Primordial Code in the Universe

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ABSTRACT

Dimensional analyses identify running modes for dimensional parameters. Relationships with the gravitational parameter *G* introduce an apparent primordial code, designated the 'interaction constant' for now, which appears to be embedded within every wave-particle duality, process and interaction. Dimensional parameters are emergent from this interaction constant. Least energy occurs at speed of light (*c*) for quantum wave-particles (wavicles). Wavicle-specific, dimensional quantum parameters scale mostly linearly at *c* with energy. Scaling becomes non-linear < *c* for many parameters (including mass, gravity, and the Planck 'constant'), synonymous with symmetry breaking. This feature of the standard model ought to resolve dark matter. Quantum wavicles appear to be fractally related. Gravity is emergent, forming the spatial field interaction with matter, contracting locally, which unites with quantum theory. Multiple constants are amended and several new relationships introduced. These amendments to the standard model, with the ubiquitous interaction constant embedded as a primordial code, are invariant under multiple systems of simultaneous assessment. A finely tuned, encoded universe with emergent parameters, is inconsistent with a chaotic big bang cosmology.

1. INTRODUCTION

Particle parameters that scale with energy must be dimensional. It follows that dimensional particle parameters *must* scale with energy, velocity, or both. The fine structure constant α is known to scale with energy [1 – 4], and must therefore have some dimension within which to run. It was determined that alpha has dimensions s^{-1} or Hz, [5] and its value is wave-particle specific, increasing with mass or energy.

Particle parameter relationships include the usual, from CODATA [6]

$$\mu_0 = \frac{4\pi\alpha\hbar}{ce^2} = 1.256\ 637\ 061\ 27(20) \times 10^{-6}\ \mathrm{N\ A^{-2}} \tag{1.1}$$

$$\varepsilon_0 = \frac{1}{\mu_0 c^2} = 8.854\ 187\ 8188(14) \times 10^{-12}\ \mathrm{F\ m^{-1}} \tag{1.2}$$

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} = 7.297\ 352\ 5643(11) \times 10^{-3}. \tag{1.3}$$

Four other principal constants and their values [6] are:

Elementary charge, $e = 1.602\ 176\ 634 \times 10^{-19}$ C (exact);

Speed of light, $c = 299\ 792\ 458\ \mathrm{m\ s^{-1}}$ (exact);

Planck constant, $h = 6.626\ 070\ 15 \times 10^{-34}\ \mathrm{J\ Hz^{-1}}$ (exact);

Newtonian constant of gravitation, $G = 6.674\ 30(15) \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$.

A problem arises immediately: the parameters above are all dimensional, which must scale with energy, velocity, or both. If the measured speed of light in vacuum is as above, and we accept the fine structure constant alpha at its value as shown, but with dimensions Hz, all other parameter values (and any errors) and their dimensions may be ascertained from common relationships.

An alternative dimensional analysis system [5] reducing dimensions to those of time (s) and distance (m) only, provided insight. Parameters with time dimensions retain their values at c, for velocities < c. A mode change occurs for running parameters for wave-particle velocities < c, where scaling is determined by the exponent on the length component. Scaling of wave-particles with energy is usually linear at c, but mostly nonlinear at velocities < c. This is synonymous with symmetry-breaking.

This alternative dimensional analysis system – in 'original units' (OU) identified dimensional errors in the SI system for some parameters, created via the dimensional fine structure constant. Many particle parameters are wave-particle specific, mostly electron-valued. (See Table 1 for running modes.) The subscript $_0$ (in vacuum) is duly removed for the remainder of this work for all dimensional parameters. The OU system showed $\Omega \equiv s^2$, $H \equiv s^3$, $F \equiv s^{-1}$, and $A \equiv m^{-2}$. This resulted in the magnetic permeability constant μ having dimensions $\Omega\ m^{-1}$, or $s^2\ m^{-1}$, and ε having dimensions m^{-1}. [5]

The amended standard model then becomes invariant under multiple systems of simultaneous assessment, including four running modes, and two systems of dimensional analysis (SI and OU). Gravity is also united with quantum theory. It is anticipated that running parameters will resolve several outstanding problems in physics, including dark matter, strong and weak interactions, and unification of gravity with the electromagnetic interaction. It may identify new physics, perhaps.

2. GRAVITATIONAL CONSTANT

The enigmatic gravitational constant G has not previously been associated with other common constants, yet such relationships must exist in a unified theory. Experimental data values range from 6.671 91(99) × 10^{-11} to 6.675 59(27) × 10^{-11} [6]. Measurement errors are exacerbated by G scaling with temperature and energy, which must be accounted for [5]. A preliminary investigation anticipated that values for ε and μ would be slightly different than CODATA values. G looks like $\alpha^2\mu$, and the following analysis tests this idea. The product $G\varepsilon$ is:

$$G\varepsilon = \frac{\alpha\mu e^2}{2hc} = \frac{\alpha^2}{c^2} = 5.925\ 012\ 249 \times 10^{-22}. \tag{2.1}$$

Then, ÷ G provides:

$$\varepsilon = \frac{\alpha\mu e^2}{2hGc} = \frac{1}{\mu c^2} = 8.877\ 353\ 803 \times 10^{-12}\ \text{m}^{-1}. \tag{2.2}$$

(Dimensions for G discussed below). This provides new values for μ at 1.253 357 792 × $10^{-6}\ \Omega\ m^{-1}$, and 1.994 780 881 × 10^{-7} for the Ampere (smaller by 0.26%). A new value for the von Klitzing constant is shown, and since

$$R_K = \frac{h}{e^2} = \frac{\mu c}{2\alpha} = 25\ 745.447\ 41\ \Omega, \tag{2.3}$$

G is then:

$$G = \frac{\alpha\mu e^2}{2h\varepsilon c} = \frac{\alpha^2}{\varepsilon c^2} = \alpha^2\mu = 6.674\ 30 \times 10^{-11}\ \text{m}^{-1}. \tag{2.4}$$

The electromagnetic constant, c is then:

$$c = \frac{\alpha}{\sqrt{G\varepsilon}} = 299\ 792\ 458\ \text{m s}^{-1}. \tag{2.5}$$

The expressions above use alpha as found by Morel *et al* [7] which is used throughout this work. (This is within the error range for CODATA 2022 [6] and only differs by 1 at 9th decimal place.) An amended value for μ requires that experimental processes and calculations for values for h and e need revising. It appears likely from relationships that errors in h, e, and μ cancel out if values for alpha and c are well known.

Table 1: Scaling modes for physical parameters.

Parameter	symbol	Blue shift at *c* (fixed velocity, *E* increasing)	Red shift at *c* (fixed velocity, *E* decreasing)	Velocity < *c* (fixed frequency) Wavelength shift	original units
Planck constant	h			n^4	$s^4\ m^{-4}$
Photon constant	c			n^{-1}	$m\ s^{-1}$
Wavicle	$m\lambda$			n^5	$s^5\ m^{-5}$
Boltzmann Constant	k				
voltage	V			n^2	$s^2\ m^{-2}$
mass	m	n	n^{-1}	n^6	$s^5\ m^{-6}$
momentum	p	n	n^{-1}	n^5	$s^4\ m^{-5}$
energy	E	n	n^{-1}	n^4	$s^3\ m^{-4}$
frequency	f, v	n	n^{-1}		s^{-1}
temperature	T	n	n^{-1}	n^4	$s^3\ m^{-4}$
fine-structure ‘const.’	α	n	n^{-1}		s^{-1}
vacuum permittivity	ε	n	n^{-1}	n	m^{-1}
gravitational ‘const.’	G	n	n^{-1}	n	m^{-1}
elementary charge	e	n	n^{-1}	n^2	$s\ m^{-2}$
electrostatic int.	I_e	n	n^{-1}	n^3	$s^2\ m^{-3}$
magnetic flux density	B	n	n^{-1}	n^4	$s^3\ m^{-4}$
Elect. capacitance	F	n	n^{-1}		s^{-1}
vacuum permeability	μ	n^{-1}	n	n	$s^2\ m^{-1}$
electric ‘impedance’	z	n^{-1}	n		s
wavelength	λ	n^{-1}	n	n^{-1}	m
time	t	n^{-1}	n		s
Coulomb ‘constant’	k_e	n^{-1}	n	n^{-1}	m
Magnetic moment	μ_x	n	n^{-1}		s^{-1}
magnetic flux	Wb	n^{-1}	n	n^2	$s^3\ m^{-2}$
gravity	I_g	n^2	n^{-2}	n^7	$s^5\ m^{-7}$
power	W	n^2	n^{-2}	n^4	$s^2\ m^{-4}$
force	N	n^2	n^{-2}	n^5	$s^3\ m^{-5}$
electric current	A	n^2	n^{-2}	n^2	m^{-2}
elect. Resistance	Ω	n^{-2}	n^2		s^2
Von Klitzing ‘constant’	R_K	n^{-2}	n^2		s^2
Rydberg ‘constant’	R_∞	n^3	n^{-3}	n	$m^{-1}\ s^{-2}$
Hartree ‘energy’	E_h	n^3	n^{-3}	n^4	$s\ m^{-4}$
Wavicle volume	V	n^{-3}	n^3	n^{-3}	m^3
Electrical inductance	H	n^{-3}	n^3		s^3

Table 1: Scaling of major dimensional parameters; at *c* with (L) blue shift; (centre) red shift, and (R), < *c*.

