Theory that predicts elementary particles and explains data about dark matter, early galaxies, and the cosmos

Thomas J. Buckholtz

Ronin Institute, Montclair, New Jersey 07043, USA

Abstract

We try to solve three decades-old physics challenges. List all elementary particles. Describe dark matter. Describe mechanisms that govern the rate of expansion of the universe. We propose new theory. The theory uses an extension to harmonic oscillator mathematics. The theory points to all known elementary particles. The theory suggests new particles. Based on those results, we do the following. We explain ratios of dark matter amounts to ordinary matter amounts. We suggest details about galaxy formation. We suggest details about inflation. We suggest aspects regarding changes in the rate of expansion of the universe. We interrelate the masses of some elementary particles. We interrelate the strengths of electromagnetism and gravity. Our work seems to offer new insight regarding three branches of physics. The branches are elementary particles, astrophysics, and cosmology.

Keywords: Beyond the Standard Model, Dark matter, Dark energy, Inflation, Galaxy evolution, Rate of expansion of the universe, Quantum gravity, Harmonic oscillator, Mathematical physics

July 17, 2020

Contents

Email address: Thomas.Buckholtz@RoninInstitute.org (Thomas J. Buckholtz)

1. Introduction and summary

We offer theory that may solve at least the following three physics challenges. List all elementary particles. Describe dark matter. Explain some seemingly unresolved aspects regarding the rate of expansion of the universe.

The theory outputs and adds to the elementary particle Standard Model particle set. The theory outputs and adds to a set of Standard Model symmetries that includes $SU(3) \times SU(2) \times U(1)$ boson symmetries. The theory suggests a well-specified description of dark matter particles. The theory adds aspects to concordance cosmology.

This essay discusses relationships between data, so-called ongoing theory, and so-called proposed theory. The data features the domains of elementary particle physics, astrophysics, and cosmology. Ongoing theory denotes established physics theory and unverified theory that other people propose. Proposed theory denotes our work.

Each of ongoing theory and proposed theory includes a core component and another component. Core ongoing theory includes established theories of motion, the Standard Model particle set, and concordance cosmology. Ongoing theory also includes unverified theories and models such as supersymmetry. Core proposed theory outputs a set of elementary particles that includes and adds to the Standard Model elementary particle set. Supplementary proposed theory includes a theory of motion that has some similarities to quantum field theory.

Each one of core ongoing theory and core proposed theory embraces symmetries that correlate with, for example, conservation of momentum and conservation of angular momentum.

The core of this essay has bases in synergies between core ongoing theory and core proposed theory.

Our work progressed through three phases. Each later phase enriched methods and results from prior phases. Phase one pursued the following two goals. Explain three eras in the rate of expansion of the universe. Explain the ratio of dark matter density of the universe to ordinary matter density of the universe. Phase two pursued the following two goals. Develop and use a model that outputs the list of all known elementary particles and a set of well-specified suggested elementary particles. Describe dark matter. Phase three pursued the following goal. Explain ratios, that pertain to galaxy clusters and to galaxies, of dark matter amounts to ordinary matter amounts.

Table 1 summarizes some of the results that our theory produces. (Table 13b notes the new property - isomer or isomers - that pertains regarding elementary particles. Discussion regarding table 13 points to additional information about isomers.)

Table 1: Some results

Field	Area	Results
Mathematics	Harmonic oscillators	Solutions that lie below traditional ground states
Modeling	Mathematical physics	Models that output known and new elementary particles
Elementary particles	Existence	A list of possibly all elementary particles
Elementary particles	Properties	A new property
Astrophysics	Dark matter	A description of dark matter
Astrophysics	Dark matter	Explanations for ratios of dark matter amounts to ordinary matter amounts
Cosmology	Dark energy negative pressure	An explanation for three eras in the rate of expansion of the universe
Cosmology	Early universe	Details regarding the inflationary epoch
Cosmology	Early universe	A cause for baryon asymmetry
Astrophysics	Galaxy evolution	Predictions and explanations regarding galaxy formation
Physics	Fundamental	Relationships between masses of elementary particles
Physics	Fundamental	A relationship between the strengths of electromagnetism and gravity

Table 2 discusses relationships between some aspects of ongoing theory and some aspects of proposed theory.

The following remarks provide perspective about this essay.

Table 2: Relationships between some aspects of ongoing theory and some aspects of proposed theory

(a) Core ongoing theory and core proposed theory

Aspect of core ongoing theory - Discussion based on core proposed theory
• The elementary particle Standard Model - Proposed theory outputs a list of elementary particles. The list includes all Standard Model elementary particles that people have found. The list suggests other elementary particles. Our work suggests possibilities for adding the suggested particles to the Standard Model.
• The Lambda-CDM (cosmology) model - Proposed theory embraces observed aspects (of nature) that the Lambda-CDM model embraces. Proposed theory suggests explanations for some of the observed aspects for which people have yet to agree on explanations. Proposed theory suggests aspects that people might want to add to the Lambda-CDM model.
• Dark matter - Proposed theory suggests that much dark matter has some similarities to unverified ongoing theory notions of so-called WIMPs (or, weakly interacting massive particles). Unlike would-be WIMPs, this dark matter features hadron-like particles (which include elementary particles) that people would not consider to be elementary particles. Proposed theory can be compatible with ongoing theory notions that some dark matter might have clumped to form so-called primordial black holes.
• Modeling regarding large-scale phenomena - People allude to possible problems regarding using the Hubble constant, models that compute pressures based on densities, and general relativity to model some of the largest-scale phenomena that people observe. Proposed theory points to reasons why such modeling may not apply adequately accurately to some aspects of large-scale phenomena.
• Theories of motion - People can use core proposed theory with theories of motion that comport with conservation of energy, conservation of angular momentum, and conservation of momentum. Each one of core ongoing theory and supplementary proposed theory includes such theories of motion.

(b) Unverified ongoing theory and core proposed theory

Aspect of unverified ongoing theory - Discussion based on core proposed theory
• Quantum gravity - Proposed theory outputs (rather straightforwardly) a theory of quantum gravity. That theory and other concepts that this essay discusses seem to point to difficulties regarding trying to describe quantum gravity by quantizing aspects of general relativity.
• Supersymmetry - The proposed theory list of elementary particles may suffice to explain phenomena that led people to suggest supersymmetry. The list does not exhibit supersymmetry. There may be little further physics need for people to explore supersymmetry.

(c) Core ongoing theory and supplementary proposed theory

Aspect of core ongoing theory - Discussion based on supplementary proposed theory
• Quantum field theory - Supplementary proposed theory suggests a somewhat parallel to ongoing theory QFT (or, quantum field theory). The two theories differ. For example, the proposed theory parallel to QFT features modeling that is quadratic in energy, whereas ongoing theory QFT features modeling that is linear in energy. Proposed theory QFT might provide or point to useful bases for modeling, for example regarding anomalous magnetic moments or regarding nuclear physics.

Table 3: Goals for PEPT (or, proposed elementary particle theory)

PEPT should include theory that ...
• Points to all known elementary particles and possibly to all unknown elementary particles.
• Outputs representations correlating with the elementary particles.
• Outputs information about properties of the elementary particles.
• Outputs information about interactions in which elementary particles participate.
• Embraces conservation laws pertaining to motion.
• Embraces established ongoing theories of motion.
• Helps explain data that ongoing theory seems not to explain.

Reference [1] suggests standards regarding discussing theories and models. Regarding individual theories and models, we discuss correlations with data, limits of applicability, opportunities to make improvements, unresolved aspects, and alternatives. Regarding collections of theories or models, we discuss possible synergies and possible discord between theories and models.

This essay makes correlations between aspects of data, ongoing theory, and proposed theory. Such correlations can consider that aspects of one theory do not necessarily equal similar aspects of another theory. Wording of the form AA correlates with BB does not necessarily imply concepts such as AA equals BB or AA implies BB.

2. Methods

We provide perspective about our development and use of proposed theory.

2.1. Goals, concepts, and steps

We use the four-word term proposed elementary particle theory to describe a core of our work. The acronym PEPT abbreviates the four-word term proposed elementary particle theory.

Table 3 suggests goals for PEPT. Interactions can change, regarding objects in general, each of internal properties and motion.

Our work contributes to each of the goals that table 3 lists.

Ongoing theory does not necessarily achieve the first few goals. Development of ongoing theory has tended to produce theories of motion without necessarily completely knowing the nature of objects that move or without necessarily completely cataloging types of objects that move.

Goals that table 3 lists correlate with potential synergy between proposed theory and ongoing theory. Together, proposed theory and ongoing theory seem to explain data that ongoing theory seems not to explain.

Table 4 notes concepts and steps that underlie this essay's development of PEPT. (Regarding the correlation between spin and number of particles, see table 15c.) The acronym PDE abbreviates the three-word term partial differential equation. The three-letter term ALG stands for the word algebraic.

We provide perspective about harmonic oscillator mathematics.

Mathematics pertaining to harmonic oscillators includes two types of expressions. PDE modeling features solutions that feature sums of terms of the form that equation (1) shows. The symbol x denotes a continuous variable. ALG modeling features solutions that feature one or more terms, with each term being a product of one or more factors of the form that equation (2) shows. The occupation number n is an integer.

$$x^{\nu} \exp(x^{-2}) \tag{1}$$

$$|n> \tag{2}$$

Table 5 characterizes some similarities and some differences between ongoing theory modeling based on harmonic oscillators and proposed theory modeling based on harmonic oscillators. The term KS abbreviates the two-word term kinematics space. The term KS refers to modeling that can - and, in ongoing theory, often does - use coordinates that people use to model aspects that people correlate with space-time. The term PS abbreviates the two-word term particle space. The term PS refers to modeling that generally does not correlate directly with space-time. For each of the cases KS PDE and PS PDE, this essay uses symbols such as t and r to denote relevant coordinates. PS PDE use of such a symbol does not necessarily completely correlate with KS PDE use of the same symbol. Regarding KS PDE modeling

Table 4: Concepts and steps underlying development of PEPT (with the word particles denoting the two-word term elementary particles)

Concepts and steps
• Correlations exist between spins and numbers of similar particles.
• So-called PDE modeling, based on math that echoes those correlations, can be useful.
• PDE modeling uses partial differential equations pertaining to harmonic oscillators.
• PDE modeling mathematically correlates allowed spins with three spatial dimensions.
• PDE modeling uses information about some particles to output aspects of other particles.
• So-called ALG modeling features ladder operators pertaining to harmonic oscillators.
• ALG modeling uses symmetries pertaining to harmonic oscillators.
• ALG modeling has bases in models that correlate with the excitement of boson states.
• ALG modeling outputs representations that correlate with particles.
• ALG modeling points to symmetries that correlate with properties of particles.
• ALG modeling augments, regarding particle properties, PDE modeling.
• ALG modeling proposes new property-centric conservation laws.
• ALG modeling points to symmetries that correlate with properties of interactions.
• ALG modeling embraces symmetries correlating with kinematics conservation laws.
• ALG modeling helps bridge between proposed theory and ongoing theory.
• ALG modeling bridging includes aspects correlating with motion.

Table 5: KS and PS applications of harmonic oscillator mathematics

Use	2ν	n	Applications
Ongoing theory	Nonnegative even integer	Nonnegative integer	KS
Proposed theory	Nonnegative even integer	Nonnegative integer	KS
Proposed theory	Negative integer	Integer	PS

that people correlate with the notion of space-time, we think that people might benefit by considering PS PDE modeling to pertain mathematically to a tangent space to space-time. This essay does not further explore this notion of a tangent space.

Generally, core proposed theory embraces motion via representations for motion-centric conservation laws and via relying on ongoing theory models for motion. Hence, core proposed theory uses, at least indirectly, KS modeling. Core proposed theory uses PS modeling to, for example, match known and predict new elementary particles. Supplementary proposed theory suggests uses of KS modeling to, for example, model aspects of multicomponent objects.

