Origins of Nonlinear Physics

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ABSTRACT

Nonlinear physical processes arise via dimensional parameters scaling with energy. Parameter dimensions determine the scaling character at speed of light *c*, and at velocities < *c*. Reducing dimensional analysis to time and length dimensions only, resolves this scaling paradigm. A mode change occurs for running parameters for wave-particle velocities < *c*, consistent with symmetry breaking, where scaling is determined by the exponent on the length component. The fine structure constant alpha is found to have dimensions Hz, requiring dimensional amendments to a number of fundamental parameters. The gravitational constant *G* is found to have dimensions m^{-1}, implying that gravity is not a force. Gravity is shown to have dimensions of linear density. Running parameters ought to resolve multiple anomalies within the standard model, leading to unification of gravity with electromagnetism.

1. INTRODUCTION

Gravity and the electromagnetic interaction are traditionally assumed to be forces. This expectation creates dimensions for the gravitational constant of m^3 kg^{-1} s^{-2}. [1-2] Via this convention, gravity in the cosmos is understood and measured as an attractive force between massive bodies, mediated by a theoretical particle, the graviton. [1] Quantum electrodynamics (QED) successfully explains electromagnetic interactions. [1, 3]

An alternative gravitational model is general relativity (GR), where matter and electromagnetic radiation interact within a curved space-time metric. The metric tensor, or energy-momentum tensor, in GR has dimensions energy density (J m^{-3}). [3] It couples with Einstein's constant *k*, to describe the curvature strength of the metric. The metric tensor is a dynamic field, whereas mass is deemed to be a fixed quantity. [3] General relativity describes gravity *'…as a universal deformation of the Minkowski metric.'* [1] Quantum theory and GR are incompatible, however, and likely incomplete, requiring a unifying theory. QED is regarded as linear, while GR is non-linear, and non-renormalizable. [3]

Unifying gravity with quantum theory requires the prior determination and resolution of running parameters that scale with energy. Parameters such as the fine structure 'constant' were not known to be variable in 1948 when multiple common constants (e.g. magnetic permeability) were set by convention, at the 41st CIPM in 1946. [4-6] Many dimensional constants remain presently set by convention: e.g. speed of light (*c*), Planck, Josephson, von Klitzing, Boltzmann constants (h, K_J, R_K, k,), the elementary charge (*e*), and the Avogadro number (N_A), [2] among others. Such a practice prevents a full understanding as to how dimensional parameters scale with energy and velocity.

As recently as 2018 the magnetic permeability constant (μ_0) was agreed to be exactly $4\pi \times 10^{-7}$ H m^{-1} in vacuum. [6] Pi does not provide dimensions henries per metre for μ_0, so this value must be a close coincidence only. It was set as a consequence of the description of the Ampere, and is not itself a precisely measured quantity. It follows that dimensions for the electric constant ε_0 (and multiple others) require reassessment.

Scaling of dimensional parameters are further separated into linear and nonlinear modes. It is imperative at an elementary level that such scaling modes are understood prior to the setting of values, or undertaking experimental evaluations.

Common standard model parameters and their running modes are presented here, providing a framework for the resolution of multiple anomalies. Despite challenging present convention, these amendments are an inevitable consequence of dimensional analyses. The amended standard model then becomes invariant under multiple systems of simultaneous assessment, including four running modes, and two systems of dimensional analysis. Gravity is also united with quantum theory.

2. SIMPLIFIED DIMENSIONAL ANALYSIS

Parameters that scale with energy must be dimensional, since obviously some dimension(s) is/are required within which such scaling can occur. Equally, dimensional parameters *must* scale with energy, either at c, or some velocity < c, or both. Two examples of dimension-related anomalies have already been mentioned. The fine structure constant (α) is regarded as dimensionless, except it is known to run with energy [1, 7-10]. Experimental data shows alpha^{-1} varies from ~137 at the electron mass, [1-2] to ~128 at the mass of the Z-boson, [1]. Alpha is clearly dimensional. Magnetic permeability μ_0 had a set value (and until recently *was* this value) at $4\pi \times 10^{-7}$ H m^{-1}. μ_0 is dimensional, therefore scales with energy. The subscript $_0$ (in vacuum) is duly removed for the remainder of this work for all dimensional parameters. Since the speed of light squared is inverse to $\varepsilon\mu$, the setting of μ also set the value and dimensions for ε, the latter with SI units F m^{-1}. [Ampere set at 2×10^{-7}.]