Present dimensions for G are $m^3\ kg^{-1}\ s^{-2}$, from the Newtonian model of gravity as a force. Dimensional analyses here demonstrate that G with traditional dimensions would decrease in value at n^{-9} at velocities below c, i.e. on *increasing* energy. Fortunately, this is not observed, since if gravity was so seriously impaired, stellar objects and galaxies would not be able to form. (Gravity discussed briefly below at 3.4). Gravity is therefore not a force.

Dimensions for *G* are m^{-1}, and *G* scales with wave-particle energy. The presently accepted CODATA value for *G* is at the electron 'rest' mass, i.e. at *c*. [Note: all fundamental wave-particles share the same value however, when scaled to the electron charge radius at *c*.] The charge radius is

$$r_e = \frac{\lambda}{2\pi}. \tag{2.6}$$

G is inversely proportional to velocity, which must be accounted for in experimental measurements. As such, scaling provides that all experimental values for *G* will be correct for some mass at some velocity. If gravity propagates at *c*, then *G* is involved at *c* also, irrespective of the expressions and dimensions used to define it.

Under high-energy conditions, *G* obviously increases as does mass. Values for *G* found at nuclear fusion will be an order of 10^5 larger (proton charge radius ~3.4×10^{-18} m). [A future article will describe this.]

From the following

$$\frac{\alpha}{c} = \frac{\mu e^2}{2h} = 2.434\,134\,805 \times 10^{-11}, \tag{2.7}$$

it appears a small constant multiplied by this will equal the value for *G*, with that number being ~2.741 959 889. This is close to the ratio $\pi\phi^2/3$, larger by ~1.000 132, where ϕ is phi, the golden mean. The mean for high and low experimental values for *G* is $6.673\,75 \times 10^{-11}$, which would provide the ratio 2.741 733 936. This is larger than $\pi\phi^2/3$ by ~1.000 05. Extending the experimental mean to include extremes of error ranges, the mean is $6.673\,39 \times 10^{-11}$, which yields

$$\frac{Gc}{\alpha} = 2.741\,586\,04. \tag{2.8}$$

This is smaller than $\pi\phi^2/3$ by just 1.000 004 647 or 0.000 465%, which appears more than just coincidentally close. The presence of pi and phi suggests a geometric origin. For multiple reasons, including that this constant appears to unite all parameters, it is accepted from here on as being correct.

Then, *G* is:

$$G = \frac{\pi\phi^2\alpha}{3c} = \frac{\pi\phi^2\mu e^2}{6h} = \alpha^2\mu = \frac{\alpha^2}{\varepsilon c^2} = 6.673\,421\,016 \times 10^{-11}\ \mathrm{m}^{-1}. \tag{2.9}$$

This is the value for *G* at CODATA electron mass. New values for μ and ε are presented below. These parameters scale with energy, and all experimental values (for *G*, ε, and μ) will be correct for some velocity, temperature, and energy. Dimensions m^{-1} for *G* render all Planck units incorrect dimensionally, and place doubt on the existence of such units. Table 2 compares the theoretical result here with some experimental data, for *G*.

Table 2: Gravitational constant from experiment and theory

Source	Method	G value × 10^{-11}	Relative uncertainty u_r
Mean: 16 results (CODATA 2022)[6]	various	6.6738(20)	3.0×10^{-4}
Karagioz and Izmailov (1996)[8]	Fibre torsion balance, dynamic mode	6.6729(5)	7.5×10^{-5}
Bagley and Luther (1997)[9]	Fibre torsion balance, dynamic mode	6.67398(70)	1.0×10^{-4}
Kleinevoß (2002)[10]	suspended body, displacement	6.67422(98)	1.5×10^{-4}
Armstrong and Fitzgerald (2003)[11]	strip torsion balance, compensation mode	6.67387(27)	4.0×10^{-5}
Luo *et al* (2009)[12]	Fibre torsion balance, dynamic mode	6.67349(18)	2.7×10^{-5}
Tu et al (2010)[13]	Fibre torsion balance, dynamic mode	6.67349(18)	2.7×10^{-5}
This work	($k_l\alpha$/c)	6.67342101639(54)	8.1×10^{-11}

Table 2: Experimental values for *G* compared to this work. The theoretical result from this work shows *G* for an electron at *c*, where the relative uncertainty is that for alpha [7]. This represents a significant improvement over experimental results, which need to account for velocity and mass.

3. CONSTANTS AND RELATIONSHIPS

3.1 Interaction constant

A dimensionless constant (as mentioned) has been discovered that links other parameters as shown: [14]

$$k_I = \frac{\pi\phi^2}{3} = \frac{2Gh}{\mu e^2} = 2\alpha^2 R_K = \frac{Gc}{\alpha} = \frac{\alpha}{\varepsilon c} = \frac{\mu e^2}{2h\varepsilon} = c\alpha\mu = 2.741\ 598\ 782\ldots \qquad (3.1.1)$$

For this work, it is named the 'Interaction Constant' and symbolised k_I for now; the usual units are shown, and the irrational number phi squared is –

$$\phi^2 = 2\cos\left(\frac{\pi}{5}\right)+1 = \frac{3Gc}{\pi\alpha} = \frac{\left(\sqrt{5}+1\right)^2}{4} = \frac{6\alpha^2 h}{\pi e^2} = \frac{\pi^7}{216hc^4} = \frac{\pi^3\alpha}{6ec^2} = 2.618\ 033\ 988\ldots \qquad (3.1.2)$$

The interaction constant may also be shown as an expression of irrational numbers –

$$\left(\sqrt{5}+3\right)\cos^{-1}\left(\frac{\sqrt{3}}{2}\right) = \frac{\left(\sqrt{5}+3\right)\cos^{-1}(-1)}{6} = k_I\ . \qquad (3.1.3)$$

[To 21 dp = 2.741 598 781 968 531 456 216 …] This constant appears to be a primordial code embedded within all wave-particles, relationships, and interactions. It appears highly improbable to have occurred via random chance. [This constant usually appears as the base $\pi\phi^2$ with an integer multiple of 3 in the denominator. The constant appears in the inverse also.] Note: the term wave-particle duality is rather awkward. An older term, now dropped from usage is '*wavicle*', first used by Arthur Eddington [15], which is the preferred term in this work, and used from here on.

3.2 Planck constant

From (3.1.1, 3.1.2) the Planck constant h may be determined from theory to a high accuracy, subject only to the designated value for the speed of light, c.

$$h = \frac{e^2}{2\varepsilon c\alpha} = \frac{k_I e^2}{2\alpha^2} = \frac{mc^2}{v} = m\lambda c = \frac{E\lambda}{c} = \frac{\pi^7}{216\phi^2 c^4} = \frac{\pi^3 e\mu}{12\phi^2 c} = 6.612\ 067\ 303 \times 10^{-34}\ \text{J s}. \qquad (3.2.1)$$

This is ~ 0.212% smaller than the CODATA value [6], but relies solely on *one* parameter (c) set by human convenience. Note also that the Planck parameter is velocity-dependent, having a *least value* at c. [Using 3rd last expression provides a value of 6.612 067 302 572 028 564 293… × 10^{-34} to 21 d.p.] As velocity decreases, the Planck 'constant' increases at n^4, in proportion with E.

Consequently, more precise values are determined for the elementary charge e, (~0.031% larger); magnetic permeability parameter μ (~0.275% smaller); electric permittivity ε (~0.275% larger); gravitational constant G (~0.013% smaller than the CODATA recommended value, but within error range of the CODATA 2010 value); and many other parameters.

It is clear from (3.1.1) to (3.2.1) that these fundamental wavicle parameters are *emergent* properties arising from the interaction constant. This implies a geometric origin, likely from the geometry of the universe. Each of these parameters may be determined from the ratio formed from its relationship with alpha and the interaction constant, where their dimensions determine their running character.