KS PDE modeling can feature linear coordinates or radial plus angular coordinates. PS PDE modeling features radial coordinates. Each of ongoing theory and proposed theory uses modeling for which solutions that correlate with equation (1) normalize. Each normalized PS $\nu < 0$ solution normalizes because the number of dimensions is adequately large.

Proposed theory associates the one-element term TA-side with modeling that correlates with the two-word term temporal aspects. The two-word term temporal aspects echoes notions of temporal aspects of ongoing theory KS modeling that uses space-time coordinates. We use the term temporal aspects in the context of PS modeling and in the context of KS modeling. Proposed theory associates the one-element term SA-side with modeling that correlates with the two-word term spatial aspects. The two-word term spatial aspects echoes notions of spatial aspects of ongoing theory KS modeling that uses space-time coordinates. We use the term spatial aspects in the context of PS modeling and in the context of KS modeling.

2.2. *PDE mathematics*

We explore mathematics underlying PDE modeling.

Equations (3) and (4) correlate with an isotropic quantum harmonic oscillator. Here, r denotes the radial coordinate and has dimensions of length. The parameter η_{SA} has dimensions of length. The parameter η_{SA} is a non-zero real number. The magnitude $|\eta_{SA}|$ correlates with a scale length. The positive integer D correlates with a number of dimensions. Each of ξ_{SA} and ξ'_{SA} is a constant. The symbol $\Psi(r)$ denotes a function of r and, possibly, of angular coordinates. The symbol ${\nabla_r}^2$ denotes a Laplacian operator. In some ongoing theory applications, Ω_{SA} is a constant that correlates with aspects correlating with angular coordinates. Our discussion includes the term Ω_{SA} and, otherwise, tends to de-emphasize

Table 6: Terms correlating with an SA-side PDE equation (assuming that $(\xi'_{SA}/2) = 1$ and $\eta_{SA} = 1$)

Term/ $\exp(-r^2/2)$	Symbol for term	Change in power of r	Non-zero unless ...	Notes
$-r^{\nu_{SA}+2}$	K_{+2}	$+2$	-	Cancels V_{+2}
$(D+\nu_{SA})r^{\nu_{SA}}$	K_{0a}	0	$D+\nu_{SA}=0$	-
$\nu_{SA}r^{\nu_{SA}}$	K_{0b}	0	$\nu_{SA}=0$	-
$-\nu_{SA}(\nu_{SA}+D-2)r^{\nu_{SA}-2}$	K_{-2}	-2	$\nu_{SA}=0$ or $(\nu_{SA}+D-2)=0$	Cancels V_{-2}
$\Omega_{SA}r^{\nu_{SA}-2}$	V_{-2}	-2	$\Omega_{SA}=0$	Cancels K_{-2}
$r^{\nu_{SA}+2}$	V_{+2}	$+2$	-	Cancels K_{+2}

some angular aspects. We associate the term SA-side with this use of symbols and mathematics. We anticipate that the symbols used correlate with spatial aspects of some physics modeling. We anticipate that TA-side symbols and mathematics pertain for some physics modeling.

$$\xi_{SA}\Psi(r) = (\xi'_{SA}/2)(-(\eta_{SA})^2{\nabla_r}^2 + (\eta_{SA})^{-2}r^2)\Psi(r) \tag{3}$$

$${\nabla_r}^2 = r^{-(D-1)}(\partial/\partial r)(r^{D-1})(\partial/\partial r) - \Omega_{SA}r^{-2} \tag{4}$$

Including for $D = 1$, each of equation (3), equation (4), and the function Ψ pertains for the domain that equation (5) shows. (We de-emphasize exploration of possible solutions for $D \leq 0$.)

$$0 < r < \infty \tag{5}$$

We consider solutions of the form that equation (6) shows. (For $\nu_{SA} < 0$, this work pertains for the domain that equation (5) defines. For $\nu_{SA} \geq 0$, this work can pertain for the domain $0 \leq r < \infty$. For $\nu_{SA} \geq 0$ and $r = 0$, angular aspects, Y, of $\Psi \propto \phi(r)Y$(angular coordinates) can be undefined. People might ignore that lack of definition, based on the notion that, for cases in which Y is undefined, $\phi(0) = 0$.)

$$\Psi(r) \propto (r/\eta_{SA})^{\nu_{SA}} \exp(-r^2/(2(\eta_{SA})^2)), \text{ with } (\eta_{SA})^2 > 0 \tag{6}$$

Equations (7) and (8) characterize solutions. The parameter η_{SA} does not appear in these equations.

$$\xi_{SA} = (D + 2\nu_{SA})(\xi'_{SA}/2) \tag{7}$$

$$\Omega_{SA} = \nu_{SA}(\nu_{SA} + D - 2) \tag{8}$$

Table 6 provides details that lead to equations (7) and (8). We consider equations (3), (4), and (6). The table assumes, without loss of generality, that $(\xi'_{SA}/2) = 1$ and that $\eta_{SA} = 1$. More generally, we assume that each of the four terms $K_{\_}$ and each of the two terms $V_{\_}$ includes appropriate appearances of $(\xi'_{SA}/2)$ and η_{SA}. The term V_{+2} correlates with the rightmost term in equation (3). The term V_{-2} correlates with the rightmost term in equation (4). The four $K_{\_}$ terms correlate with the other term to the right of the equals sign in equation (4). The sum of the two $K_{0\_}$ terms correlates with the factor $D + 2\nu_{SA}$ in equation (7).

Equation (9) correlates with the domains of D and ν_{SA} for which normalization pertains for $\Psi(r)$. For $D + 2\nu_{SA} = 0$, normalization pertains in the limit $(\eta_{SA})^2 \to 0^+$. Regarding mathematics relevant to normalization for $D+2\nu_{SA} = 0$, the delta function that equation (10) shows pertains. Here, x^2 correlates with r^2 and 4ϵ correlates with $(\eta_{SA})^2$. Reference [2] provides equation (10). The difference in domains, between $-\infty < x < \infty$ and equation (5), is not material here. (Our use of this type of modeling features normalization. Considering normalization leads to de-emphasizing possible concerns, about variations - as a function of angular coordinates - as r approaches zero, regarding Y(angular coordinates). Considering normalization leads to de-emphasizing possible concerns, regarding singularities as r approaches zero, regarding some $\Psi(r)$.)

$$D + 2\nu_{SA} \geq 0 \tag{9}$$

$$\delta(x) = \lim_{\epsilon\to 0^+}(1/(2\sqrt{\pi\epsilon}))e^{-x^2/(4\epsilon)} \tag{10}$$

We use the one-element term volume-like to describe solutions for which $D+2\nu_{SA} > 0$. Here, assuming that we ignore angular coordinates or that a zero value of a factor pertaining to angular coordinates does not pertain, $\Psi(r)$ is non-zero for all $r > 0$. The term volume-like pertains regarding behavior with respect to coordinates that underlie modeling. We use the one-element term point-like to describe solutions for which $D + 2\nu_{SA} = 0$. Here, $\Psi(r)$ is effectively zero for all $r > 0$. The term point-like pertains regarding behavior with respect to coordinates that underlie modeling.

We anticipate using PDE modeling that combines TA-side aspects and SA-side aspects. The following equations define the operators A_{TA}^{PDE} and A_{SA}^{PDE}. The symbol $\Psi(t,r)$ denotes a solution.

$$A_{TA}^{PDE}\Psi(t,r) = \xi_{TA}\Psi(t,r) = (\xi'_{TA}/2)(-(\eta_{TA})^2{\nabla_t}^2 + (\eta_{TA})^{-2}t^2)\Psi(t,r) \tag{11}$$

$${\nabla_t}^2 = t^{-(D_{TA}-1)}(\partial/\partial t)(t^{D_{TA}-1})(\partial/\partial t) - \Omega_{TA}t^{-2} \tag{12}$$

$$A_{SA}^{PDE}\Psi(t,r) = \xi_{SA}\Psi(t,r) = (\xi'_{SA}/2)(-(\eta_{SA})^2{\nabla_r}^2 + (\eta_{SA})^{-2}r^2)\Psi(t,r) \tag{13}$$

$${\nabla_r}^2 = r^{-(D_{SA}-1)}(\partial/\partial r)(r^{D_{SA}-1})(\partial/\partial r) - \Omega_{SA}r^{-2} \tag{14}$$

For core proposed theory, we assume that equation (15) pertains.

$$0 = A^{PDE} = A_{TA}^{PDE} - A_{SA}^{PDE} \tag{15}$$

Discussion above includes applications for which ν is a negative half-integer. (See, for example, table 5.) Ongoing theory seems not to discuss modeling for which ν is a half-integer. (We are uncertain as to the extent that established mathematics considers the possibility that ν can be a half-integer.)

We generalize to the case that j is an integer, $j\nu_{XA}$ is an integer, and ν_{XA} is not necessarily an integer. We note a process for transforming fractional-integer-ν mathematics into integer-ν mathematics. We start with an equation that is an equivalent of equation (8). Equation (16) re-expresses the equivalent of equation (8). Equation (17) pertains. Equation (17) mimics the equivalent of equation (8), based on the substitution that equation (18) shows. Here, the notation denotes that $j(D-2)+2$ replaces D. The transformation pertains to the extent that equation (19) pertains. For each j, the transformation pertains to the extent that equation (20) pertains.

$$\Omega_{XA} = (1/j^2)(j\nu_{XA})((j\nu_{XA} + jD - 2j) \tag{16}$$

$$\Omega_{SA} = (1/j^2)(j\nu_{SA})(j\nu_{SA} + (j(D-2)+2) - 2) \tag{17}$$

$$D \leftarrow j(D-2)+2 \tag{18}$$

$$D > 2(1-(1/j)) \tag{19}$$

$$D \geq 2 \tag{20}$$

For the case $j = 2$, equation (21) pertains for $D \geq 2$.

$$D \leftarrow 2D - 2 \tag{21}$$

2.3. ALG mathematics

We explore mathematics underlying ALG modeling.

Equation (22) shows an ongoing theory representation for states for a one-dimensional harmonic oscillator. The symbol $|\_ >$ correlates with the notion of quantum state. (See equation (2).) Equation (23) shows the ongoing theory representation for a raising operator. Equation (24) shows the ongoing theory representation for a lowering operator. In ongoing theory, n is a nonnegative integer.

$$|n> \tag{22}$$

$$a^+|n>= (1+n)^{1/2}|n+1> \tag{23}$$

Table 7: Representations for ALG solutions

(a) Representation showing individual oscillators

Side	0	1	2	3	4	...	16	...	20
TA	n_{TA0}	n_{TA1}	n_{TA2}	n_{TA3}	n_{TA4}	...	n_{TA16}	...	n_{TA20}
SA	n_{SA0}	n_{SA1}	n_{SA2}	n_{SA3}	n_{SA4}	...	n_{SA16}	...	n_{SA20}

(b) Representation featuring pairings of individual oscillators

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20
TA	n_{TA0}	n_{TA1}, n_{TA2}	...								
SA	n_{SA0}	n_{SA1}, n_{SA2}	...								

$$a^-|n>=n^{1/2}|n-1> \tag{24}$$

Proposed theory extends the domain correlating with equation (22) from the KS domain of $n \geq 0$ to the PS domain of $n \geq -1$. Proposed theory includes equations (25) and (26).

$$a^+|-1>=0|0> \tag{25}$$

$$a^-|0>=0|-1> \tag{26}$$

Equation (27) correlates with equations (11), (12), (13), and (14). Here, XA can be either one of TA and SA. For each of the two values of XA, A_{XA}^{ALG} includes D_{XA} one-dimensional oscillators.

$$A_{XA}^{ALG} = (\xi'_{XA}/2) \sum_{\iota=0}^{D_{XA}-1} -(\eta_{XA})^2(\frac{d}{dr_{XA\iota}})^2 + (\eta_{XA})^{-2}(r_{XA\iota})^2 \tag{27}$$

For ALG modeling, equation (28) pertains. Each of A_{TA}^{ALG} and A_{SA}^{ALG} correlates with the concept of an isotropic quantum harmonic oscillator. The word isotropic (or, the two-word term equally weighted) also pertains to the pair consisting of A_{TA}^{ALG} and A_{SA}^{ALG}. The one-element term double-entry pertains. For example, increasing a TA-side excitation number by one requires either decreasing a different TA-side excitation by one or increasing one SA-side excitation by one. The two-element term double-entry bookkeeping pertains.

$$0 = A^{ALG} = A_{TA}^{ALG} - A_{SA}^{ALG} \tag{28}$$

For core proposed theory, we assume that equation (28) pertains. Equation (28) provides an ALG analog to PDE equation (15).