To determine the scaling mode for each parameter, a simplified dimensional analysis system is employed here using only length (metres) and time (seconds), referred to as 'original units' (OU). This OU system verifies, validates, and ultimately must be compatible with the SI system, once anomalies within the latter are remedied or explained. Both SI and OU systems must operate invariantly for running parameters. From SI units henry, ohm, and farad, one observes:

$\mathrm{H} = \Omega^2\ \mathrm{F} = \Omega\ \mathrm{s} = \frac{\mathrm{s}^2}{\mathrm{F}} = \frac{\mathrm{H}\,\Omega\,\mathrm{F}}{\mathrm{s}}$, and $\frac{\Omega\,\mathrm{F}}{\mathrm{s}}$ cancels; and $\frac{\mathrm{H}}{\mathrm{F}} = \Omega^2 = \frac{\Omega\,\mathrm{s}}{\mathrm{F}}$, $\frac{\mathrm{H}}{\Omega} = \mathrm{s}$, $\Omega = \frac{1}{\mathrm{F\,Hz}}$, and $\mathrm{F\,H} = \mathrm{s}^2$. Also, $\mathrm{H}\,\Omega\,\mathrm{F}^2 = \mathrm{H\,F\,s} = \mathrm{s}^3$, so, $\mathrm{H} = \frac{\mathrm{H}\,\Omega\,\mathrm{F}^2}{\mathrm{F\,s}} = \frac{\mathrm{H}\,\Omega\,\mathrm{F}}{\mathrm{s}} = \frac{\mathrm{s}^3}{\mathrm{F\,s}} = \frac{\mathrm{s}^3\,\Omega}{\mathrm{s}^2} = \frac{\mathrm{s}^3\,\Omega}{\mathrm{H\,F}} = \frac{\mathrm{s}^3}{\Omega\,\mathrm{F}^2}$. It then becomes obvious that $\mathrm{F\,s} = \Omega\,\mathrm{F}^2 = \frac{\mathrm{F\,s}}{\Omega\,\mathrm{F}^2} = \frac{\mathrm{s}^2}{\Omega} = \frac{\mathrm{H\,F}}{\Omega} = \frac{\mathrm{s}}{\Omega\,\mathrm{F}}$, and since the last expression cancels, *all* these expressions cancel. This shows that the farad has the same units as hertz, which provides

$$\mathrm{F} \equiv \mathrm{s}^{-1},\ \Omega \equiv \mathrm{s}^2, \mathrm{H} \equiv \mathrm{s}^3. \tag{2.1}$$

The original description of the ampere would appear to provide dimensions of (current producing a force) m^{-2}. [5] Solving for the ampere: $\mathrm{J} = \frac{\Omega\,\mathrm{C}^2}{\mathrm{s}} = \mathrm{s}^3\ \mathrm{A}^2 = \mathrm{H\,A}^2$, and dimensions for the von Klitzing constant are, $\frac{h}{e^2} = \frac{\mathrm{J\,s}}{\mathrm{C}^2} = \Omega = \frac{\mathrm{kg\,m}^2}{\mathrm{s}^3\ \mathrm{A}^2}$, so, as $\Omega\ \equiv\ \mathrm{s}^2$, mass has dimensions $\mathrm{kg} = \frac{\mathrm{s}^5\ \mathrm{A}^2}{\mathrm{m}^2}$.

To deliver ohms for the von Klitzing constant, $\mathrm{A} \equiv \frac{1}{\mathrm{m}^2}$, and $\mathrm{kg} \equiv \frac{\mathrm{s}^5}{\mathrm{m}^6}$. (2.2)

It follows that: $$E = mc^2 = \mathrm{J} = \mathrm{V\,C} = \frac{\mathrm{kg\,m}^2}{\mathrm{s}^2} \equiv \frac{\mathrm{s}^3}{\mathrm{m}^4}\ , \tag{2.3}$$

And for e: $$\mathrm{C} \equiv \frac{\mathrm{s}}{\mathrm{m}^2},\ \text{ so }\ \mathrm{V} \equiv \frac{\mathrm{s}^2}{\mathrm{m}^2}. \tag{2.4}$$