3.3 Core parameters

From (3.1.1) to (3.2.1) above, the following values and dimensions are found: -

$$\mu = \frac{k_I}{\alpha c} = \frac{\pi\phi^2}{3\alpha c} = 1.253\ 192\ 728\ 78(10) \times 10^{-6}\ \Omega\ \text{m}^{-1} = \text{s}^2\ \text{m}^{-1}, \tag{3.3.1}$$

$$\varepsilon = \frac{\alpha}{k_I c} = \frac{3\alpha}{\pi\phi^2 c} = 8.878\ 523\ 075\ 50(72) \times 10^{-12}\ \text{F s m}^{-1} = \text{m}^{-1}, \tag{3.3.2}$$

$$G = \frac{k_I\alpha}{c} = \frac{\pi\phi^2\alpha}{3c} = 6.673\ 421\ 016\ 39(54) \times 10^{-11}\ \text{m}^{-1}, \tag{3.3.3}$$

$$e = \frac{k_I\pi^2\alpha}{2\phi^4 c^2} = \frac{\pi^3\alpha}{6\phi^2 c^2} = 1.602\ 680\ 712\ 81(13) \times 10^{-19}\ \text{C} = \text{s m}^{-2}, \tag{3.3.4}$$

$$k_e = \frac{k_I\phi^2}{12G} = \frac{\phi^2 c}{12\alpha} = 8.962\ 917\ 691\ 29(72) \times 10^{9}\ \text{m, and} \tag{3.3.5}$$

$$c = \frac{k_I\alpha}{G} = \frac{\pi\phi^2}{3\alpha\mu} = \frac{3\alpha}{\pi\phi^2\varepsilon} = 299\ 792\ 458\ \text{m s}^{-1}. \tag{3.3.6}$$

[U_r shown for (3.3.1) to (3.3.6) is that for alpha from Morel *et al*, [7] at 81 ppt.] Notes on dimensions: from $\mu = \frac{2\alpha h}{ce^2}$ we get $\frac{\text{J.s}}{\text{m.C}^2} = \frac{\Omega}{\text{m}}$. It is shown from $h = \frac{\pi^7}{216\phi^2 c^4}$ and $m = \frac{h}{c\lambda}$ that *h* has units $\text{s}^4\ \text{m}^{-4}$ and mass has OU units $\text{s}^5\ \text{m}^{-6}$. From an alternative expression for electric permittivity (vacuum), $\varepsilon = \frac{\pi\phi^2 e^2}{6Ghc^2}$ has dimensions $\frac{\text{C}^2\ \text{m s}^2}{\text{J s m}^2} = \frac{\text{s}^2}{\Omega\ \text{m}} = \frac{\text{F s}}{\text{m}}$, = m^{-1}, showing how the SI units are derived from OU.

Core parameters, (2.7) and (1.3) show how alternative expressions for alpha include the interaction constant:

$$\alpha = \frac{e^2}{2\varepsilon hc} = \frac{c\mu e^2}{2h} = \frac{6\phi^2 ec^2}{\pi^3} = \frac{Gc}{k_I} = k_I\varepsilon c = 7.297\ 352\ 562\ 787(11) \times 10^{-3}\ \text{s}^{-1}. \tag{3.3.7}$$

From (3.3.4) there is an elementary charge-to-alpha constant that is velocity dependent:

$$\frac{\alpha}{e} = \frac{6\phi^2 c^2}{\pi^3} = \frac{Gc}{k_I e} = \frac{\pi^4}{36hc^2} = 4.553\ 216\ 685\ldots \times 10^{16}\ \text{m}^2\ \text{s}^{-2}. \tag{3.3.8}$$

[To 21 d.p = 4.553 216 685 303 518 222 460… × 10^{16}.] This confirms dimensions for the fine structure constant and confirms running for the elementary charge.

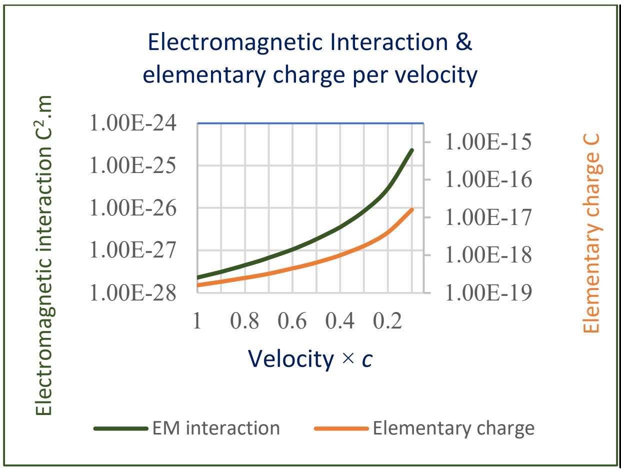
From (3.3.2, 3.3.3) a dimensionless constant exists between electric permittivity and the gravitational constant:

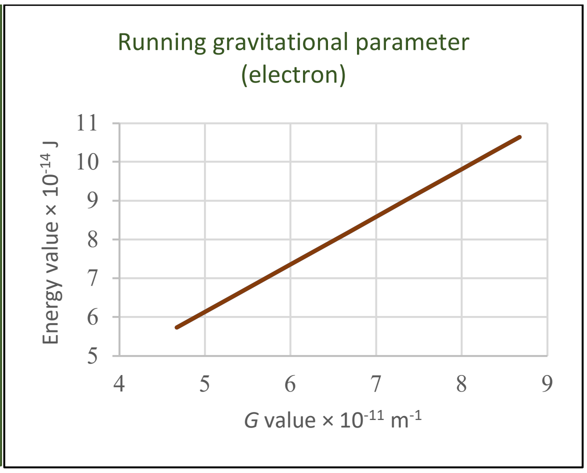
$$\frac{G}{\varepsilon} = \frac{\pi^2\phi^4}{9} = \frac{\alpha^2}{\varepsilon^2 c^2} = \left(c\alpha\mu\right)^2 = k_I^2 = 7.516\ 363\ 867\ldots \tag{3.3.9}$$

[To 21 d.p. = 7.516 363 881 290 345 719 50…] This is velocity and energy-invariant. As *ε* varies (any cause), so does *G*. There are multiple such dimensionless ratios, e.g. *G*, *e*, and *c* as a ratio –

$$\frac{G}{ce} = \frac{6k_I\phi^2}{\pi^3} = \frac{2\phi^4}{\pi^2} = 1.388\ 931\ 448\ 051\ 385\ldots \tag{3.3.10}$$

Figures 1a and 1b show how the electromagnetic interaction and elementary charge scale with velocity, and G with energy. Datapoints are based on electron values for these parameters.





Figures 1a, 1b: Examples of parameters scaling with energy; Left: (1a) electromagnetic interaction and elementary charge scale linearly at c, non-linearly < c. Right: (1b) gravitational parameter scales linearly at any velocity.

The electromagnetic interaction (see [5]) does not require distance terms dimensionally, and is not a force. Distance terms only find the value along a gradient. This interaction is labelled I_e to distinguish from energy E:

$$I_e = \frac{e^2}{4\pi\varepsilon} = c\alpha\hbar = Bc = \frac{k_l c e^2}{4\pi\alpha} = 2.302\ 202\ 012\ 57(19) \times 10^{-28}\ \mathrm{C^2\ m} = \mathrm{s^2\ m^{-3}}, \qquad (3.3.11)$$

where the value is at the electron mass at c, and relative uncertainty per alpha. Dimensions are also V m^{-1} or N C^{-1} [5], in agreement with [16]. B is the magnetic field strength (flux density) for the interaction, related as above [17] and shown separately as:

$$B = \alpha\hbar = \frac{k_l e^2}{4\pi\alpha} = 7.679\ 319\ 312\ 862(11) \times 10^{-37}\ \mathrm{T} = \mathrm{s^3\ m^{-4}}. \qquad (3.3.12)$$

This is also electron valued, having the same dimensions in OU as energy. Dimensions for alpha are clearly s^{-1}.

A further constant (at c) arises between energy and the gravitational constant –

$$\frac{E}{G} = \frac{mc^2}{\alpha^2\mu} = \frac{Ec}{k_l\alpha} = \frac{2Eh}{k_l\mu e^2} = \frac{\pi^2 p}{2\phi^4 e} = 1.226\ 822\ 9079(4) \times 10^{-3}\ \mathrm{J\ m} = \mathrm{s^3\ m^{-3}}. \qquad (3.3.13)$$

The last expression shows the relationship between momentum and elementary charge. These relationships with G refer to fundamental wavicles, where E and G scale linearly only at c. [$U_r = 3 \times 10^{-10}$ due to mass.]

At some nominal distance from a fundamental wavicle, elementary charges must cancel out in the sea of virtual (and real) particles. The gravitational constant ought to have a uniform, density-averaged value, but not necessarily the electron value.

3.4. Gravity – brief overview

Newton introduced gravity as a force between massive bodies, [6, 17-18] usually given as

$$F_g = G\frac{m_1 m_2}{r^2}\text{, in N,} \qquad (3.4.1)$$

where gravity is the force acting between two masses separated by distance r. The distance term r is redundant for the purposes of *dimensions* for gravity, since distance simply relates gravitational strength along a gradient from or between massive sources. Dimensions for gravity in general relativity (GR) don't scale correctly for fusion to occur [5]. [Relativity is not discussed further in this article. For a more extensive discussion on gravity, see [14]. Future articles will discuss gravity in detail.]

Gravity is the interaction of a wavicle with the spatial medium (fields) it propagates within, yet it is not a force. Essentially, gravity modifies the traversed medium via the electromagnetic interaction, causing local contraction towards the centre of mass for all bodies. This is synonymous with contraction via the Coulomb 'force'. Modifying Newton's expression for gravity by removal of distance terms, and using the simplest expression for a body's 'self' gravity, unifies gravity naturally with Einstein's mass-energy relation $E = mc^2$. Mass, and associated gravitational constant G (with dimensions m^{-1}) both run proportionally with alpha (at c), giving rise to an inverse distance-squared proportionality for gravity as observed. [17] A few expressions then are –

$$I_g = Gm = \alpha^2 \mu m = \frac{GE}{c^2} = \frac{Gh}{c\lambda} = \frac{he^3c^3}{12k\alpha} = \frac{k_I^2 e^2}{2\alpha\lambda c^2} \quad \text{kg m}^{-1}. \tag{3.4.2}$$

Gravity scales accordingly with other running parameters. Dimensions are those of linear mass density, and scaling < c allows unification (fusion) to occur at ~10^{-18} m as found experimentally [18]. Alternative dimensions are Wb V m^{-3}, and in OU it is s^5 m^{-7}. Removal of distance terms for this interaction does not prevent gravity retaining its inverse square relationship as a gradient over distance, irrespective of velocity, from its original value at c. Notwithstanding this point, gravity *is* velocity dependent, increasing at n^7 as velocity reduces, i.e. significantly for macroscopic matter. This *is* the mechanism for macroscopic mass increase. Density ρ increases at n^9 as velocity reduces. Interestingly, the alternative SI dimensional units Wb V m^{-3} for gravity, evidence that the electromagnetic interaction is included within mass. It also indicates a non-vanishing, albeit ethereal geometry (no point particles exist).