Table 7 provides ways to visualize solutions to equation (28). For each of TA and SA, one includes just the columns XA0 through XA$(D_{XA}-1)$. Each relevant $n_{XA\_}$ is an integer. (Note equation (22).) We assume that equation (28) implies that $(\xi'_{TA}/2) = (\xi'_{SA}/2) \gtrless 0$. We can assume, without loss of generality, that $(\xi'_{TA}/2) = (\xi'_{SA}/2) > 0$. Paralleling results that equations (7) and (8) show, we assume, without loss of generality for ALG modeling, that $\eta_{TA} = \eta_{SA} = 1$.

Equations (28) and (29) characterize all solutions that we include in ALG modeling that is based on isotropic harmonic oscillators.

$$A_{XA}^{ALG} = \sum_{\iota=0}^{D_{XA}-1} (n_{XA\iota} + 1/2) \tag{29}$$

We posit that equations (30) and (31) extend equation (28). Here, the number, n, correlating with excitations satisfies $n \geq 0$.

$$a^+ A_{TA}^{ALG} = a^+ A_{SA}^{ALG} \tag{30}$$

$$a^- A_{TA}^{ALG} = a^- A_{SA}^{ALG} \tag{31}$$

We discuss symmetries that correlate with mathematics for isotropic harmonic oscillators.

Table 8: Number of oscillators, symbols, groups, and contributions to A_{XA}^{ALG}

Oscillators	Symbol	Group	Generators	Contribution to A_{XA}^{ALG}
2	A0−	-		-1
2	[blank], $\kappa_{0,-1}$	-	-	0
2	$\pi_{@_0,@_{-1}}$	-	-	0
2	A0+	-	-	1
1	χ_{-1}	$S1G$	1	$-1/2$
1	χ_0	$S1G$	1	$1/2$
2	$\pi_{0,@_{-1}}$	$U(1)$	2	0
2	$\pi_{0,@_0}$	$U(1)$	2	1
j	$\kappa_{-1,\cdots,-1}$	$SU(j)$, $j \geq 2$	$j^2 - 1$	$-j/2$
j	$\kappa_{0,\cdots,0}$	$SU(j)$, $j \geq 2$	$j^2 - 1$	$j/2$
2	$\kappa'_{0,0}$	$SU(2) \times U(1)$	6	1

Table 8 shows symbols that we use and groups to which proposed theory refers. Aside from the appearance of items using the aspect $n\_ = -1$ or the symbol A0−, information in the table comports with standard relationships between mathematics of group theory and mathematics for isotropic quantum harmonic oscillators. The leftmost column shows the relevant number of oscillators. For each row, the symbol XA can be TA, in which case all of the oscillators are TA-side oscillators, or SA, in which case all of the oscillators are SA-side oscillators. The symbol $S1G$ denotes a group with one generator. The number of generators for $U(1)$ is two. One generator correlates with integer increases regarding the number of excitations that pertain for the oscillator for which the table shows $n\_ = 0$. One generator correlates with integer decreases regarding the number of excitations that pertain for the oscillator for which the table shows $n\_ = 0$. The number of generators for $SU(j)$ is $j^2 - 1$. The symbol π correlates with the concept of permutations. The symbol $\pi_{a,b}$ denotes two possibilities. Regarding the two oscillators, for one possibility, a pertains to the first oscillator and b pertains to the second oscillator. For the other possibility, a pertains to the second oscillator and b pertains to the first oscillator. The symbol χ correlates with the concept of choice. The symbol χ_a pertains to one oscillator and correlates with the equation $n_{XA\_} = a$. The symbol κ correlates with the concept of a continuous set of choices. For example, regarding two oscillators XA1 and XA2, equations (32) and (33) describe the continuum of possibilities correlating with $\kappa_{0,-1}$. Here, each of d and e is a complex number. Regarding $SU(j)$, each of the symbols $\kappa_{-1,\cdots,-1}$ and $\kappa_{0,\cdots,0}$ correlates with a continuous set of choices involving amplitudes pertaining to j oscillators. Equation (34) pertains regarding the symbol $\kappa'_{0,0}$. In ongoing theory, the notion of $\kappa'_{0,0}$ has relevance to aspects of the weak interaction. For proposed theory, we show that $\kappa'_{0,0}$ pertains to aspects of the weak interaction. The symbol A0− denotes $\pi_{@_{-1},@_{-1}}$. The symbol A0+ denotes $\pi_{@_0,@_0}$. The symbol [blank] - in the second row of table 8 - denotes the concept that, in tables such as table 21, one can interpret a blank cell as correlating with $\kappa_{0,-1}$.

$$d|n_{XA1} = 0,\, n_{XA2} = -1 > \;\; + \;\; e|n_{XA1} = -1,\, n_{XA2} = 0 > \tag{32}$$

$$|d|^2 + |e|^2 = 1 \tag{33}$$

$$\kappa'_{0,0} = \kappa_{0,0} \times \pi_{0,@_{-1}} \tag{34}$$

We discuss relationships between the numbers of generators for some $SU(j)$ groups.

In equation (35), g_j denotes the number of generators of the group $SU(j)$, the symbol $|$ denotes the word divides (or, the two-word phrase divides evenly), and the symbol $\not|$ denotes the four-word phrase does not divide evenly. For some aspects of physics modeling, equation (35) correlates with ending the series $SU(3)$, $SU(5)$, $\cdots$ at the item $SU(7)$. For some aspects of physics modeling, the series $SU(3)$, $SU(5)$, $SU(7)$, and $SU(17)$ might pertain.

$$g_3|g_5,\, g_3|g_7,\, g_5|g_7 \quad g_5\not|g_9,\, g_7\not|g_9,\, g_7\not|g_{11} \quad g_3|g_{17},\, g_5|g_{17},\, g_7|g_{17} \tag{35}$$

We anticipate invoking the mathematical notion of ending a series $SU(3)$, $SU(5)$, $\cdots$ at the item $SU(7)$. Sometimes, we correlate an ending with physics data. Sometimes, we correlate an ending with symmetries related to kinematics conservation laws.

We note a relationship between $SU(j)$ groups and the group $U(1)$.

Equation (36) echoes mathematics and some ongoing theory modeling. Here, each of the positive integers j_1 and j_2 is at least two. The symbol $\supset$ correlates with the notion that each group to the right of the symbol is a subgroup of the group to the left of the symbol.

$$SU(j_1 + j_2) \supset SU(j_1) \times SU(j_2) \times U(1) \tag{36}$$

3. Results: elementary particles

This unit predicts elementary particles that people have yet to find.

3.1. Summary: a table of known and suggested elementary particles

Table 9 catalogs elementary particles that ongoing theory recognizes or proposed theory suggests. Our use of the two-word term elementary particles parallels use of that term in ongoing theory. Each row in the table 9a features one value of spin S. The symbol S denotes spin, in units of $\hbar$. (Technically, S correlates with the S in the ongoing theory expression $S(S+1)\hbar^2$.) The definition $\Sigma = 2S$ provides for numbers Σ that are non-negative integers. The value of Σ appears as the first element of each two-element symbol $\Sigma\Phi$. The letter value of Φ denotes a so-called family of elementary particles. The symbol $\Sigma\Phi$ denotes a so-called subfamily of elementary particles. Free elementary particles can model - regarding motion - as if they do not interact with other objects. Unfree elementary particles model as if they occur only in confined environments. Examples of confined environments include hadrons (such as the proton and the neutron) and atomic nuclei. Free elementary particles can model as if they can occur in confined environments and can model as if they occur outside of confined environments. The expression $m \doteq 0$ denotes a notion of zerolike mass. Some ongoing theory models correlate $m \doteq 0$ elementary fermions with small positive masses. Some ongoing theory models correlate $m \doteq 0$ elementary fermions with zero masses. The expression $m \grave{>} 0$ correlates with mass being positive in all ongoing theory models and in all proposed theory models. A number (n) denotes a number of elementary particles. A number ((n)) denotes a number of modes. Table 9b provides additional information regarding items that table 9a lists. Table 12c alludes to possible candidate elementary particles that table 9 does not include and that this essay de-emphasizes.

We use the two-word term simple particle to pertain to each entry in table 9 other than G-family entries and U-family entries. We correlate the two-element term root force with each G-family entry in table 9 and with the U-family entry in table 9. This use of the word root reflects the notion that some PDE mathematics-based modeling, which has bases in KS aspects of root forces, outputs solutions that correlate with known and suggested simple particles. (See discussion related to equation (43). This essay does not necessarily suggest physics meaning for such use of the word root.)

Particle counts in table 9 de-emphasize modeling that would count, for example, a down quark with green color charge as differing from a down quark with red color charge.

We discuss the free simple particles for which $m \grave{>} 0$ pertains.

The 0H particle is the Higgs boson. The three 1C particles are the three charged leptons - the electron, the muon, and the tauon. The two 2W particles are the two weak interaction bosons - the Z boson and the W boson.

We discuss the free simple particles for which $m \doteq 0$ pertains.

The 0I, or so-called aye, particle is a possible zerolike-mass relative of the Higgs boson. Some aspects of ongoing theory suggest a so-called inflaton elementary particle. Proposed theory suggests that the aye particle is a candidate for the inflaton. The three 1N particles are the three neutrinos. Some aspects of ongoing theory suggest that at least one neutrino mass must be positive. At least one positive mass might explain neutrino oscillations and some astrophysics data. Some aspects of ongoing theory, such as some aspects of the Standard Model, suggest that all neutrino masses are zero. Proposed theory suggests that effects of 8G forces explain neutrino oscillations and the relevant astrophysics data. For example, proposed theory suggests that components of 8G forces lead to effects that ongoing astrophysics theory would correlate with a sum of neutrino masses of $3\alpha^2 m_\epsilon$. The symbol α denotes the fine-structure constant. The symbol m_ϵ denotes the mass of an electron. The amount $3\alpha^2 m_\epsilon$ falls within the range that ongoing astrophysics theory attributes to observed data. (See equations (119) and (120).) Components of 8G do not interact with the property of mass. Proposed theory suggests the possibility that each neutrino has zero mass.

We discuss G-family forces.

