3}, \frac{\pi^2}{\phi^4}$ | F.C.m$^2$ | C.s.m$^2$/Ω = C$^2$.m$^2$/V = C$^3$.m/N = C$^2$.s/T |
| $\frac{\pi^5}{\phi^6}$ | C$^2$.m$^4$/Ω | |
| $\frac{F_g}{F_e}$ | Ω/F.m$^4$ | |
| $\Omega_m$ | nil | |
| $\Omega_\Lambda$ | Ω/C.s.m$^2$ | 1/F.C.m$^2$ |

It appears that pi and phi are dimension-sharing in some combinations. When checked against other known and proven expressions, the dimensional analysis shows the ratios must be correct.

Incorporating these changes brings dimensional analysis into agreement with mathematical and vector relationships.