4. ENERGY RELATIONSHIPS

4.1 Energy

Gravity and energy are related as follows, using relationships above –

$$E = mc^2 = hv = Tk = \frac{I_g c^2}{G} = \frac{2\pi I_e}{\alpha\lambda} = \frac{k_I mc}{\alpha\mu} = \frac{k_I e^2 v}{2\alpha^2} \quad \text{J}, \tag{4.1.1}$$

where k is the Boltzmann constant, T is temperature, and v is frequency. A dimensionless constant may be found from previous relationships

$$k_U = \frac{I_e E}{I_g} = \frac{\pi^3 ce}{72G} = \frac{hc^3}{2\pi\alpha\mu} = \frac{I_e c^2}{G} = \frac{\pi^5}{144\phi^4} = \frac{hc^4}{2\pi k_I} = 0.310\ 053\ 266... \tag{4.1.2}$$

This links gravity, energy, and the electromagnetic interaction, and is velocity invariant at least for fundamental wavicles. The label k_U signifies this is a *unification constant*. The relative strengths of gravity and electromagnetic interaction have an identical value (for electron) at 6.249 897 004 × 10^{-19}, when mass = 6.713 482 46 × 10^{-12} kg, and velocity = 214 903.8648 m s^{-1}. This is equivalent to slowing an electron from c to that velocity. It is pertinent to note the incompatibility of conversions from eV to kg or J at velocities < c, because the traditional conversion fails to account for running. Also, the CODATA value for e is smaller than the alpha-derived value in this work. The value for e here is larger by 1.000 314 623. [To 21 d.p. I_eE/I_g = 0.310 053 265 965 721 462 008…, and the reciprocal constant I_g/I_eE = 3.225 252 270 397 167 603 077…]

4.2 Temperature

The energy equation may be broken down into components of the Boltzmann constant k, and temperature. Error in the value of the latter is that of the Boltzmann constant. Currently k = 1.380 649 × 10^{-23} J K^{-1}, [6] where

$k = E/T = h\nu/T$, so the constant must first be adjusted for error in the Planck constant. The Planck constant in this work provides a value for k of 1.377 731 28 × 10^{-23} J K^{-1} as a first approximation.

Then, the temperature per mass relation below obtains excellent agreement (using electron parameters), which show that frequency per elementary charge is a constant, (at c) since both terms run proportionately.

$$\frac{T}{m} = \frac{c^2}{k} = \frac{144\phi^6 \nu}{\pi^5 e} = \frac{2\pi^2\phi^4\nu}{3hc^4 e} = 6.523\ 566\ 5261(20) \times 10^{39}\ \text{K kg}^{-1},\ \text{m}^2\ \text{s}^{-2}. \qquad (4.2.1)$$

[$U_r = 3 \times 10^{-10}$]. An amended value for the Boltzmann constant is then found to be within 0.002% of the Planck-adjusted value above, using a few of the many relationships available -

$$k = \frac{R}{N_A} = \frac{hc}{T\lambda} = \frac{E}{T} = \frac{\pi^5 he}{144\phi^6 m} = \frac{\pi\alpha hc^4}{4\phi^6\nu} = \frac{\pi^8\alpha}{864\phi^8\nu} = \frac{k_I ce^2}{2T\lambda\alpha^2} = 1.377\ 705\ 240\ 15(41) \times 10^{-23}\ \text{J K}^{-1}, \qquad (4.2.2)$$

= dimensionless in OU. [$U_r = 3 \times 10^{-10}$]. Using expressions that don't contain T, the Boltzmann constant is seen to be dimensionless in OU, so kelvin has dimensions s^3 m^{-4} as does the joule. For comparison, via the electron frequency from mass ($\nu = mc^2/h$) obtains two similar values: (a) = 1.377 705 2409 × 10^{-23} J K^{-1} (from PDG value for alpha), [18] and (b) = 1.377 705 2414 × 10^{-23} J K^{-1} (from CODATA value for alpha). [6] Table 3 shows values for the Boltzmann constant from the expression $k = \pi^8\alpha/864\phi^8\nu$ at (4.2.2).

Boltzmann Constant from electron frequency and fine structure constant				
Reference	**Fine structure const.$^{-1}$**	**Electron mass (c)**	**Electron frequency (c)**	**Boltzmann constant**
CODATA 2018	137.035999084(21)	9.1093837015(28)e-31	1.23820666097(37)e20	1.37770524138(36)e-23
PDG 2018	137.035999139(31)	9.10938356(11)e-31	1.238206662(15)e20	1.377705239(17)e-23
Morel et al 2020	137.035999206(11)	9.1093837015(28)e-31	1.23820666097(37)e20	1.37770524015(40)e-23
CODATA 2022	137.035999177(21)	9.1093837139(28)e-31	1.23820666266(38)e20	1.37770523857(37)e-23
CODATA '18/Morel '20	137.035999206(11)	9.1093837015(28)e-31	1.23820666097(37)e20	1.37770524015(40)e-23
PDG 2018/Morel '20	137.035999206(11)	9.10938356(11)e-31	1.238206662(15)e20	1.377705238(17)e-23
CODATA '22/Morel '20	137.035999206(11)	9.1093837139(28)e-31	1.23820666266(38)e20	1.37770523828(41)e-23

Table 3: Boltzmann constant from electron frequency and fine structure constant. References are CODATA 2018 [19], PDG 2018 [18], Morel *et al* [7], and CODATA 2022 [6]. The last 3 rows use alpha [7] and mass from the three references. Third-row results are implied from Morel *et al* values [7].

Using the 5 values for k with least uncertainty finds a mean value, (with $U_r = 6.3 \times 10^{-10}$) of 1.377 705 239 71(87) × 10^{-23}. This is a significant improvement over the currently accepted value [6]. Frequency, alpha and the Boltzmann constant are related in a dimensionless constant via:

$$\frac{k\nu}{\alpha} = \frac{\pi^8}{864\phi^8} = \frac{k_I e^2\nu^2}{2T\alpha^3} = 0.233\ 767\ 491... \qquad (4.2.3)$$

(To 21 dp this is 0.233 767 491 776 022 271 417…). From (4.2.1) a dimensionless temperature-charge per mass-frequency constant is found:

$$\frac{Te}{m\nu} = \frac{2\pi^2\phi^4}{3hc^4} = \frac{144\phi^6}{\pi^5} = \frac{k_I e^3}{2km\alpha^3} = 8.443\ 820\ 043... \qquad (4.2.4)$$

Mass per elementary charge is constant for any mass (at c), as both run proportionately. Upon conversion to electron-volts, since the conversion is mc^2/e, *every mass* (at c) will be the electron mass! (This is caused by a mass to charge ratio that scales proportionally at c.) The utility in using electron-volts is offset by mass scaling with energy, where velocity must be considered.

From (4.2.4), temperature – for the electron at 'rest' mass is –

$$T = \frac{hc}{k\lambda} = \frac{144\phi^6 mv}{\pi^5 e} = \frac{k_I ce^2}{2k\lambda\alpha^2} = 5.942\ 567\ 0668(25) \times 10^9 \text{ K} = \text{s}^3 \text{ m}^{-4}. \tag{4.2.5}$$

[For electron at *c.* $U_r = 4.2 \times 10^{-10}$]. And (4.2.5) leads to a temperature – wavelength constant, known as the second radiation constant [6]:

$$T\lambda = \frac{hc}{k} = \frac{2\phi^6 m}{\pi^2 I_e} = \frac{\pi^7}{216\phi^2 kc^3} = 1.438\ 804\ 071\ 67(43) \times 10^{-2} \text{ K m}^{-1}, \text{ or s}^3 \text{ m}^{-3}, \tag{4.2.6}$$

which is constant for all fundamental wavicles at *c*. [$U_r = 3 \times 10^{-10}$]. This is ~ 0.0019% larger than the CODATA value [6] due to the Boltzmann constant here.