The expressions free and $m \doteq 0$ pertain. Each G-family force exhibits two modes. Our discussion tends to focus on circularly polarized modes. One mode correlates with left circular polarization. One mode

Table 9: Elementary particles (or simple particles and root forces)

(a) Simple particles and root forces (with notation featuring names of families)

Spin	Σ	Free $m\dot{>}0$	Free $m\dot{=}0$	Unfree $m\dot{>}0$	Unfree $m\dot{=}0$
0	0	0H (1)	0I (1)	0P (1), 0K (1)	
1/2	1	1C (3)	1N (3)	1Q (6)	1R (6)
1	2	2W (2)	2G ((2))	2T (4)	2U (8)
2	4		4G ((2))		
3	6		6G ((2))		
4	8		8G ((2))		
...	...		...		
10	20		20G ((2))		

(b) Simple particles and root forces (with notation featuring names of elementary particles; with * denoting that people might have yet to find the elementary particles; and with TBD denoting the three-word phrase to be determined)

Spin	Σ	Free $m\dot{>}0$	Free $m\dot{=}0$	Unfree $m\dot{>}0$	Unfree $m\dot{=}0$
0	0	Higgs boson (1)	Aye* (1)	Pie* (1), Cake* (1)	
1/2	1	Charged leptons (3)	Neutrinos (3)	Quarks (6)	Arcs* (6)
1	2	Z and W bosons (2)	Photon ((2))	Tweaks* (4)	Gluons (8)
2	4		Graviton* ((2))		
3	6		TBD* ((2))		
4	8		TBD* ((2))		
...	...		...		
10	20		TBD* ((2))		

correlates with right circular polarization. For 2G, ongoing theory suggests classical physics models and quantum physics models. The word electromagnetism can pertain. Proposed theory suggests modeling that provides for 2G aspects that include and complement ongoing theory electromagnetism. Regarding gravitation, ongoing theory suggests classical physics models. Proposed theory suggests modeling for 4G aspects that include and complement ongoing theory gravitation. Proposed theory regarding 4G includes classical physics aspects and quantum physics aspects. Proposed theory regarding 4G includes aspects that ongoing theory correlates with the four-word term dark energy negative pressure. Proposed theory suggests that quantum interactions, involving simple fermions, mediated by 4G can correlate with a notion of somewhat conservation of fermion generation. Ongoing theory does not include 6G aspects and does not include 8G aspects. Proposed theory suggests that 8G interacts with lepton number minus baryon number. Regarding G-family forces, a lack of use of the two-word term simple particles correlates with modeling that suggests, in some sense, more than one component for each one of some ΣG. For example, 2G includes one component that correlates with interactions with charge and one component that correlates with interactions with nominal magnetic dipole moment. This notion of components is appropriate because aspects of proposed theory can address the topics of properties and interactions without necessarily selecting an ongoing theory of motion or an ongoing theory model for motion. (See, for example, discussion regarding table 39 and discussion regarding table 40.) The notion of components is essential for proposed theory models that suggest explanations for observed ratios of dark matter amounts (or other effects) to ordinary matter amounts (or other effects). (See discussion regarding table 63 and discussion regarding tables 64 and 65.)

Proposed theory includes the possibility that nature includes 10G, 12G, 14G, 16G, 18G, and 20G bosons. (See discussion related to table 57.) These G-family bosons would interact with anomalous properties and not with nominal properties. Examples of nominal properties include charge (which correlates with 2G), nominal magnetic dipole moment (which also correlates with 2G), and rest mass (which correlates with 4G). An example of an ongoing theory anomalous property is anomalous magnetic dipole moment. Detecting effects of ΣG for which $\Sigma \geq 10$ might be difficult. (See discussion related to equation (117).)

We discuss the unfree simple particles for which $m\dot{>}0$ pertains.

Table 10: Some possible correlations between observed phenomena, ongoing theory, and proposed theory (with specifics about 4G forces correlating with the notion of isomers and with the notion of components)

Phenomenon	Ongoing theory	Proposed theory
	Quantum vacuum	Aye
	Inflaton	Aye
	Inflationary dark energy	Components of 4G forces
Accelerating expansion	Dark energy negative pressure	Component of 4G forces
Neutrino oscillations	At least one non-zero neutrino rest mass	8G forces
Some astrophysics data	At least one non-zero neutrino rest mass	8G forces
Nuclear physics	Attractive residual strong force	Pie
Nuclear physics	Repulsive residual strong force	Cake
Baryon asymmetry		Charged tweaks

Table 11: Some possible correlations between root forces and phenomena

Proposed theory	Phenomena	Ongoing theory
2G	Charge, nominal magnetic moment	Charge, nominal magnetic moment
4G	Rest energy	Rest energy
6G	Freeable energy	Internal energy above ground state energy
8G	Spin, 3LB number	Spin (internal angular momentum)
2U	Color charge	Color charge

The 0P, or so-called pie, possible particle would correlate with a core ongoing theory notion of an attractive component of the residual strong force. The 0K, or so-called cake, possible particle would correlate with a core ongoing theory notion of a repulsive component of the residual strong force. The six 1Q particles are the six quarks. The four 2T, or so-called tweak, possible particles are analogs to the weak interaction bosons. The charge of one non-zero-charge 2T particle is two-thirds the charge of the W boson. The charge of one non-zero-charge 2T particle is one-third the charge of the W boson. The non-zero-charge tweak particles may have played roles in the creation of baryon asymmetry. The non-zero charge tweak particles might correlate with unverified ongoing theory notions of leptoquarks.

We discuss the unfree simple particles for which $m \doteq 0$ pertains.

The six 1R, or so-called arc, possible particles are zero-charge zerolike-mass analogs of the six quarks. Hadron-like particles made from arcs and gluons contain no charged particles and measure as dark matter.

We discuss U-family forces.

The eight 2U particles are the eight gluons. In each of core ongoing theory and core proposed theory, gluons correlate with the strong interaction and bind quarks into hadrons. Proposed theory suggests that gluons bind arcs into hadron-like particles.

Table 10 summarizes some possible correlations between observed phenomena, ongoing theory, and proposed theory. For each row in the table, proposed theory suggests that the item in the third column might explain aspects correlating with the other two columns. (Regarding the entries that allude to one or more components of 4G forces, see table 40 and specifically see table 40b. Regarding the notion of isomers, see tables 13b, 13d, 40b, and 41.)

Table 11 summarizes possible correlations between root forces and phenomena. For other than 2G, 4G, and 2U, ongoing theory does not necessarily correlate, with a root force, an item listed under ongoing theory. Proposed theory suggests that interactions correlating with 6G can decrease or increase the rest energy of an object. Proposed theory suggests the relevance of a concept for which we use the two-element term 3LB number. (In the symbol 3LB, the number 3 correlates with a factor of three. The letter L correlates with the word lepton. The letter B correlates with the word baryon.) We define 3LB number in terms of the two on-going theory two-word terms lepton number and baryon number. (See discussion related to equation (53).)

3.2. Modeling leading to the table of elementary particles

We discuss concepts and methods that lead to the table of known and suggested elementary particles.

We provide perspective regarding development of the table.

Ideally, we might use a method that features notions that we might call small data-sets and small-data techniques. An input small data-set could be the set of known elementary particles. The small-data techniques could feature not very many formulas or other mathematics techniques. The output would feature a presumably-small data-set of all elementary particles that nature includes.

Some aspects of table 9 point to possibilities for the scenario that we just described. The table exhibits three organizing principles. One principle features the choice between values of Σ. One principle features the choice between free and unfree. One principle features the choice between non-zero mass and zerolike mass.

Some aspects of table 9 point to possible difficulties regarding the scenario that we just described. The notions of free and unfree correlate with ongoing theory KS modeling. The notion of zerolike mass correlates with ongoing theory KS modeling. For some models, zerolike means zero. For some models zerolike means non-zero. More generally, ongoing theory KS modeling includes models that use the notion of potential energy and, thereby, bypass some needs to consider elementary bosons. Some of those models correlate with classical physics. Some of those models correlate with quantum physics (and, for example, with the Schrodinger equation).

Similar ambiguities pertained regarding the periodic table for chemical elements. There were two organizing principles - atomic weight and similarity regarding chemical interactions. (Perhaps, note reference [3].) People originally did not understand bases for those principles. Neither principle proved to be strictly rigorous. After people developed nuclear physics theory and atomic physics theory, people better understood the principles and the chemical elements.

Our method features an input small data-set that is the set of known elementary particles. The output features a small data-set that might include all elementary particles that nature includes. (See table 9.)

We characterize our method as using (non-computerized or mental) techniques that correlate with the two-word term machine learning and with the two-element term big-data techniques.

A pivotal aspect of the method features the following steps. Recognize that some parts of a partial differential equation, which ongoing theory uses for KS PDE modeling, seem to encode information correlating with ongoing theory KS modeling for potentials that correlate with electromagnetism and with the strong interaction. Use the equation in a context of proposed theory PS PDE modeling. Anticipate that solutions correlating with the equation will correlate with simple particles. This duality - that some particles correlate with the equation and some particles correlate with solutions - portends complexity regarding the method.

Another pivotal aspect of the method features the notion that one can use PS ALG modeling to represent elementary particles and to add (compared to results from PS PDE modeling) information about conservation-law symmetries that pertain. However, without inputs based on PS PDE modeling, PS ALG modeling could point to an overly large set of candidate elementary particles.

The method has iterative aspects. Look at data and theory. Reuse, extend, create, or integrate theory. Match, explain, predict, or reinterpret data. Iterate.

Assuming that our modeling proves useful, the possibility that people can gain more understanding becomes relevant.

Regarding the periodic table for chemical elements, gaining new understanding correlated with developing nuclear physics and with developing atomic physics.

If we assume that (at least fermion) elementary particles are truly elementary, gaining more understanding (might include embracing a notion of dark matter isomers but) would not necessarily feature deeper aspects of nature. New understanding could feature new modeling. Aspects of PS modeling might point to how to develop a so-called theory of everything. That theory might point not only to all elementary particles and their properties but also to an adequately encompassing set of quantum mechanics theories of motion and classical mechanics theories of motion.

3.2.1. Proposed elementary particle theory

We continue discussion regarding proposed elementary particle theory. (See discussion related to tables 3 and 4.)

Mathematics and ongoing theory include partial differential equations pertaining to isotropic harmonic oscillators. A partial differential equation correlating with an isotropic multidimensional quantum harmonic oscillator includes an operator that correlates with r^{-2} and an operator that correlates with r^2. (See equations (3) and (4).) The symbol r denotes a radial spatial coordinate. We consider KS modeling. (See table 5.) The r^{-2} operator in equation (4) can model aspects correlating with the square of an electrostatic potential. The potential correlates with r^{-1}. The force correlates with r^{-2}. The r^{-2} operator can model aspects correlating with the square of a gravitational potential. The r^{-2} operator can model aspects correlating with each G-family force ΣG for which $\Sigma \leq 8$. (See table 31.) The r^{-2} operator can model aspects correlating with excitations that pertain for each G-family force ΣG and that, thereby, have relevance for each G-family force component ΣGΓ. (See discussion that includes equation (47).) The r^2 operator in equation (3) can model aspects correlating with the square of a strong interaction potential. Ongoing theory includes the concept of asymptotic freedom. The potential correlates with r^1. The force correlates with r^0. (Apparently, over time, ongoing theory discussion might have de-emphasized a possible correlation between asymptotic freedom and the notion that aspects of a potential that might approach - at sufficiently large distance - r^1 behavior pertains. Independently of that possible de-emphasizing, the next two sentences pertain. Technically, our use of equations (3) and (4) to match and predict elementary particles correlates with PS modeling and does not depend on the extent to which the strong interaction correlates with a potential that correlates with r^1. Similarly, technically, our use of equations (3) and (4) to match and predict elementary particles does not depend on the extent to which either of the electromagnetic interaction or the gravitational interaction correlates with a potential that correlates with r^{-1}.) This strong interaction potential would correlate with excitations related to the 2U subfamily (or, gluons) and with interactions within hadron-like particles. (Ongoing theory includes within the two-word term strong force the notion of a residual strong force. The three-word term residual strong force pertains to interactions between hadron-like particles. Proposed theory suggests correlating the residual strong force with so-called 0P - or, pie - simple bosons and so-called 0K - or, cake - simple bosons.)

Proposed theory PS PDE modeling might point to results pertaining to other than the G family and the U family. For example, the next two sentences might pertain. Operator aspects that correlate with r^0 might correlate with simple fermions. Operator aspects that correlate with r^0 might correlate with aspects of the weak interaction. (Here, the expression r^0 does not correlate with non-residual aspects of the strong interaction.)

Table 12 outlines steps that our modeling takes. (This table symbolizes steps. Understanding this table is not necessary for understanding aspects below in this essay.) For each step, the leftmost two columns list items that correlate with inputs to the step. The next column notes modeling concepts that are key to taking the step. The rightmost two columns list items that correlate with outputs from the step. PS modeling pertains. (See table 5.) In table 12a, the first step uses the notion that correlates aspects of PDE modeling with potentials that we associate with root forces. The steps output a list of elementary particles. In table 12b, steps output masses. Table 12c shows possible steps that this essay generally de-emphasizes. The notion that one item, which might point to axions, in table 12c might not have physics relevance does not necessarily preclude the notion that other aspects of proposed theory might point to possible axions. However, this essay does not necessarily point to other possibilities that correlate with axions. Table 12d discusses symbols that appear in tables 12a, 12b, and 12c.