Temperature equals energy per Boltzmann's constant k; however, this has the same OU units as energy via $T = \frac{E}{k}$, and $k = \frac{hc^3e^3}{12I_g\alpha}$, where dimensions cancel out (I_g is gravity – see below), so

dimensions for T are $$\mathrm{K} \equiv \frac{\mathrm{s}^3}{\mathrm{m}^4}. \tag{2.5}$$

The Planck constant has dimensions $$h = \mathrm{J\,s} \equiv \frac{\mathrm{s}^4}{\mathrm{m}^4}. \tag{2.6}$$

The Planck constant h is inversely proportional to c^4 (as is E), therefore has its *least* value at c, where it is actually constant. At velocities < c the Planck 'constant' increases in value at n^4, where n is an index c/velocity. If these observations (regarding c at least energy) were incorrect, the universe would not exist as we observe it. [All wave-particles, including photons, would favour clumping. A dark universe is non-conducive for life: it does not provide sunlight for photosynthesis. What mechanisms would create an atmosphere, or prevent runaway gravitational collapse everywhere, for example?]

Conversely, macroscopic matter tends towards lowest velocity, being ionically-bound, complex structures (collections of fundamental matter) with multiple competing and thus cancelling electromagnetic fields. Least value for *h,* and E at c poses significant challenges for special relativity, for fundamental wave-particles. It presents significant issues for quantum physics regardless of relativity, not least because of the problem of 'constants' set by convention at fixed values.

3. SPEED OF LIGHT, ELECTROMAGNETIC INTERACTION, AND ALPHA

The 'speed of light' has a defined value at 299,792,458 m s^{-1} in vacuum [2]. It relates the electric field **E** to the magnetic field **B** as $E = Bc$, [11] where E and B are the magnitudes of the fields, with dimensions V m^{-1} = N C^{-1} for E, and tesla T, for B. [12] This velocity c may equally be described as the ratio of the electric field strength versus magnetic flux density for a wave-particle duality propagating through some medium. [Note: the term wave-particle duality is rather awkward. An older term, now dropped from usage is '*wavicle*', first used by Arthur Eddington [13], which is the preferred term in this work, and used from here on.] Lowest energy for the wavicle occurs when the ratio E/B is greatest, i.e. at the 'speed of light'. This applies to *all* fundamental wavicles, including photons. To avoid confusion, the electric field interaction is labelled I_e here to distinguish this from energy, E.

This electric field interaction with the wavicle is classically regarded as a 'force': $F_e = k_e \frac{|q_1 q_2|}{r^2}$, where q is a charge, k_e the Coulomb 'constant', and r is the distance between charges [11]. The distance term simply relates the strength of the interaction as a gradient at some arbitrary length between sources, so r terms do not contribute to the actual interaction. Removal of the distance term provides dimensions for the electromagnetic interaction of C^2 m (see below).

Dimensions for the fine structure constant are found from B as follows:

$$B = \frac{I_e}{c} = \alpha\hbar, \text{ with units } \mathrm{T} = \frac{\mathrm{J}}{\mathrm{A\,m^2}}. \tag{3.1}$$

This provides dimensions for α of C^{-1} m^{-2}, which, since A m^2 cancel, reduces to s^{-1} or Hz.

The electric field interaction is simply

$$I_e = \frac{e^2}{4\pi\varepsilon} = c\alpha\hbar. \tag{3.2}$$

Dimensions are $\mathrm{C^2\ m} = \frac{\mathrm{V}}{\mathrm{m}} = \frac{\mathrm{N}}{\mathrm{C}} \equiv \frac{\mathrm{s^2}}{\mathrm{m^3}}$, in agreement with [12]. Dimensional analysis per (2.1) is confirmed via (3.2) also, where the electromagnetic interaction as $I_e = \frac{e^2}{4\pi\varepsilon}$ has dimensions $\frac{\mathrm{C^2\ m}}{\mathrm{F\ s}} = \mathrm{C^2\ m}$, and as $I_e = c\alpha\hbar$ has dimensions $\frac{\mathrm{J\,s\,m}}{\mathrm{s^2}} = \frac{\mathrm{J\,m}}{\mathrm{s}} = \mathrm{W\ m}$, therefore W = C^2, confirming A ≡ m^{-2}, and Ω ≡ s^2.