4.3 Wavicle velocity

From the Boltzmann constant (4.2.2) another dimensionless relationship arises

$$\frac{Ee}{mv} = \frac{he}{m} = \frac{144\phi^6 k}{\pi^5} = \frac{\pi^3\alpha}{6\phi^2 v} = \frac{\pi^7 e}{216\phi^2 c^4 m} = ce\lambda = 1.163\ 309\ 513\ 62(34) \times 10^{-22}, \tag{4.3.1}$$

at electron 'rest' mass [6] (where *c* and velocity are interchangeable), and the electron elementary charge in this work. It is velocity independent, and leads to

$$\frac{e}{m} = \frac{\pi^3\alpha}{6\phi^2 hv} = \frac{\pi^3\alpha}{6\phi^2 E} = 1.759\ 373\ 370\ 52(51) \times 10^{11} \text{ C kg}^{-1} = \text{m}^4 \text{ s}^{-4}, \tag{4.3.2}$$

which is the elementary charge per mass constant (at *c*). [U_r for (4.3.1) and (4.3.2) is 2.9×10^{-10}.] From (4.2.5), and (4.3.1) we obtain

$$h = \frac{144\phi^6 km}{\pi^5 e} = \frac{4\phi^6 kv}{\pi\alpha c^4} = 6.612\ 067\ 303 \times 10^{-34} \text{ J s}. \tag{4.3.3}$$

Since (4.3.2) and (4.3.3) are constant at *c*, and *h* here has the same value as at (3.2.1), the electron must propagate at 299 792 458 m s^{-1}.

What is this 'speed of light'? It is the ratio of the electric field strength to the magnetic flux density of the vacuum, typically expressed as **E** = **B***c* [17], and represented in this work as $I_e = Bc$. Parameters at (3.3.1) to (3.3.5) have their present values at *c*, valid at the electron 'rest mass'. These parameters scale with energy at velocities < *c*. All unbound, fundamental wavicles propagate at *c* in vacuum, synonymous with the so-called 'rest' state. Electromagnetic (3.3.11) and gravitational interactions (3.4.2) occur at *c*. Gravitational waves could not propagate at *c* unless fundamental wavicles do (gravity includes mass). If lowest energy occurred at zero velocity, the majority of bosons and fermions in the universe would be arranged in large clumps of aggregated matter. The cosmos would be greatly inhomogeneous at large scales: this is not observed however [18, 20].

The fine structure constant *α* is specific to each wavicle species, and doesn't vary (for each fundamental wavicle) on deceleration, or reduced velocity from *c*. From (4.2.3), (4.3.1 – 4.3.3) the fine structure constant has a permanent dimensionless relationship with frequency.

$$\frac{\alpha}{v} = \frac{\alpha\lambda}{c} = \frac{6\phi^2 he}{\pi^3 m} = \frac{G\lambda}{k_I} = \frac{864\phi^8 k}{\pi^8} = 5.893\ 485\ 1369(18) \times 10^{-23}. \tag{4.3.4}$$

Since *α* is observed to scale with energy [1 – 4], such variance can only occur at *c.* A further constant, mass per alpha (but constant only at *c*), identifies that fundamental wavicles *must* propagate at *c* (in vacuum, at least initially), in order that alpha may be observed to increase with energy as shown experimentally.

$$\frac{m}{\alpha}=\frac{I_g}{G\alpha}=\frac{m\mu c}{k_I}=\frac{36h^2c}{\pi^4 e\lambda}=1.248\ 313\ 499\ 39(37)\times10^{-28}\ \text{kg s}^{-1}=\text{s}^6\ \text{m}^{-6}. \tag{4.3.5}$$

For velocities < c, use $\dfrac{m_x n_x^6}{\alpha_x}$ where $n = c$/velocity, and α_x (alpha for the specific wavicle, at c) is found from a dimensionless constant (where c is synonymous with velocity)

$$\frac{m_x c_x^6}{\alpha_x}=\frac{h_x c_x^4 v_x}{\alpha_x}=\frac{\pi^3 m_x c_x^4}{6\phi^2 e_x}=9.062\ 497\ 1835(27)\times10^{22}. \tag{4.3.6}$$

For generations of known mass, e.g. 'heavy' leptons, velocity may be found via (4.3.6), or if the frequency is known, alpha is also resolved, leading to velocity. For example, PDG Review [18] reported α_Z^{-1} = 127.955(10). Since α doesn't change < c, and α_Z and m_Z (in eV) are known, then velocity may be calculated in the following method.

Converting to kg for m_Z: 91.1876 GeV = 1.626 078 063 × 10^{-25} kg, [18] using e from this work. (Note: e in this work is larger than CODATA by 1.000 314 623.) Velocity is then found from (4.3.6) –

$$vel=\sqrt[6]{\left(\alpha_Z\times9.062497171\times10^{22}\Big/m_Z\right)}=40\ 411\ 800.96\ \text{m s}^{-1}. \tag{4.3.7}$$

The Z-boson mass at c via (4.3.6) is 9.755 879 002 × 10^{-31} kg, ~ 1.071 larger than the electron mass. This is hinting at lepton oscillation (ignoring lepton charge for the moment).

At full mass, n (m_Z) = 7.418 438 448, and other parameters can now be calculated from this, e.g. G_Z = 5.301 984 236 × 10^{-10} m^{-1}. Velocity may also be obtained from the index at full mass via –

$$n=\sqrt[6]{\frac{m_Z\alpha_e}{\alpha_Z m_e}}=7.418\ 438\ 448. \tag{4.3.8}$$

Due to (4.2.6) & (4.3.1) every wavicle has a mass-specific value for e, and at c, *every wavicle* is 0.510 838 2284 MeV c^{-2}.

Note: converting from mass to eV requires running to be accounted for with velocities < c, where the overall running is at n^6 (n^4 for E, and n^2 for velocity^2 < c). Any calculations using (4.3.8) where m may be substituted by E in eV (for velocities < c), require that n^6 must apply.

$$\text{eV}=\frac{mc^2n^6}{e},\quad \text{in s}^2\ \text{m}^{-2}. \tag{4.3.9}$$

Likewise, from mass to eV -

$$m(\text{at } c)n^6=\frac{\text{eV}e}{c^2}\ \text{kg}. \tag{4.3.10}$$

From (4.2.2) further dimensionless constants arise -

$$G\lambda=\frac{Gh}{cm}=\frac{k_I\alpha}{v}=\frac{12\phi^2 I_e e\mu}{\pi^2 m}=\frac{\pi^8\alpha}{648Ec^4}=\frac{2\phi^4 he}{\pi^2 m}=1.615\ 757\ 169\ 47(47)\times10^{-22}, \tag{4.3.11}$$

$$\text{and}\quad hc^4=\frac{\pi^7}{216\phi^2}=m\lambda c^5=\frac{\pi^8}{648c\alpha\mu}=\frac{Ec^4}{v}=5.340\ 969\ 245..., \tag{4.3.12}$$

both of which are velocity independent. [(4.3.12) to 21 d.p. = 5.340 969 245 461 141 484 267…]. (4.3.12) shows a mass to velocity constant. This should apply for all wavicles.

From (4.2.4) to (4.3.3) it is clear there is a velocity-dependent charge-to-mass constant. This may appear problematic for QED initially, in that the proton charge must be ~ 1836.152 times larger than that of the electron. This ratio arises however, from comparison of the electron mass (at *c*) with proton full mass. At the proton mass at *c* the ratio is ~ 352.1391, and the charge radius $\lambda/2\pi$ of the proton is of the same proportion smaller. At the electron radius both opposing charges are equal in strength. For velocities < *c* the index *n* may be found using (4.3.6) to calculate charge and charge radius. The charge increases < *c* by n^2. [Scaling of protons to unification will be covered in a future paper.]

When scaled to the electron charge radius, *all* elementary wavicles have electron-specific parameters: in effect they 'look' like electrons (charge sign excepted). This includes gravity, mass, alpha and energy. At the electron charge radius, the gravitational constant *G* and fine structure constant *α* are then 'universal', with their values as at (3.3.3) and (1.3). [But limited to $\lambda_e/2\pi$ or r_e.] These should be specified accordingly, and only used as such, in scientific publications.

From these relationships, and (2.6), there is also a charge-to-charge-radius constant, which is likewise velocity dependent (constant here at *c*)

$$\frac{e\lambda}{2\pi} = \frac{\pi^2\alpha\lambda}{12\phi^2c^2} = \frac{G\lambda h}{k_I\pi e\mu} = 6.175\ 821\ 1306(18) \times 10^{-32}\ \text{s m}^{-1}. \tag{4.3.13}$$

An interesting consequence may arise from (4.3.13) regarding fractional quark charges in QCD theory, despite the elegance and expedience of such a theory [18].

4.4 Wavicle volume

To find wavicle volume, a dimensionless constant is introduced (velocity independent) relating electric charge to energy, which includes the charge radius (2.6) -

$$\frac{I_e}{Ec} = \frac{\alpha\lambda}{2\pi c} = \frac{\pi^3 e}{72mc^4} = \frac{G\lambda}{2\pi k_I} = \frac{\alpha}{2\pi v} = 9.379\ 772\ 9283(27) \times 10^{-24}. \tag{4.4.1}$$

Multiplying by $c\lambda^2/\alpha$ for the electron finds volume –

$$V_e = \frac{\lambda^3}{2\pi} = 2.258\ 930\ 308\ 44(68) \times 10^{-36}\ \text{m}^3. \tag{4.4.2}$$

This may be regarded as the electron 'charge volume'. An interesting geometric feature is that this value is also obtained for the volume of a torus, where $V = 2\pi^2Rr^2$, the major radius $R = 2r$, and minor radius $r = \lambda_e/2\pi$, (the charge radius) from (2.6),

$$V_e = 2\pi^2Rr^2 = 2.258\ 930\ 308\ 44(68) \times 10^{-36}\ \text{m}^3. \tag{4.4.3}$$

From (4.4.1) and (4.4.2) volume incorporates spin. Wavicles are not point-particles.