We discuss objects and properties.

Each of ongoing theory and proposed theory includes the notion of an object. Models for an object may include notions of internal properties upon which all observers would agree. One such property is charge (or, charge that people would observe in the context of a frame of reference in which the object does not move). Models for objects may include notions of kinematics properties upon which observers might legitimately disagree. One such notion is velocity, relative to observers, of an object. Models can include notions of interactions between objects. An interaction can change - for an object - at least one of some internal properties and some kinematics properties.

Table 13 lists some properties that people attribute to objects. Proposed theory PEPT tends to work from table 13a toward table 13e. In contrast, development of aspects of ongoing theory, including QFT (or, quantum field theory), has emphasized - from early on in the development of ongoing theory - aspects correlating with table 13e. The symbol q_ϵ denotes the charge of an electron. The symbol c denotes the speed of light. Table 94 addresses the apparently dual use - regarding spin and regarding 3LB number - of $\lambda = 8$ in table 13a. In table 13a, S correlates with the S in the expression $S(S+1)\hbar^2$ and not with a notion of spin with respect to a particular axis. In tables 13b and 13d, the notion of isomers correlates with the topic of dark matter and with aspects of tables 40b, 41, and 63. In table 13c, the use of the symbol S does not correlate with notions of spin. (Compare with, for example, table 13a.) Elsewhere, this essay tends to de-emphasize discussing entropy and does not use the symbol S to pertain to entropy. The symbol NR denotes the two-word phrase not relevant.

Table 14 lists aspects correlating with some symmetries that table 8 lists. We anticipate that the first two items in table 14 pertain regarding the items ι_Q and ι_{3LB} that table 13a lists.

Each of the symbols, except m, in table 13a denotes a quantity that is always an integer. Each of the quantities in table 13a pertains for each elementary particle. Each of the quantities in table 13a can pertain for objects that contain more than one elementary particle. (Note table 14.) In terms of measurements, equation (37) pertains. The symbol ε_0 denotes the vacuum permittivity.

$$\iota_Q = 1 \text{ correlates with } (|q_\epsilon|/3)/(4\pi\varepsilon_0)^{1/2} \tag{37}$$

Table 12: Steps, regarding modeling

(a) Steps that output elementary particles

From free	From unfree	Via	To free	To unfree
ΣG	2U	PS PDE	0H, 1C, 2W	
0H, 1C, 2W		$m\grave{>}0 \ \rightarrow \ m\doteq0$	0I, 1N, 2G	
1C, 1N, 2W		$\lvert\iota_Q\rvert = 3$ or $= 0 \ \rightarrow \ \lvert\iota_Q\rvert = (2$ or $1)$ or $= 0$		1Q, 1R, 2T
	2U	$SU(3) \ \rightarrow \ SU(3) \uplus I$		0P, 0K

(b) Steps that output masses

From free	From unfree	Via	To free	To unfree
ΣG		PS ALG, PS PDE	0H, 0I, 2W	
ΣG		PS ALG, PS PDE	2T	
Ongoing		m_π		0P, 0K

(c) Possible steps that the modeling de-emphasizes

From free	From unfree	Via	To free	To unfree
	2U	PS ALG		~~(≥4)U~~
	~~(≥4)U~~	$SU(3) \ \rightarrow \ SU(3) \oplus I$	~~axion or ?~~	
0H, 0I		$\lvert\iota_Q\rvert = 3$ or $0 \ \rightarrow \ \lvert\iota_Q\rvert = (2$ or $1)$ or 0		~~?~~, ~~?~~

(d) Explanations regarding some symbols

Discussion
• $m\grave{>}0 \ \rightarrow \ m\doteq0$ denotes extending results for $m\grave{>}0$ to results for $m\doteq0$.
• The symbol ι_Q denotes charge, in units of one-third the negative of the charge of an electron (or, in units of the negative of the charge of a down quark).
• $\lvert\iota_Q\rvert = 3$ or $0 \ \rightarrow \ \lvert\iota_Q\rvert = (2$ or $1)$ or 0 denotes extending results for $\lvert\iota_Q\rvert = 3$ or 0 to results for $\lvert\iota_Q\rvert = 2$ or 0 and to results for $\lvert\iota_Q\rvert = 1$ or 0. The results correlating with the word from pertain to free particles. The results correlating with the word to pertain to unfree particles.
• $SU(3) \ \rightarrow \ SU(3) \uplus I$ denotes extending modeling to, in effect, include the identity operator, which operator-centric modeling regarding $SU(3)$ lacks.
• The word ongoing denotes aspects of ongoing theory that model the attractive component of the residual strong force via modeling that includes notions of virtual pions.
• The symbol m_π denotes the mass (or masses) of pions.
• The notation $\not{X}$ denotes the notion that this essay generally de-emphasizes the concept X.

Table 13: Some properties of objects

(a) Invariant properties of objects

Symbol	Definition	Concept	Related symbol (ongoing theory)
ι_Q	$= 3Q$	charge, in units of $\|q_\epsilon\|/3$	Q - charge, in units of $\|q_\epsilon\|$
m		rest mass, in units of energy$/c^2$	m - rest mass
j	$1 \leq j \leq 3$	generation, for simple fermions	1 or 2 or 3
ι_S	$= 2S$	spin, in units of $\hbar/2$	S - spin (nonnegative), in units of $\hbar$
ι_L	$= 3L$	lepton number, in units of $3L$	L - lepton number (integer)
ι_B	$= 3B$	baryon number, in units of $3B$	B - baryon number (integer $\times$ 1/3)
ι_{3LB}	$= 3(L - B)$	3LB number	

(b) Other invariant property of elementary particles (proposed theory)

Symbol	Definition	Concept	Related symbol (ongoing theory)
-	relevant isomers	a list of isomers of charge (or, a list of isomers of charged elementary particles) with which an excitation of the elementary particle correlates	-

(c) Other properties (ongoing theory)

Symbol	Definition	Concept	Related symbol (ongoing theory)
		color charge	r or b or g
		entropy	S - entropy ($k_b \ln \Omega$)

(d) Other invariant property of the universe (proposed theory)

Symbol	Definition	Concept	Related symbol (ongoing theory)
ι_I	= NR, 1, 6, or 36	number of isomers of charge (or, number of isomers of charged elementary particles)	-

(e) Observer-centric properties

Symbol	Concept	Related symbol (ongoing theory)
E	energy, in units of energy	E
$\overrightarrow{P}$	momentum, in units of momentum	$\overrightarrow{P}$
$\overrightarrow{J}$	angular momentum, in units of angular momentum	$\overrightarrow{J}$

Table 14: TA-side aspects correlating with some symmetries

Aspect
• A TA-side $\pi_{0,@_{-1}}$ symmetry correlates with a quantity (such as charge) for which an exact (and, not a somewhat) conservation law pertains.
• A TA-side $\pi_{0,@_{-1}}$ symmetry correlates with a quantity (such as charge) that sums across objects (including elementary particles) that a so-called larger object includes.
• A TA-side $SU(2)$ symmetry correlates with an approximate symmetry. A somewhat (and, not an exact) conservation law pertains.

We discuss the notion of double-entry bookkeeping.

Ongoing theory includes modeling, for photons, that features mathematics correlating with two harmonic oscillators. Ongoing theory correlates modeling for each of two polarization modes with one harmonic oscillator. Each mode can correlate with a spatial dimension that is orthogonal to both the direction of motion of the photon and to the spatial dimension correlating with the other mode. These notions correlate with KS modeling.

Proposed theory PS ALG modeling has bases in the concept that modeling photons based on four harmonic oscillators has uses. The concept has bases in the ongoing theory notion of KS modeling based on four dimensions. One of those four dimensions is temporal. The other three of those four dimensions are spatial. The concept points to equation (28) and to a concept to which we apply the two-element term double-entry bookkeeping. The term refers to ALG modeling that maintains a numeric balance between TA-side aspects and SA-side aspects. The balance reflects a notion that a sum pertaining to TA-side aspects equals a sum pertaining to SA-side aspects.

Proposed theory PDE modeling also exhibits aspects that we correlate with the two-element term double-entry bookkeeping. Here, the balance refers to effects of a TA-side quantum operator and to effects of an SA-side quantum operator. (See, for example, equation (15).)

3.2.2. Patterns regarding properties of known elementary particles

We discuss possibilities regarding an analog - to the periodic table for chemical elements - for elementary particles.

The periodic table reflects properties of chemical elements. (Note reference [3].) One relevant property is the types of chemical interactions in which an element participates. One relevant property is the atomic weight. A usual display of the periodic table features an array with columns and rows. Elements listed in a column participate in similar interactions. For a row, the atomic weight of an element is usually greater than the atomic weight for each element to the left of the subject element. Atomic weights in one row exceed atomic weights in rows above the subject row.

We look for patterns regarding the known elementary particles. (See table 9.)

Table 15 reflects a concept that the number of elementary particles in a subfamily correlates with the spin of the elementary particles in the subfamily. Table 15b explains notation that table 15a uses. The spin S correlates with an overall angular momentum for which the expression $S(S+1)\hbar^2$ pertains. The spin S does not depend on a choice of an axis. Each of the three columns that correlate with the one-word label unfree correlates with a magnitude of charge that differs from the magnitude of charge pertaining to the other two columns labeled unfree.

Equation (38) pertains for $m\grave{>}0$. (See table 15c.) Spin and the number of particles are related to each other.

$$\iota_S + 1 = \sum n \tag{38}$$

3.2.3. Some applications of PDE mathematics

Table 16 notes some applications of modeling that people can base on the mathematics that underlies PDE modeling. Applications for which the table shows the symbol † pertain regarding supplementary proposed theory. These applications are generally not necessary for core proposed theory work regarding elementary particles, astrophysics, and cosmology. We assume that ongoing theory kinematics and dynamics modeling generally suffices. Each of ongoing theory and proposed theory can use KS applications.

Table 5 discusses some aspects regarding PDE modeling. For KS modeling, the variable t can correlate with ongoing theory notions of temporal aspects and the variable r can correlate with ongoing theory notions of spatial aspects. Solutions Ψ can correlate with wave functions. For PS modeling, the variable t does not necessarily correlate with ongoing theory notions of temporal aspects and the variable r does not necessarily correlate with ongoing theory notions of spatial aspects. Solutions Ψ do not correlate with the ongoing theory notion of wave functions.

3.2.4. PDE aspects of proposed elementary particle theory

We discuss modeling correlating with the first row in table 16. The notion of PS modeling pertains. The expression $\nu_{SA} < 0$ pertains.