Since A m^2 cancel out for the magnetic field strength B, tesla has the same dimensions in OU as energy: after all, magnetic energy, and temperature are all forms of energy.

Consequently, dimensions for magnetic permeability $\mu = \dfrac{2\alpha h}{ce^2}$ are amended to ohms per metre. The square of the speed of light has dimensions m^2 s^{-2} and since $c^2 = \dfrac{1}{\varepsilon\mu}$, it follows that electric permittivity ε must have dimensions farad-seconds per metre, and F s cancel out leaving dimensions m^{-1}.

Dimensions for the fine structure constant imply that alpha can *only* vary at the speed of light. It is inevitable then, that *all* fundamental wavicles must be capable of propagation at *c* in vacuum, in order that the fine structure constant may be observed to scale with energy as experimentally observed. All wavicles are equal-valued (at *c*) via

$$m\lambda = \frac{h}{c} = \frac{Bh}{I_e} = \frac{\mu e^2}{2\alpha} = \frac{e^2}{2\varepsilon\alpha c^2} \text{ kg m.} \tag{3.3}$$

Mass dimensions at (2.2) confirmed also by $e^2/2\varepsilon\alpha c^2$ at (3.3). Wavicle energy is inversely proportion to wavelength (at *c*), via $E\lambda = hc$. For velocities < *c* however, wavicle frequency remains unchanged from its specific frequency at *c*. Wavicle energy is expected to either decrease upon refraction as velocity decreases per $E = mc^2$ (static mass), or remain unchanged via $E = hv$ (massless). However, the Planck 'constant' is velocity dependant, (2.6) resulting in a substantial increase for energy, momentum, temperature, elementary charge, and electromagnetic interaction at velocities < *c*. The magnetic constant (vacuum permeability μ) and electric constant (vacuum permittivity ε) also increase, and mass increases by n^6.

This index system replaces the Lorentz factor in special relativity, permitting all fundamental wavicles to propagate at *c* in vacuum. (See Table 1 for running.) A future paper will discuss special relativity in detail.

The 'speed of light' *c* ought to be renamed the electromagnetic constant, having dimensional units

$$\frac{\mathrm{C^2\ m}}{\mathrm{T}} = \frac{\mathrm{V}}{\mathrm{T\,m}} = \frac{1}{\mathrm{C\,m}} = \frac{\mathrm{m\ s}}{\Omega} = \mathrm{F\ m} = \frac{\mathrm{m}}{\mathrm{s}}. \tag{3.4}$$

Common 'constants' set by convention include *c*, *h*, *e*, *k*, and N_A, and of these, only N_A and *k* are actually constant. (Dimensions for *k* cancel.) Planck's constant *h* is constant at *c* only. The elementary charge *e* is electron-valued (i.e. scales for each wavicle) and scales up at n^2 as velocity decreases. Many parameters are electron-valued: e.g. R_∞, G, e, μ, ε, z, K_J, R_K, ϕ_0, μ_B, α, a_0, E_h, and F. The nuclear magneton = the Bohr magneton, since dimensions for $\dfrac{e\hbar}{m}$ cancel, and *h*, and *e* for the proton are scaled up accordingly. A dimensional fine structure constant requires dimensional amendment to parameters that include it: e.g. Hartree 'energy' is not energy. The Bohr 'radius' is not a radius.

4. GRAVITATIONAL CONSTANT

The enigmatic gravitational constant *G*, [1] 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} [2]. Measurement errors are exacerbated by *G* scaling with temperature and energy, which must be accounted for. A preliminary investigation anticipated that values for ε and μ would be slightly different than CODATA values. For a brief analysis on this, the product $G\varepsilon$ is as follows

$$G\varepsilon = \frac{\alpha\mu e^2}{2hc} = \frac{\alpha^2}{c^2} = 5.925\ 012\ 249 \times 10^{-22}. \tag{4.1}$$

Then, ÷ *G* provides:
$$\varepsilon = \frac{\alpha\mu e^2}{2hGc} = \frac{1}{\mu c^2} = 8.877\ 353\ 803 \times 10^{-12} \text{ m}^{-1}. \tag{4.2}$$