5. RELATIONSHIPS WITH ALPHA

5.1 Lepton relationship with alpha

Alpha runs with energy, but the relationship is not proportional, i.e. non-linear < *c*. [1-4] This clearly implies (e.g. (3.3.13), (4.3.1-4.3.8), that energy (and mass) scale exponentially at velocities < *c*.

The muon/electron mass difference [6] is 206.768 2827(46), and α_μ^{-1} from the PDG review [18] is 135.901. The conversion below produces $\Delta m_\mu/m_e$ = 206.768 2814, well within error range above.

Table 4 shows lepton and weak boson values, both at *c*, and < *c*.

Lepton & weak boson parameters					
Parameter	**Z-boson**	**W-boson**	**Tau**	**Muon**	**Electron**
Alpha	7.815247548E-03	7.798669547E-03	7.491983578E-03	7.358297584E-03	7.297352563E-03
α^{-1}	127.955	128.227	133.476	135.901	137.0359992
$\Delta\alpha_x/\alpha_e$	1.070970257	1.068698474	1.026671456	1.008351662	1
mass at *c*(kg) [a]	9.755879002E-31	9.735184459E-31	9.352344224E-31	9.185462194E-31	9.109383702E-31
Full mass (kg) [b]	1.626078063E-25	1.433336645E-25	3.168537244E-27	1.883531613E-28	9.109383702E-31
index: $n = c/\mathrm{v}$	7.418438448	7.266645992	3.875458187	2.428353921	1
mass velocity [c]	4.041180096E+07	4.125596022E+07	7.735664883E+07	1.234550102E+08	2.997924580E+08
wavelength (*c*)	2.260737599E-12	2.265543356E-12	2.358283864E-12	2.401129307E-12	2.421182726E-12
wavelength (full)	3.047457514E-13	3.117729085E-13	6.085174321E-13	9.887888607E-13	2.421182726E-12
charge radius (*c*)	3.598075639E-13	3.605724239E-13	3.753325341E-13	3.821515982E-13	3.853431991E-13
charge radius (full)	4.850179272E-14	4.962019951E-14	9.684855727E-14	1.573706349E-13	3.853431991E-13
G (at *c*)	7.147035422E-11	7.131874858E-11	6.851410871E-11	6.729155175E-11	6.673421016E-11
G (full mass)	5.301984236E-10	5.182480985E-10	2.655235635E-10	1.634077035E-10	6.673421016E-11
μ_x (at *c*)	1.170147090E-06	1.172634527E-06	1.220636575E-06	1.242813174E-06	1.253192728E-06
μ_x (full mass)	8.680664162E-06	8.521119986E-06	4.730526008E-06	3.017990244E-06	1.253192728E-06
ε_x (at *c*)	9.508634135E-12	9.488464058E-12	9.115326207E-12	8.952673496E-12	8.878523091E-12
ε_x (full mass)	7.053921706E-11	6.894930932E-11	3.532606558E-11	2.174025979E-11	8.878523091E-12
e_x (at *c*)	1.716423374E-19	1.712782431E-19	1.645426540E-19	1.616065760E-19	1.602680713E-19
e_x (full mass)	9.446032061E-18	9.044201008E-18	2.471295106E-18	9.529782650E-19	1.602680713E-19
Energy, at *c*(J)	8.768146776E-14	8.749547449E-14	8.405467805E-14	8.255481716E-14	8.187105777E-14
En^4 (J) [d]	2.655570293E-10	2.439616734E-10	1.896068885E-11	2.870716816E-12	8.187105777E-14
$En^6 = \mathrm{eV}e$(J) [e]	1.461446081E-08	1.288218733E-08	2.847739257E-10	1.692833793E-11	8.187105777E-14
eV [f]	9.118760000E+10	8.037900000E+10	1.776860000E+09	1.056251426E+08	5.108382284E+05

[a] from mc^6/α; [b] apparent mass from eV values (PDG), muon and electron from unified atomic mass units; [c] velocity at apparent mass;

[d] as mc^2 at *c*, × n^4; [e] conversion from eV does not account for values < *c*, requiring a further n^2; [f] PDG values except muon and electron

Table 4: Some useful parameters for the 'heavy' leptons, compared to W and Z 'bosons' which are at the lepton limit. Mass and alpha from PDG, [18] muon and electron amended by reducing eV values by 1.000 314 623 due to amended *e* here. Alpha for the W-boson is obtained from strong coupling constant.

Using (4.3.7) to find velocity –

$$vel = \sqrt[6]{\left(\alpha_{\mu} \times 9.062497171 \times 10^{22} \Big/ m_{\mu}\right)} = 123\,455\,010.4 \text{ m s}^{-1}. \quad (5.1.1)$$

This is the velocity at full muon mass. From (4.3.8) the factor *n* is found, and mass at *c* from (4.3.6). The PDG Review [18] found α_Z^{-1} = 127.955(10), and from (4.3.8) *n* is obtained.

$$n_Z = \sqrt[6]{\frac{m_Z \alpha_e}{\alpha_Z m_e}} = 7.418\,438\,448\ldots \quad (5.1.2)$$

If the Z-boson mass is correct, the value for n_Z appears to be some limit, perhaps even as shown from this dimensionless constant –

$$\frac{\pi^4 k_I}{36} = \frac{\pi^4 Gc}{36\alpha} = \frac{I_g \lambda c^4}{e} = \frac{Ghc^3}{e} = \frac{k_I m\alpha c^4}{ev} = 7.418\,240\,148\ldots, \quad (5.1.3)$$

involving the interaction constant; where $\frac{\pi^4}{36} = \frac{m\alpha c^4}{ev} = \frac{h\alpha c^2}{e} = 2.705\,808\,084\ldots,$ (5.1.4)

is also a dimensionless constant, as is $\frac{mc^4}{e} = 4.591\,185\,033 \times 10^{22}.$ (5.1.5)

These are also velocity invariant. From (5.1.2), at the Z-boson mass at 91.1876(21) GeV, [18] if (5.1.3) is the lepton limit, the value obtained then for α_Z^{-1} is 127.934 4797 s. This is still in good agreement with PDG. From an alternative perspective, the most precise measurements for nucleon masses are known in unified atomic units [18].

In Table 4 the electron and muon mass are converted to kg from unified atomic units, other masses reduced from their eV values, [18] by the adjustment. Values for alpha are those of PDG, [18] however α_W^{-1} is adjusted slightly for a strong coupling at ~ 0.12200, to 128.227 (PDG shows α_W^{-1} ~ 128). [18]

5.2 Alpha and strong coupling

The strong interaction binds nucleons within atoms, and at very close-range, binds constituent quarks within their nucleons. A simple, dimensionless strong coupling may arise from the unification constant at (4.1.2), where k_U = 0.310 053 266… is the base value, multiplied by the ratio of alpha-*z* per alpha for the wavicle, where that fraction is then multiplied by a fractal unit as follows:

$$\alpha_S(x) = k_U \left(\frac{\alpha_Z}{\alpha_x Y_x}\right), \quad (5.2.1)$$

where Y_x is a fractal at (5.2.2) providing relationships as follows:

$$Y_\tau = 1,\ Y_W = \frac{\pi\phi}{2} = \frac{3k_I}{2\phi},\ Y_Z = \phi^2 = \frac{3k_I}{\pi},\ Y_H = k_I\,; \quad (5.2.2)$$

$$(k_U)\frac{\alpha_Z}{\alpha_\tau} = 0.323\,431\,438;$$ (PDG 0.323(+0.018, -0.014) [18], Tau); (5.2.3)

$$(k_U)\frac{3k_I \alpha_Z}{2\phi\alpha_W} = 0.122\,250\,604;$$ (W-boson); (5.2.4)

$$\frac{k_U}{\phi^2} = 0.118\ 429\ 808; \text{ (PDG 0.1184(+0.0020, -0.0014) [18], Z-boson);} \tag{5.2.5}$$

$$\left(k_U\right)\frac{\alpha_Z}{\alpha_H k_I} = 0.111\ 743\ 392; \text{ (Higgs boson).} \tag{5.2.6}$$

Alpha for each species is per [18], with $\alpha_H^{-1} \approx 126.429$. (It can be seen above that if the numerator for Y_x is $3k_I$, the denominator in the series from tau to Higgs is respectively $3k_I$, 2ϕ, π, and 3). These values are an excellent fit within the error range of the data from PDG at Figure 2. [21] This coupling 'runs' solely due to the ratio of alpha between wavicle and Z-boson. It appears to imply a fractal hierarchy is involved. Figure 2 shows the strong coupling with the values above.