This work features the numbers of dimensions that equations (39) and (40) show. Even though our work here features PS modeling, people might want to consider the extent to which equation (39) correlates with a KS modeling notion of three spatial dimensions. A possible SA-side aspect features

Table 15: Known elementary particles

(a) Elementary particles

$\iota_S = 2S$	Free	Free	Unfree	Unfree	Unfree
	$m\grave{>}0$	$m\grave{=}0$	$m\grave{>}0$	$m\grave{>}0$	$m\grave{=}0$
0	$0\mathrm{H}^0$:1				
1	$1\mathrm{C}^3_j$:2	$1\mathrm{N}^0_j$:{1 or 2}	$1\mathrm{Q}^2_j$:2	$1\mathrm{Q}^1_j$:2	
2	$2\mathrm{W}^0$:1				
2	$2\mathrm{W}^3$:2	$2\mathrm{G}^0$:((2))			$2\mathrm{U}^0$:8
4		{$4\mathrm{G}^0$:((2))}			

(b) Notation

Notation	Note	Discussion
ι_S		Spin, in units of $\hbar/2$
S		Spin, in units of $\hbar$
	Free (unimpeded)	Can move independently of other objects
	Unfree	Found only in systems that include other objects
$m\grave{>}0$	Non-zero mass	The mass is at least the mass of an electron
$m\grave{=}0$	Zerolike mass	Models (in some models) as having zero mass
$\iota_S\Phi^{\lvert\iota_Q\rvert}_{\_}$	$\iota_S\Phi$	A subfamily of the Φ family of elementary particles
	$\lvert\iota_Q\rvert$	|Charge| in units of one-third the charge of a positron
	$\lvert x\rvert$	The absolute value of x
	_	Generation, for fermions, with $1 \leq j \leq 3$; NR for bosons
	NR	Not relevant
:n	$n = 1$ or 2	n particles plus antiparticles
	{1 or 2}	Majorana fermion or Dirac fermion, respectively
	8	Number of gluons
:((2))		One particle with two modes
$\{\iota_S\Phi^{\iota_Q}_{\_}\}$		Hypothetical subfamily (hypothesized, but not yet found)
	{$4\mathrm{G}^0$:((2))}	Graviton (hypothesized, but not yet found)

(c) Subfamilies for which $m\grave{>}0$

Subfamily and (if not NR) generation	Particles	$\sum n$ (per :n)
0H	Higgs boson	1
$1\mathrm{C}_j$	j-th generation of charged leptons	2
$1\mathrm{Q}^2_j$	j-th generation of $\lvert\iota_Q\rvert = 2$ quarks	2
$1\mathrm{Q}^1_j$	j-th generation of $\lvert\iota_Q\rvert = 1$ quarks	2
2W	Z and W (W^{-3} and W^{+3}) bosons	3

(d) Subfamilies $m\grave{=}0$

Subfamily and (if not NR) generation	Particles	$\sum n$ (per :n)
$1\mathrm{N}_j$	j-th generation of neutrinos	{1 or 2}
2G	Photon	((2))
{4G}	Graviton (hypothetical)	((2))
2U	Gluons	8

Table 16: Some applications of modeling that people can base on the mathematics that underlies PDE modeling (with the symbol † denoting applications that pertain regarding supplementary proposed theory and generally are not necessary for core proposed theory work regarding elementary particles, astrophysics, and cosmology)

Application	PS / KS	ν_{SA}	Focus
Simple particles that nature embraces	PS	< 0	One simple particle
Interaction vertices that modeling includes †	PS	< 0	Multiple elementary particles
Modeling for some aspects of excitations	KS	≥ 0	Multi-object system
Modeling for some aspects of dynamics	KS	≥ 0	Multi-object system

Table 17: PDE notions that pertain for some physics applications

Notion
• The symbol S denotes spin divided by $\hbar$. The symbol $\hbar$ denotes the reduced Planck's constant.
• For some solutions - which comport with equation (41) - to equation (8), $D_{SA} \neq D^*_{SA}$.
• Solutions for which $\nu_{SA} = -1/2$ can correlate with notions of fields for simple fermions.
• Solutions for which $\nu_{SA} = -1$ can correlate with notions of fields for simple bosons.
• Solutions for which $\nu_{SA} = -3/2$ can correlate with notions of particles for simple fermions.
• TA-side PDE solutions are radial with respect to t, the TA-side analog to the SA-side radial coordinate r.
• For some TA-side PDE solutions, $D_{TA} \neq D^*_{TA}$.

correlations between numbers of simple particles, which would be a PS modeling topic, and numbers of spin states, which would be a KS modeling topic. (See discussion related to table 15.)

$$D^*_{SA} = 3 \tag{39}$$

$$D^*_{TA} = 1 \tag{40}$$

We anticipate using equations (41) and (42). Here, each of $2S$ and $2S_{TA}$ is a nonnegative integer. (We de-emphasize using the symbol S_{SA} instead of the symbol S.) The case that features equation (41), $\sigma_{SA} = +1$, and $S = \nu_{SA}$ is a restating of equation (8). The case that features equation (41) and $\sigma_{SA} = -1$ correlates with some aspects of proposed theory modeling. (See discussions related to table 52.) Similar concepts pertain regarding equation (42) and σ_{TA}.

$$\Omega_{SA} = \sigma_{SA} S(S + D^*_{SA} - 2) = \sigma_{SA} S(S+1), \text{ for } \sigma_{SA} = \pm 1 \tag{41}$$

$$\Omega_{TA} = \sigma_{TA} S_{TA}(S_{TA} + D^*_{TA} - 2) = \sigma_{TA} S_{TA}(S_{TA} - 1), \text{ for } \sigma_{TA} = \pm 1 \tag{42}$$

Table 17 lists notions that pertain for some physics applications.

Along with mathematics correlating with three dimensions and $D^*_{SA} = 3$ and with mathematics correlating with one dimension and $D^*_{TA} = 1$, we anticipate needing mathematics correlating with two dimensions and a case that we denote by $D'' = 2$. (Discussion above does not adequately cover the topic of notions of particles for simple bosons. The case of $D'' = 2$ is relevant to notions of particles for simple bosons.)

Table 18 shows some relationships between some PDE parameters. The symbol XA can denote either SA or TA. Here, we correlate with D'' the symbols S'', ν'', Ω'', and σ''. Each of S'', ν'', Ω'', and σ'' does not necessarily correlate with uses of S, ν_{SA}, Ω_{SA}, σ_{SA}, S_{TA}, ν_{TA}, Ω_{TA}, or σ_{TA} in models regarding simple particles. For $\Omega'' = 0$, the table uses the letters NR to denote that the sign of σ'' is not relevant.

3.2.5. PDE modeling regarding free simple particles

We explore bounds regarding the simple particles that proposed theory suggests.

The order of rows in table 18b correlates with non-decreasing values of Ω_{SA}. A value of spin S correlates with the value of Ω_{SA}. Proposed theory posits that each simple particle correlates with a field. No larger values of S comport with equation (43). (For example, for fermion fields, $S = 3/2$ would correlate with $\Omega_{SA} = 15/4$ and with a negative value, -5, for D_{SA}.) Equation (44) correlates with a limit that pertains regarding simple particles. (Our assumptions regarding the existence of simple particles include excluding solutions for which $\sigma_{SA} = -1$. See table 18d. If we included solutions for which $\sigma_{SA} = -1$, table 18d indicates a possibility for indefinitely large values of S.) We do not expect that nature embraces simple particles with spins other than zero, one-half, and one.

$$S \geq 0 \text{ and } D \geq 1 \tag{43}$$

$$0 \leq S \leq 1 \tag{44}$$

We explore modeling regarding the simple particles that proposed theory suggests. This exploration pertains within the bounds that equations (43) and (44) imply.

Table 18: Relationships between some PDE parameters

(a) Relationships relevant to D^*_{XA} and D''

D^*_{XA}	D''	ν_{XA}	ν''	$D^*_{XA}+2\nu_{XA}$	$D''+2\nu''$
1		$-1/2$		0	
1		-1		-1	
1		$-3/2$		-2	
	2		-1		0
3		$-1/2$		2	
3		-1		1	
3		$-3/2$		0	

(b) SA-side relationships, for $\sigma_{SA} = +1$ (with D denoting D_{SA}; with Ω denoting Ω_{SA}; and with * denoting a possible cause for concern regarding a possible lack of normalization)

ν_{SA}	D	S	Ω_{SA}	σ_{SA}	D	$D+2\nu_{SA}$	$D^*_{SA}+2\nu_{SA}$	Re simple particles	ι_S
-1	$3-\Omega$	0	0	$+1$	3	1	1	Boson field	0
$-1/2$	$(5-4\Omega)/2$	1/2	3/4	$+1$	1	0	2	Fermion field	1
$-3/2$	$(21-4\Omega)/6$	1/2	3/4	$+1$	3	0	0	Fermion particle	1
-1	$3-\Omega$	1	2	$+1$	1	-1*	1	Boson field	2

(c) TA-side relationships, for $\sigma_{TA} = +1$ ((with D denoting D_{TA}; with Ω denoting Ω_{TA}; and with * denoting a possible cause for concern regarding a possible lack of normalization)

ν_{TA}	D	S_{TA}	Ω_{TA}	σ_{TA}	D	$D+2\nu_{TA}$	$3+2\nu_{TA}$	Re simple particles	ι_S
-1	$3-\Omega$	0	0	$+1$	3	1	1	Boson field	0
$-1/2$	$(5-4\Omega)/2$	3/2	3/4	$+1$	1	0	2	Fermion field	1
$-3/2$	$(21-4\Omega)/6$	3/2	3/4	$+1$	3	0	0	Fermion particle	1
-1	$3-\Omega$	1	2	$+1$	1	-1*	1	Boson field	2

(d) SA-side relationships, for $\sigma_{SA} = -1$ (with D denoting D_{SA}; and with Ω denoting Ω_{SA})

ν_{SA}	D	S	Ω_{SA}	σ_{SA}	D	$D+2\nu_{SA}$	$2S+1$
$-1/2$	$(5-4\Omega)/2$	1/2	$-3/4$	-1	4	3	2
$-1/2$	$(5-4\Omega)/2$	3/2	$-15/4$	-1	10	$\cdots$	$\cdots$
$-1/2$	$(5-4\Omega)/2$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
-1	$3-\Omega$	0	0	-1	3	1	1
-1	$3-\Omega$	1	-2	-1	5	3	3
-1	$3-\Omega$	2	-6	-1	9	$\cdots$	$\cdots$
-1	$3-\Omega$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$-3/2$	$(21-4\Omega)/6$	1/2	$-3/4$	-1	4	1	2
$-3/2$	$(21-4\Omega)/6$	3/2	$-15/4$	-1	6	$\cdots$	$\cdots$
$-3/2$	$(21-4\Omega)/6$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$

(e) Relationships between some parameters, for $D'' = 2$ and $D''+2\nu'' = 0$ (with NR denoting that the sign of σ'' is not relevant)

ν''	D	S''	Ω''	σ''	D	$D+2\nu''$	$2S''+1$
-1	$3-\Omega''$	1	1	$+1$	2	0	3
-1	$3-\Omega''$	0	0	NR	3	1	1
-1	$3-\Omega''$	1	-1	-1	4	2	3
-1	$3-\Omega''$	2	-4	-1	7	5	5
-1	$3-\Omega''$	3	-9	-1	12	10	7
-1	$3-\Omega''$	4	-16	-1	19	17	9
-1	$3-\Omega''$	5	-25	-1	28	26	11
-1	$3-\Omega''$	6	-36	-1	39	37	13
-1	$3-\Omega''$	7	-49	-1	52	50	15
-1	$3-\Omega''$	8	-64	-1	67	65	17
-1	$3-\Omega''$	9	-81	-1	84	82	19

Tables 18b and 18c show solutions that correlate with fields for all relevant cases. Tables 18b and 18c show solutions that correlate with particles for all relevant elementary fermion cases. The tables do not discuss particles for relevant elementary boson cases.

Table 18b includes a column with label $D^*_{SA}+2\nu_{SA}$. Table 18c includes a column with label $3+2\nu_{TA}$. These columns comport with the notion that a relevant $D'+2\nu_{XA}$ should be positive for fields and zero for particles. For each of tables 18b and 18c, $D'=3$.

We pursue discussion based on relevance of the three TA-side oscillators TA0, TA1, and TA2 and on relevance of the three SA-side oscillators SA0, SA1, and SA2. (Compare with equation (27).)

In general, use of equation (27) allows separation of terms into clusters. Equation (27) is a sum of D_{XA} terms. Each one of the D_{XA} terms appears in exactly one cluster. For $D_{XA}=1$, there is one term (which correlates with the XA0 oscillator) and one cluster (which contains the one term). For $D_{XA}=3$, we use two clusters. One cluster correlates with the XA0 oscillator. One cluster correlates with the XA1-and-XA2 oscillator pair. In these and similar cases, we apply - for each two-oscillator cluster - an analog to equations (3) and (4).

Here, specifically, $D_{TA}=D_{SA}=D'=3$.

We discuss modeling for fields for simple bosons.

Regarding modeling for fields for $\iota_S=0$ simple bosons, one can use results that tables 18b and 18c show.