(Dimensions for *G* discussed below). This provides new values for μ at 1.253 357 792 × 10^{-6} Ω 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

$$R_K = \frac{h}{e^2} = \frac{\mu c}{2\alpha} = 25\,745.447\,41\ \Omega, \tag{4.3}$$

G is then:
$$G = \frac{\alpha \mu e^2}{2h\varepsilon c} = \frac{\alpha^2}{\varepsilon c^2} = \alpha^2 \mu = 6.674\,30 \times 10^{-11}\ \mathrm{m^{-1}}. \tag{4.4}$$

The electromagnetic constant, *c* is then: $c = \frac{\alpha}{\sqrt{G\varepsilon}} = 299\,792\,458\ \mathrm{m\ s^{-1}}$. (4.5)

The expressions above use alpha as found by Morel *et al* [14] which is used throughout this work. (Differs from CODATA 2022 [2] 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 via $\frac{2\alpha}{c} = \frac{\mu e^2}{h}$, if values for alpha and *c* are well known.

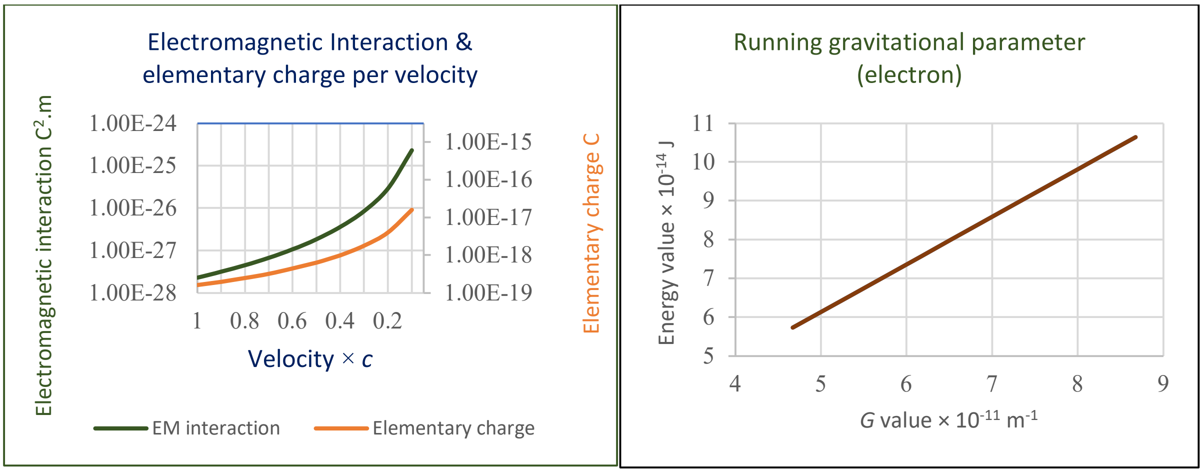
Present dimensions for *G* are $\mathrm{m^3\ kg^{-1}\ s^{-2}}$, from the Newtonian model of gravity as a force. Dimensional analyses here demonstrate that *G* with traditional dimensions would decrease in value at n^{-9} at velocities below *c*, i.e. on *increasing* energy. Fortunately, this is not observed, since if gravity was so seriously impaired, stellar objects and galaxies would not be able to form. (Gravity discussed briefly below). Gravity is therefore not a force. Dimensions for *G* are $\mathrm{m^{-1}}$, and *G* scales with wavicle energy. The presently accepted CODATA value for *G* is at the electron 'rest' mass, i.e. at *c*. [Note: all fundamental wavicles share the same value however, when scaled to the electron charge radius at *c*.] The charge radius is

$$r_e = \frac{\lambda}{2\pi}. \tag{4.6}$$

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.]

Figures 1a and 1b: Examples of scaling parameters. 1a shows the elementary charge and electromagnetic interaction scaling non-linearly < *c*, while 1b shows linear scaling of *G*.



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.

Table 1 shows three scaling modes for major dimensional parameters, and some SI units.

Parameter	symbol	Blue shift at c (fixed velocity, E ↑)	Red shift at c (fixed velocity, E ↓)	Refraction $< c$ (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}
Josephson ‘const.’	K_J	n	n^{-1}	n^{-2}	$m^2\ s^{-3}$
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), $< c$.