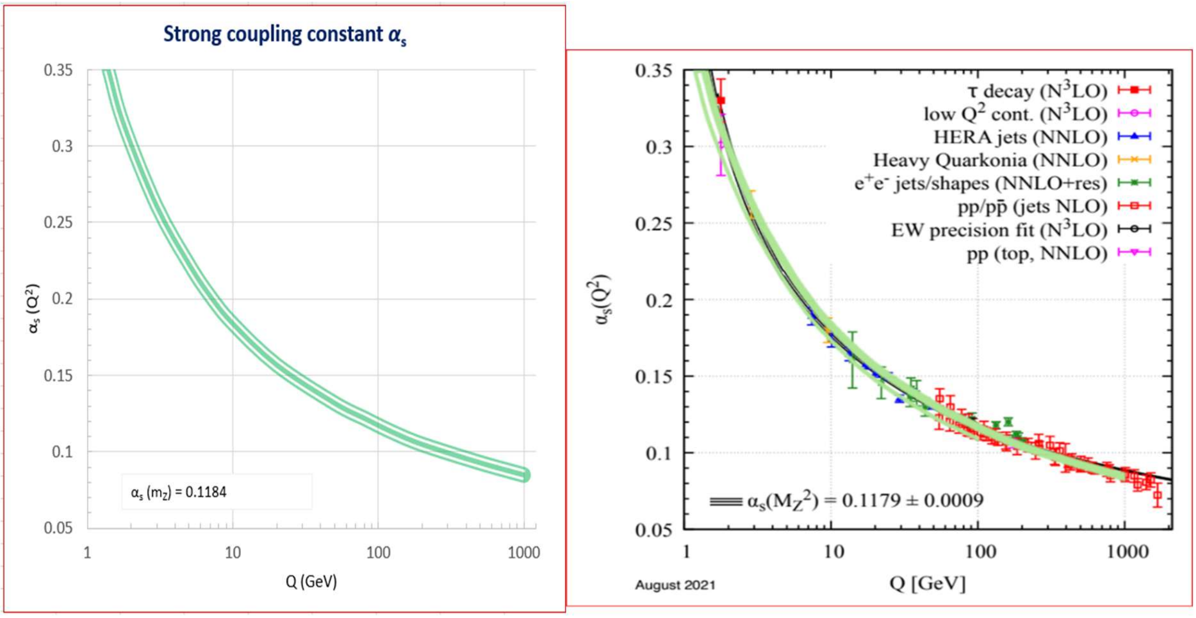


Figure 2: Left: Results from running of the strong coupling 'constant'. At m_Z the coupling value is ~0.1184, and the curve is in excellent agreement with experimental data [18, 21]. Right: Strong coupling 'constant' as a transparency over the data range from PDG Review [18]. (Original chart reproduced courtesy of PDG [21].)

5.3 Muon decay, lepton fractals

In the dominant muon decay process, a W^- boson is briefly emitted before decaying into an electron, muon neutrino, and an electron anti-neutrino [18]. From (4.3.6 & 5.2.1) a muon can attain the mass of a W^- boson when slowed to 40 858 225.83 m s^{-1}, or ~ 0.1363 c. An electron then carries the muon charge, post decay. [Note: the decay may produce a muon almost immediately if the media – e.g. Earth's atmosphere – is sufficiently opaque.]

It is highly probable that the charged leptons oscillate with energy, as do neutral neutrinos. Without evidence for continuous mass evolution (i.e. lepton generations appear fractal) there must be some mechanism for fractal mass evolution. An obvious candidate for this process is the running fine structure constant, if alpha changes in discreet jumps. These incremental steps have no clear pattern, except the steps increase with mass nonlinearly. An interesting concept emerges via a dimensionless constant that includes (4.1.2) and the interaction constant as follows:

$$\frac{2k_I}{hc^4} = \frac{144\phi^4}{\pi^6} = \frac{Te}{\pi\phi^2 mv} = \frac{I_g}{\pi I_e E} = \frac{G}{\pi I_e c^2} = \frac{he}{\pi\phi^2 k_B m} = \left(\pi k_U\right)^{-1} = 1.026\ 629\ 683\ldots \tag{5.3.1}$$

[To 21 d.p. = 1.026 629 683 104 134 875 114.] Lepton values for alpha > α_e then closely approximate –

$$\left[\alpha_e\left(\frac{2k_I}{hc^4}\right)^{\sqrt{0.1}}\right]^{-1}=\alpha_\mu^{-1}\simeq \text{ 135.9018 (PDG = 135.901) [18];} \tag{5.3.2}$$

$$\left[\alpha_e\left(\frac{2k_I}{hc^4}\right)\right]^{-1}=\alpha_\tau^{-1}\simeq \text{133.4814 (PDG = 133.476(7)) [18];} \tag{5.3.3}$$

$$\left[\alpha_e\left(\frac{2k_I}{hc^4}\right)^{\left(\pi\phi/2\right)}\right]^{-1}=\alpha_W^{-1}\simeq \text{ 128.1815 (PDG ~ 128) [18];} \tag{5.3.4}$$

$$\left[\alpha_e\left(\frac{2k_I}{hc^4}\right)^{\phi^2}\right]^{-1}=\alpha_Z^{-1}\simeq \text{ 127.9243 (PDG = 127.955(10)) [18];} \tag{5.3.5}$$

$$\left[\alpha_e\left(\frac{2k_I}{hc^4}\right)^{\pi}\right]^{-1}=\alpha_H^{-1}\simeq \text{ 126.176.} \tag{5.3.6}$$

[Dimensions for alpha are s^{-1}.] Exchanging the exponent √0.1 in (5.3.2) for $\sqrt{(\pi^{-1})}$ gives α_μ^{-1} = 135.894 3936, close to the PDG value [18], except the latter has no error range specified. At α_μ^{-1} = 135.894 3936 the difference in velocity at full mass is ~ 0.0008%. Muon mass at *c* increases by < 0.005%. Replacing the exponent in (5.3.4) with $8/\pi$ provides α_W^{-1} = 128.165 0537, for close comparison. The exponents in (5.3.2) to (5.3.6) include those used at section 5.2 above.

Note: Wavicle frequency is related to the fine structure constant (4.3.4) so, if alpha runs in discreet steps at *c*, the same incremental steps apply for frequency. From (4.2.2), (4.3.1) and (4.3.4) alpha is found as follows –

$$\alpha_x=\frac{4\phi^6 kv_x}{\pi hc^4}=\frac{864\phi^8 kv_x}{\pi^8}=\frac{G_x c}{k_I}\quad \text{s}^{-1}. \tag{5.3.7}$$

From (4.2.2), (4.3.4), and (5.3.7) a dimensionless constant is found relating k_B, α and v –

$$\frac{kv}{\alpha}=\frac{\pi^8}{864\phi^8}=\frac{\pi^3 vm}{6\phi^2 Te}=\frac{Ev}{T\alpha}=\frac{\left(\cos^{-1}(-1)\right)^8}{432\left(\sqrt{5}+2\right)^2\left(\sqrt{5}+3\right)}=0.233\ 767\ 4918\ldots \tag{5.3.8}$$

This applies to all wavicles. If using (4.3.11) for $G\lambda$ where the wavelength is known (from mass at *c*), alpha is also found via *G* for the wavicle -

$$\frac{G}{\alpha}=\frac{k_I}{c}=\alpha\mu=9.144\ 989\ 171\ 036\ 889\ 31\times 10^{-9}\ \text{s m}^{-1}, \tag{5.3.9}$$

which is constant at *c*. Lepton generations are likely accounted for by lepton mass scaling or oscillating with energy in discreet increments. From (5.3.1) to (5.3.6) lepton masses may be found using (4.3.5) at *c*, for muon through to Higgs wavicles. Full mass is found via

$$m_W=m_e n_1^6 n_2=m_e\left(\frac{c}{vel_W}\right)^6\left(\frac{\alpha_W}{\alpha_e}\right)\ \text{kg}, \tag{5.3.10}$$

where n_1 is due to velocity (*vel*) and n_2 the alpha ratio between the W-boson and the electron. In the traditional view, in Earth's atmosphere, muon production from pion decay occurs via the weak interaction, 'mediated' by the W-boson [22, 23]. However, an electron at *c* only needs to increase mass (via frequency) by ~1.069 (linear at c), then scale at n^6 below c to the W-boson full mass. Muons produced by pion decay need to increase mass by only ~1.06 (at c) then scale at n^6 below c to attain the W-boson full mass, where they decay spontaneously. In this analysis the W-boson is not an independent particle that magically appears wherever a muon decays: it is simply the original lepton scaled up to the charged current decay limit. Lepton showers or cascades follow.

Charge is conserved in this process. Neutrino oscillation is simply part of the same process.

Figure 3 contrasts traditional muon decay with oscillation in the running model.