Regarding modeling for fields for $\iota_S=2$ simple bosons, one can use the notion of mapping the $D=1$ solutions - that tables 18b and 18c show - into the three dimensions that correlate with $D'=3$. Here, each one of the SA-side solution and the TA-side solution normalizes. SA-side use of $D'=3$ is compatible with (PS modeling and) the existence of three elementary boson states (the Z boson, the negatively charged W boson, and the positively charged W boson). SA-side use of $D'=3$ is compatible with (KS modeling and) the existence of three spin states. TA-side use of $D'=3$ is compatible with (PS modeling and) somewhat conservation of fermion generation. (See table 19 and discussion related to table 25.)

We discuss modeling for particles for simple bosons.

For simple bosons, we expect that modeling regarding particles correlates with the equations $D''=2$, $\nu''=-1$ and $D+2\nu''=0$. (See table 18e.) We base this expectation on the notion that, for simple fermions, modeling regarding particles correlates with the expression $D_{TA}+2\nu_{TA}=0=D_{SA}+2\nu_{SA}$. (See tables 18b and 18c.)

Regarding modeling for particles for simple bosons, we start from the $D_{TA}=D_{SA}=D'=3$ models for fields. We use the clusters TA1-and-TA2, TA0-and-SA0, and SA1-and-SA2. For each cluster, we use the equations $D''=2$, $\nu''=-1$ and $D+2\nu''=0$.

Regarding modeling for particles for $\iota_S=0$ simple bosons, the SA-side one of the two perhaps seemingly extra oscillator pairs - TA1-and-TA2 and SA1-and-SA2 - correlates with the notion of channels. (See discussion related to table 28 and discussion related to equation (111).)

Regarding modeling for particles for $\iota_S=2$ simple bosons, notions - such as somewhat conservation of fermion generation - that pertain for fields for $\iota_S=2$ simple bosons continue to pertain.

We discuss modeling for fields for simple fermions.

Regarding modeling for fields for $\iota_S=1$ simple fermions, the $D^*_{SA}+2\nu_{SA}$ column in table 18b shows a value of two. The $3+2\nu_{TA}$ column in table 18c shows a value of two. For fields for simple bosons, the corresponding four values are one. Regarding fields for elementary fermions, modeling could feature $D'=2$ instead of $D'=3$. (Note, for example, discussion regarding table 29.) For $D'=2$, $D'+2\nu_{SA}=D'+2\nu_{TA}=1$. From $D'=2$, proposed theory applies the transformation that correlates with equation (21). A $D'=(2\cdot 3)-2=4$ pertains. In effect, the transformations add two TA-side oscillators and two SA-side oscillators. Each new oscillator pair can correlate with an $SU(2)$ symmetry. (See table 8.) Elsewhere, we correlate (for modeling for elementary fermion fields and for modeling for elementary fermion particles, the additional two TA-side oscillators with the TA5-and-TA6 pair and the two additional SA-side oscillators with the SA5-and-SA6 pair. (See, for example table 36.)

Table 19 shows and interprets symmetries that pertain to all elementary fermions. (Note tables 14 and 36.)

We discuss modeling for particles for simple fermions.

Table 18b shows $D=3$ and $D+2\nu_{SA}=0$. Table 18c shows $D=3$ and $D+2\nu_{TA}=0$. One can reuse results that pertain for fields for simple particles. A first step would be to pursue modeling that features $D'=2$ instead of $D=3$. Results that table 19 features pertain.

Table 19: Some symmetries and interpretations that pertain to all elementary fermions

Pair	Symmetry	Interpretation
TA1-and-TA2	$\pi_{0,@_{-1}}$	This symmetry correlates with conservation of charge.
SA1-and-SA2	$\pi_{@_0,@_{-1}}$	This symmetry correlates with matter and antimatter.
TA5-and-TA6	$SU(2)$	This symmetry correlates with somewhat conservation of fermion generation.
SA5-and-SA6	$SU(2)$	The three generations of elementary fermions correlate with the three generators of $SU(2)$.

Table 20: Known and proposed free simple particles

(a) Subfamilies for known and proposed simple particles

$\iota_S = 2S$	Free $\lvert\iota_Q\rvert\acute{=}3$ $m\grave{>}0$	Free $\lvert\iota_Q\rvert\acute{=}3$ $m\grave{=}0$
0	$0\mathrm{H}^0$:1	$0\mathrm{I}^0$:1
1	$1\mathrm{C}^3_j$:2	$1\mathrm{N}^0_j$:{1 or 2}
2	$2\mathrm{W}^0$:1	
2	$2\mathrm{W}^3$:2	

(b) Subfamilies and generations for known free simple particles for which $m\grave{>}0$

Subfamily and (if not NR) generation	Particles	$\sum n$ (per $:n$)
$0\mathrm{H}^0$	Higgs boson	1
$1\mathrm{C}^3_j$	j-th generation of charged leptons	2
	$2\mathrm{W}^0$:1 - Z boson	1
	$2\mathrm{W}^3$:2 - W boson	2
2W	Z and W (W^{-3} and W^{+3}) bosons	3

(c) Subfamilies and generations for known and proposed free simple particles for which $m\grave{=}0$

Subfamily and (if not NR) generation	Particles	$\sum n$ (per $:n$)
0I	Aye (or inflaton)	1
$1\mathrm{N}_j$	j-th generation of neutrinos	{1 or 2}

3.2.6. A table of free simple particles

Table 20 lists all known free simple particles and all free simple particles that proposed theory suggests. (Compare with table 15.) PEPT work leading to table 18 does not depend on making assumptions regarding $m\grave{>}0$ and $m\grave{=}0$. PEPT assumes that a partial symmetry between $m\grave{>}0$ and $m\grave{=}0$ pertains. In table 20a, the $m\grave{=}0$ column reflects that partial symmetry. Regarding $\iota_S = 2S$, ongoing theory might suggest a possibility for adding photons. Table 9 might correlate with this notion. However, our development classifies 2G as other than a simple particle. PS PDE modeling correlates 2G with inputs to modeling that outputs table 20a. Equation (45) explains the notation $|\iota_Q|\acute{=}3$. For the case of $|\iota_Q|\acute{=}3$ and $m\grave{=}0$, only $|\iota_Q| = 0$ pertains.

$$|\iota_Q|\acute{=}n \;\text{ denotes }\; |\iota_Q| = n \text{ or } 0 \tag{45}$$

3.2.7. Concepts regarding representations for photons

We discuss notions that, with respect to PDE modeling, correlate with KS modeling.

Ongoing theory describes photon states via two harmonic oscillators. Ongoing theory features four space-time dimensions.

Why not describe photon states via four harmonic oscillators?

Proposed theory describes photon states via ALG modeling that features four harmonic oscillators.

The four-oscillator models correlate with PS modeling.

One might assume that four-oscillator models must correlate with non-zero longitudinal polarization and with a photon rest mass that would be non-zero. However, mathematics allows a way to avoid this perceived possible problem. (See equation (25).)

Table 21: Field-centric representation for excitations for the left circular polarization mode of a photon

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	n								
SA	-1	n, $@_0$							

Table 22: Representations - field-centric and interaction-centric

Notes
• The two-element term field-centric representation contrasts with the two-element term interaction-centric representation.
• The notion of field-centric correlates with the ongoing theory notion of excitations of a field.
• The notion of interaction-centric correlates with symmetries that pertain regarding interactions between fields. (The ongoing theory notion of a QFT (or, quantum field theory) interaction vertex can pertain.)
• The interaction-centric representations that this essay shows correlate with, but sometimes do not completely match in details, field-centric representations for ground states.

One might assume that using four oscillators would add no insight. However, using four oscillators leads to a framework for expressing aspects of proposed theory and leads to insight about a family of phenomena that includes photons.

3.2.8. ALG representations for free elementary particles

We discuss aspects of ALG modeling. (Here, PS modeling pertains, except for aspects that we explicitly identify as correlating with KS modeling.)

We consider the left circular polarization mode of a photon. We denote the number of excitations of the mode by n. Here, n is a nonnegative integer. One temporal oscillator pertains. We label that oscillator TA0. The excitation number $n_{TA0} = n$ pertains. Here, $n_{TA0} = n \geq 0$ pertains. Harmonic oscillator mathematics correlates a value of $n + 1/2$ with that oscillator. Three spatial oscillators pertain. Here, $n_{SA0} = -1$, $n_{SA1} = n$, $n_{SA2} = @_0$. Oscillator SA0 correlates with longitudinal polarization and has zero amplitude for excitation. (See equation (25).) Oscillator SA1 correlates with left circular polarization. Oscillator SA2 correlates with right circular polarization. The symbol $@\_$ denotes a value of $\_$ that, within a context, never changes. For left circular polarization, $@_0$ pertains for oscillator SA2. The sum $n + 1/2$ correlates with each of the one TA-side oscillator and the three SA-side oscillators. For the TA-side oscillator, the sum - with which we correlate the symbol A_{TA}^{ALG} - equals $(n + 1/2)$. For the SA-side oscillators, the sum - with which we correlate the symbol A_{SA}^{ALG} - equals $(-1+1/2)+(n+1/2)+(0+1/2)$.

Table 21 shows excitations for the left circular polarization mode of a photon.

Table 22 discusses the notions of field-centric representations and interaction-centric representations.

For the right circular polarization mode of a photon, one exchanges the values of n_{SA1} and n_{SA2}. The result is $n_{SA1} = @_0$, $n_{SA2} = n$.

For each mode, for the SA-side oscillator for which n pertains, raising operators and lowering operators that correlate with $U(1)$ symmetry pertain. One generator correlates with excitation. One generator correlates with de-excitation. This $U(1)$ symmetry correlates with the $U(1)$ symmetry that the elementary particle Standard Model associates with photons.

Table 23 shows excitations for a photon. Photons interact with charge. We assume that the oscillator pair SA1-and-SA2 correlates with charge or with interactions with charge. Charge is a conserved quantity. Per table 14, the TA1-and-TA2 entry in table 21 correlates with conservation of charge. Per table 8, this term makes a zero contribution to A_{TA}^{ALG}. For this TA-side $U(1)$, the notion of summing charges across components of a multicomponent object pertains.

The representation that table 23 shows is invariant with respect to observer. In interpreting a measurement, each observer would correlate the measurement with the same one of left circular polarization

Table 23: Field-centric representation for excitations for a photon

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	n	$\pi_{0,@_{-1}}$							
SA	-1	$\pi_{n,@_0}$							

Table 24: Questions regarding interpreting the equation $n_{SA0} = -1$

Question
• To what extent do answers to the following questions differ between simple bosons and simple fermions?
• To what extent does $n_{SA0} = -1$ correlate with zero longitudinal polarization?
• To what extent does $n_{SA0} = -1$ correlate with zero rest mass?
• To what extent does $n_{SA0} = -1$ correlate with being able to excite a state via using an arbitrarily small amount of energy squared?
• To what extent does $n_{SA0} = -1$ correlate, for free environments, with travel at the speed of light?
• To what extent does $n_{SA0} = -1$ correlate with inabilities to interact with phenomena, such as the Higgs boson, that proposed theory modeling associates with the SA0 oscillator?

Table 25: Field-centric representation for the ground state for weak interaction bosons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$		$\kappa_{0,0}$					
SA	$n_Z = 0$	$n_{W^{-3}} = 0$, $n_{W^{+3}} = 0$							

and right circular polarization. For that polarization, each observer, in effect, would measure the same value of n. Observers might disagree with respect to measured values of energy or momentum.

We explore representations for elementary particles other than photons.

Table 24 lists questions that, for this discussion, we de-emphasize addressing.

We generalize from work above. We note that ongoing theory interrelates photons and weak interaction bosons.

Table 25 posits a ground state for weak interaction bosons. The relevant bosons are the Z and W bosons. The table correlates the negative charge state of the W boson with the SA1 oscillator. The table correlates the positive charge state of the W boson with the SA2 oscillator. (One might correlate negative charge with SA2 and positive charge with SA1. We do not explore this possibility further. This essay does not explore the possibility of a link between such an assignment regarding charge and the assignment of photon circular polarization modes. This essay does not explore the handedness of W bosons. Perhaps, see reference [4].) Elsewhere, we show a reason for placing $\kappa_{0,0}$ with the TA5-and-TA6 oscillator pair. (See table 36.)