5. **BRIEF OVERVIEW OF GRAVITY**

Newton introduced gravity as a force between massive bodies, [1-2, 11] usually given as

$$F_g = G\frac{m_1 m_2}{r^2}, \text{ in N,} \tag{5.1}$$

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. In GR, Einstein's field equations require that $T_{\mu\nu}$ has dimensions energy-density [3]. When multiplied by Einstein's constant $k = 8\pi G/c^4$ traditional dimensions become energy-density per force, resulting in a per area charge (m^{-2}). This scales < *c* at n^2, resulting in nuclear fusion (unification of I_e and I_g) supposedly occurring at ~10^{-25} m radius, 7 orders of magnitude too small (but see note below). If *G* has dimensions m^{-1}, $kT_{\mu\nu}$ has dimensions s^7 m^{-12}, and fusion occurs ~10^{-17} m radius, an order of magnitude too large. [But the value is 4 orders of magnitude too low.] GR does not scale correctly under traditional dimensions, or as modified here, to correctly describe gravity.

[Note: As a Newtonian 'force', gravity scaling < *c* causes fusion (unification of I_e and I_g) to occur ~10^{-20} m radius, 2 orders of magnitude too small; and if GR dimensions are energy-density, gravity scales at n^4 at *c*, which is not observed. With GR dimensions m^{-2}, unification never occurs, since the gap between values for I_e and I_g continually widens. Fusion does not occur! The test for any gravity theory is that gravity must scale as observed at *c*, and also scale correctly < *c*, for fusion to occur at ~10^{-18} m radius. For a more extensive discussion on gravity, see [15]. Future articles 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. [11] A few expressions then are –

$$I_g = Gm = \alpha^2 \mu m = \frac{GE}{c^2} = \frac{Gh}{c\lambda} = \frac{he^3c^3}{12k\alpha} = \frac{\alpha e^2 \mu^2}{2\lambda} = \frac{\alpha^2 m}{\varepsilon c^2} = \frac{\alpha^2 h}{\varepsilon c^3 \lambda} = \frac{\pi^4 \alpha \mu e}{36 c^3 \lambda} \quad \text{kg m}^{-1}. \tag{5.2}$$

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 [1]. 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).

6. **DISCUSSION**

A. **Hypotheses**

These various observations provide substantive grounds for the following hypotheses:

1. Dimensional fundamental physical parameters are predominantly wave-particle specific, with current values generally for the electron (at the so-called 'rest mass', or least energy: i.e. at *c*), including the gravitational constant *G*; with each value relevant at the charge radius of that wavicle;

2. Dimensional analyses demonstrate that the speed of light *c* is the velocity at which *least energy* occurs, confirmed by a running fine structure constant *α* with dimensions Hz, where *α* varies only at *c*; therefore, all fundamental wavicles are capable of propagation at *c* in vacuum;

3. All parameters with length dimensions are velocity dependent, scaling with index *n* = *c*/velocity, where the exponent over the length dimension provides the scaling exponent for *n*;

4. Most parameters scale linearly at *c* as energy changes, however, at velocities < *c*, most parameters, including mass, temperature, energy, and gravity all scale exponentially; therefore, velocity reduction from *c* is synonymous with symmetry-breaking;

5. Photons, having momentum, are not massless, therefore all electromagnetic emissions contribute to total mass in a system.

7. CONCLUSIONS

Dimensional parameters scale with energy, velocity or both. Reducing dimensional analysis to time and length dimensions only, resolves this scaling paradigm. A mode change occurs for running parameters for wave-particle velocities < speed of light *c*, consistent with symmetry breaking. At velocities < *c* scaling is determined by the exponent on the length component. The fine structure constant is found to have dimensions s^{-1}, requiring dimensional amendments to a number of fundamental parameters. *G* is found to have dimensions m^{-1}, and gravity is determined not to be a force. The concept of massless particles is created by the Lorentz factor in special relativity. These various properties hint that strong and weak interactions are related through gravity, [15] and unification likely occurs during the nuclear fusion process. As such, quantum tunnelling is not required for fusion. Gravity modified via running parameters integrates seamlessly with quantum theory, constituting the quantum gravity standard model (QGSM). Running parameters ought to resolve Dark Matter, Dark Energy, and multiple anomalies within the standard model.

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