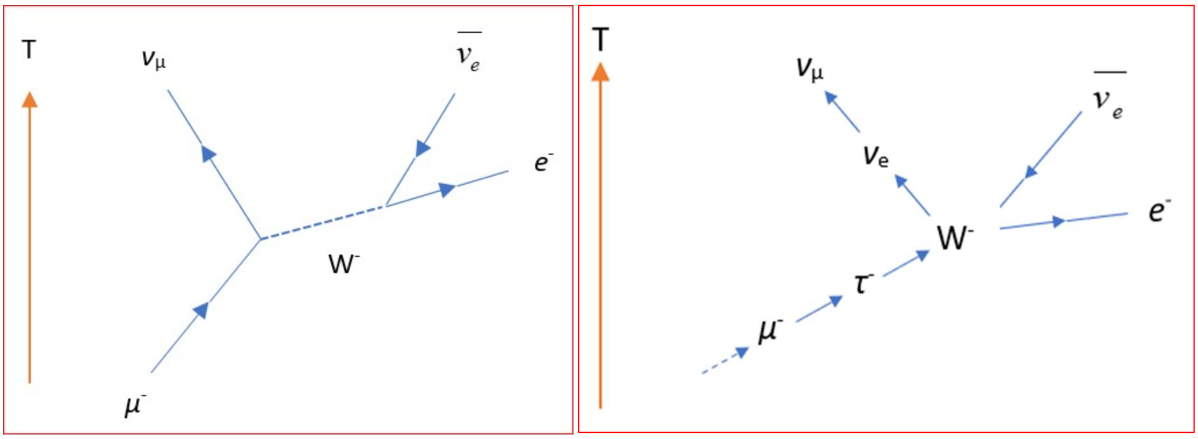


Figure 3: Feynmann diagrams: left, traditional view of muon decay mediated via the W^- boson. [22, 23] Right, a muon meets increasing resistance in Earth's atmosphere, gaining mass to tau as velocity reduces, then W-boson mass, where it spontaneously decays. This is the charged current limit. Charge is conserved. Lepton 'cascades' occur via this process. Neutrino oscillation is simply part of the same process.

Table 5 shows how the electron scales to W^- boson mass from c. This process is more energy efficient than as depicted in Table 4, therefore more probable.

		Electron scaling to W-boson		
Parameter	**Electron**	**Muon**	**Tau**	**W-boson**
$n = c/v$ [a]	1	2.431 722 35	3.892 497 152	7.347 561 019
velocity [b]	299 792 458	123 283 999.9	77 018 028.87	40 801 628.9
λ	2.421 182 726E-12	9.956 657 782E-13	6.220 127 164E-13	3.295 219 624E-13
$r_x = \lambda/2\pi$	3.853 431 991E-13	1.584 651 303E-13	9.899 639 844E-14	5.244 504 918E-14
G	6.673 421 016E-11	1.622 790 703E-10	2.597 627 230E-10	4.903 336 812E-10
μ	1.253 192 729E-06	3.047 416 769E-06	4.878 049 125E-06	9.207 910 045E-06
ε	8.878 523 073E-12	2.159 010 299E-11	3.455 962 577E-11	6.523 549 003E-11
e	1.602 680 713E-19	9.477 089 529E-19	2.428 307 144E-18	8.652 336 741E-18
E [c]	8.187 105 777E-14	2.862 769 273E-12	1.879 505 563E-11	2.386 180 032E-10

[a] from $\sqrt[6]{(m_x/m_e)}$ from Table 4; [b] full mass; [c] electron En^4; frequency is 1.238 206 661e20 for all.

Table 5: Any charged lepton/antilepton may scale to the $W^\pm$ boson at velocities < c. Contrasting these values with those of Table 4 shows this process is more energy efficient, therefore more probable. Both processes will occur naturally.

Figure 4 demonstrates how the interaction constant is involved in all parameters, leading to unification.

Figure 4: from interaction constant to unification.

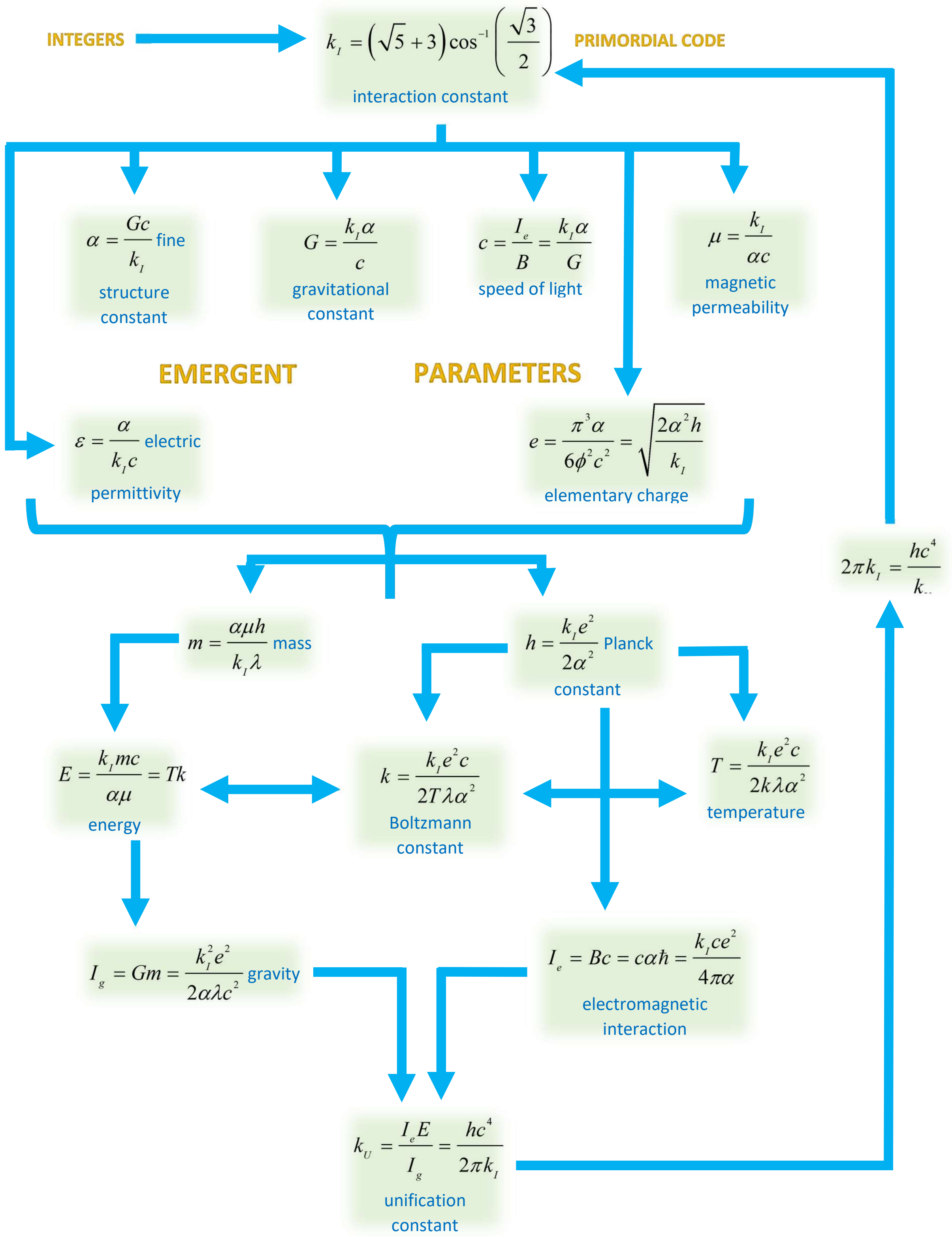


Figure 4: Integers form the interaction constant, a primordial code in the universe, from which all dimensional parameters are emergent. This primordial code is involved in every wavicle, process, and interaction, leading to unification.

From (4.3.12) & (5.3.1), and (3.1.1) & (3.1.3) two further dimensionless constants are found:

$$\frac{hc^4}{2\pi} = \frac{k_I k \phi^2 m}{he} = \frac{k_I k \phi^2}{ce\lambda} = \frac{\pi^6}{432\phi^2} = k_I k_U = 0.850\ 041\ 656\ 316\ 931\ 146\ 243\ldots, \qquad (5.3.11)$$

$$2\pi k_I = \frac{hc^4}{k_U} = \frac{I_g c^4}{I_e v} = 17.225\ 973\ 185\ 044\ 993\ 722\ 184\ldots. \qquad (5.3.12)$$

These significant constants are involved in multiple processes including fractal relationships.

6. CONCLUSIONS

All dimensional parameters scale with energy, generally linearly at *c*, where dimensional analyses identify their running modes. Dimensional parameters are wavicle-specific, mostly at the electron mass. Relationships with the gravitational parameter *G* introduce an apparent primordial code, designated the 'interaction constant'. This constant appears to be embedded within every wavicle, process and interaction. Dimensional parameters are emergent from this interaction constant. Gravity is likewise emergent, forming the spatial field interaction with matter, contracting locally. Least energy occurs at speed of light (*c*) for quantum wavicles. Scaling becomes non-linear < *c* for many parameters (including mass, gravity, and the Planck 'constant'), synonymous with symmetry breaking. Length dimensions scale exponentially below *c*, where the index exponent is the integer number of length terms using OU dimensions. This feature of the standard model ought to resolve dark matter.

The gravitational constant *G*, relevant apparently only for an electron at *c* at its presently accepted value, becomes perhaps a universal constant for fundamental wavicles when adjusted to the electron charge radius at *c*. Likewise for the fine structure constant, α, and charge *e*. Further work is required to confirm this. Scaling of fundamental wavicles with energy explains lepton oscillation, demonstrating that leptons (and likely quarks) are all fractals of their most fundamental member. Multiple constants are amended, and several new relationships are introduced.

Neither gravity, nor the electromagnetic interaction, are forces. These amendments to the standard model, with the ubiquitous interaction constant embedded as a primordial code, are invariant under multiple systems of simultaneous assessment. A finely tuned, encoded universe with emergent parameters, is inconsistent with a chaotic big bang cosmology.

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