We discuss W-family excitations and we discuss the notion of somewhat conservation of fermion generation.

To describe n excitations of the same state of one of the W-family bosons, we use $n_{TA0} = n = n_{SA\_}$, with SA_ correlating with the one boson. An isolated interaction that excites or de-excites the boson conserves the generation of the fermion that participates in the interaction. For example, an interaction between an electron (or, generation-one charged lepton) and a W^{+3} boson produces a generation-one neutrino. (Per notation that this essay uses, the charge that correlates with the symbol W^{+3} equals the charge of a positron. See table 12d.) We say that conservation of generation pertains. We consider some interactions in hadrons (such as protons and neutrons). Here, we consider an entangled emission and absorption of a pair of W bosons, with one W boson being a W^{-3} and the other W boson being a W^{+3}. Ongoing theory results suggest that conservation of fermion generation need not pertain for the relevant quarks. Regarding proposed theory, a transition from the state that table 25 shows to the state characterized by $n_{TA0} = 2$, $n_{SA0} = 0$, $n_{SA1} = 1$, and $n_{SA2} = 1$ would violate equation (30). The TA-side raising operations would produce a factor of $(1+0)^{1/2}(1+1)^{1/2}$, which equals $2^{1/2}$. The SA-side raising operations would produce a factor of $(1+0)^{1/2}(1+0)^{1/2}$, which equals 1. Equations (30) and (31) imply that one of oscillators TA5 and TA6 participates. There are three generations of quarks. Three is the number of generators of $SU(2)$. We posit that an approximate $SU(2)$ symmetry pertains. (See table 8.) We use the four-word term somewhat conservation of generation (or, the five-word term somewhat conservation of fermion generation). Ongoing theory seems to correlate this proposed theory notion of non-conservation of generation with the ongoing theory notion of CP violation. (See, for example, reference [5].) We note the possibility that, in appropriate settings, people might be able to detect non-conservation, induced by W-family effects, of lepton generation. (Reference [5] suggests that people may be on the verge of observing evidence of lepton CP violation.) Such a setting might need to be adequately conducive to multiple nearby interactions involving W bosons. Here, the word nearby pertains regarding both ongoing theory notions of temporal aspects and ongoing theory notions of spatial aspects.

Table 26: Interaction-centric representation for the ground state for weak interaction bosons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$		$\kappa_{0,0}$					
SA	0	$\kappa'_{0,0}$							

Table 27: A field-centric representation for excitations for the Higgs boson

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	n								
SA	n								

We discuss an ongoing theory W-family symmetry.

Ongoing theory associates $SU(2)\times U(1)$ symmetry with the weak interaction. For proposed theory, we associate $U(1)$ symmetry with excitation and de-excitation regarding each of the three SA-side oscillators. This aspect has parallels to the $U(1)$ symmetry that pertains for photons.

Table 26 shows an interaction-centric representation for the ground state for weak interaction bosons. (Perhaps, note table 36a.) Here, the three generators of the $SU(2)$ that correlates with the oscillator pair SA1-and-SA2 correlate with the three states - negative charge W boson, zero-charge Z boson, and positive charge W boson - of the overall weak interaction boson. The ongoing theory $SU(2) \times U(1)$ symmetry correlates with the $\kappa'_{0,0}$ (or, $SU(2) \times U(1)$) symmetry that correlates with the oscillator pair SA1-and-SA2. Regarding the TA-side $U(1)$, the notion of summing charges across components of a multicomponent object pertains.

We extend proposed theory ALG modeling to include the Higgs boson.

Table 27 shows excitations for the Higgs (or, 0H) boson. The ground state value $n_{SA0} = 0$ correlates with the non-zero mass of the Higgs boson. The lack of an SA1-and-SA2 entry correlates with the Higgs boson having zero charge and not interacting with charge.

Discussion related to tables 18b and 18c suggests that each of the oscillator pairs SA1-and-SA2 and TA1-and-TA2 has relevance regarding modeling for the Higgs boson.

Table 28 shows a field-centric representation and an interaction-centric representation for the ground state for the Higgs boson. The TA-side instance of $\pi_{0,@_{-1}}$ correlates with conservation of charge. The SA-side instance of $\kappa_{0,-1}$ correlates with the notion of a boson channel. (See discussion related to equation (111).)

A number of SA-side oscillators seems to correlate with each of spin and numbers of particles. For each of 0H, 2W, and 2G, equation (46) pertains. In the equation, N_{SA} denotes a number of relevant SA-side oscillators. (The number does not include oscillators for which the symmetry $\kappa_{0,-1}$ pertains. Also, for 0H and 2W, $2S + 1$ provides the number of particles, if one counts matter particles and antimatter particles separately. (Perhaps, compare with the PDE result that equation (38) shows.)

$$N_{SA} = 2S + 1 \tag{46}$$

Table 29 shows the applicability of equation (46) regarding ALG solutions for which $\Sigma \leq 2$. In contrast to table 9, table 29 counts both matter particles and antimatter particles. The symbol * denotes items that differ - regarding counts - between the two tables. Table 29b explains aspects of table 29a.

We extend work above to include representations for all known and suggested free simple particles and root forces. (See table 9.)

We de-emphasize showing excitations. We emphasize showing representations for ground states. One might think that the representation for, for example, the 0I boson ground state precludes excitations. (Note equation (25).) However, elsewhere, we discuss the notion that boson excitements correlate with a concept of channels. (See discussion related to equation (111).) Thus, proposed theory modeling does not preclude the 0I boson or the 2U (or, gluon) particles. For simple fermions, a state is either occupied or not occupied.

Table 28: Field-centric representation and interaction-centric representation for the ground state for the Higgs boson

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$							
SA	0	$\kappa_{0,-1}$							

Table 29: An illustration of $N_{SA} = 2S + 1$, for $\Sigma \leq 2$

(a) Relationships between ALG modeling and elementary particles

n_{TA2}	n_{TA1}	n_{TA0}	n_{SA0}	n_{SA1}	n_{SA2}	$2S$	Free $m\grave{>}0$	Free $m\dot{=}0$	Unfree $m\grave{>}0$	Unfree $m\dot{=}0$
$\emptyset$	$\emptyset$	0	0	$\emptyset$	$\emptyset$	0	0H (1)		0P (1), 0K (1)	
$\emptyset$	$\emptyset$	-1	-1	$\emptyset$	$\emptyset$	0		0I (1)		
$\emptyset$	0	0	0	0	$\emptyset$	1	1C (6*)		1Q (12*)	
$\emptyset$	0	-1	-1	0	$\emptyset$	1		1N (6*)		1R (12*)
0	0	0	0	0	0	2	2W (3*)		2T (6*)	
-1	-1	-1	-1	-1	-1	2				2U (8)
$\emptyset$	$\emptyset$	0	-1	0	0	2	2G ((2))			

(b) Notes

Assumptions and other notes
• $n_{SA\_} = 0$ correlates with non-zerolike property.
• $n_{SA\_} = -1$ correlates with zerolike property.
• Regarding n_{SA0}, the relevant properties are charge and mass.
• For each of the 1Φ subfamilies, each of the following is one of the only two possibilities that can pertain - $0 = n_{SA1} \neq n_{SA2} = -1$ and $-1 = n_{SA1} \neq n_{SA2} = 0$. (This statement correlates with the notion that $D' = 2$ pertains for modeling regarding elementary fermions. See discussion related to tables 18b and 18c.)
• For each of the 1Φ subfamilies, $0 = n_{SA1} \neq n_{SA2} = -1$ correlates with the notion of matter particle and with the notion of left-handedness. The table explicitly shows these cases. Particle counts include these cases.
• For each of the 1Φ subfamilies, $-1 = n_{SA1} \neq n_{SA2} = 0$ correlates with the notion of antimatter particle and with the notion of right-handedness. The table does not explicitly show these cases. Particle counts include these cases.
• For the 2G subfamily, n_{SA1} correlates with left circular polarization and n_{SA2} correlates with right circular polarization.
• The symbol $\emptyset$ denotes an oscillator that is not relevant for this discussion.
• Equation (46) pertains regarding the number of relevant SA-side oscillators.

Table 30: Field-centric representation and interaction-centric representation for ground states for the 0I, 1C, and 1N simple particles

(a) Field-centric representation and interaction-centric representation for the ground states for aye bosons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	-1	$\pi_{0,@_{-1}}$							
SA	-1	$\kappa_{0,-1}$							

(b) Field-centric representation and interaction-centric representation for charged leptons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$		$\kappa_{0,0}$					
SA	0	$\pi_{@_0,@_{-1}}$		$\kappa_{0,0}$					

(c) Field-centric representation and interaction-centric representation for neutrinos

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	-1	$\pi_{0,@_{-1}}$		$\kappa_{-1,-1}$					
SA	-1	$\pi_{@_0,@_{-1}}$		$\kappa_{-1,-1}$					

Table 30 shows representations for 0I, 1C, and 1N simple particles.

Throughout the proposed theory list of elementary particles, each state for which the one-word term elementary boson (or, the result that $2S$ is an even integer) pertains comports with equation (46). For elementary fermions (or, for particles for which $2S = 1$), equation (46) pertains, given two assumptions. One assumption is that we do not count the SA5-and-SA6 oscillator pair, which correlates with $SU(2)$ symmetry, three generators for that group, and three generations of simple particles. One assumption is that each of $n_{SA1} = -1$ and $n_{SA2} = -1$ disables one oscillator and, in effect, leads to the result $N_{SA} = 2$. For each of charged leptons and neutrinos, states are either populated or not populated. Each of charged leptons and neutrinos exhibits a TA5-and-TA6 approximate $SU(2)$ symmetry. That symmetry correlates with somewhat conservation of fermion generation. For each of charged leptons and neutrinos, the SA1-and-SA2 appearance of a $U(1)$ symmetry may seem surprising. Unlike for elementary bosons, multiple excitations for a single state do not pertain. However, multicomponent objects can include more than one identical (for this discussion) fermion. For example, an atom can contain more than one electron.

Table 20 provides a roadmap for developing representations for non-zero spin simple particles for which we do not show representations above. A representation for each unfree non-zero spin simple particle equals the representation for the corresponding free simple particle. For example, a representation for the $1Q_j^2$ quarks equals the representation for the $1C_j^3$ charged leptons.

Table 31 shows representations for 4G, 6G, and 8G root forces. Each representation comports with equation (46). Paralleling results regarding the 2W subfamily, the appearance of $\kappa_{0,0}$ in table 31a correlates with somewhat conservation of fermion generation. (While this leaves the possibility that occurrences of multiple close-by interactions could explain neutrino oscillations, proposed theory offers another explanation. See discussion related to equation (119). The proposed theory treatment seems to explain observed data.) Regarding table 31b, we are uncertain as to whether it would make a significant difference if the * regarding TA3-and-TA4 pertained, instead, to TA7-and-TA8.

Representations for 10G, 12G, ..., and 20G correlate with extrapolations from results that table 31 shows.

3.2.9. Gluons

Table 32 shows representations for 2U forces. Each representation comports with equation (46). Each representation includes symmetries that comport with somewhat conservation of fermion generation. Here, o denotes a positive odd integer and e denotes the positive even integer that is one greater than o. Table 36 nominally assumes that o equals nine. Table 36b notes the possibilities that o could be 11, 13, or 15. (For an interaction-centric representation regarding gluons, see table 51.) Table 32 shows SA1-and-SA2 as correlating with a boson channel. (See discussion related to equation (111).) This essay de-emphasizes discussing the positive integer that correlates with the number of channels that pertains for gluons.

Table 31: Field-centric representation for ground states for the 4G, 6G, and 8G root forces

(a) Field-centric representation for ground states for 4G bosons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$		$\kappa_{0,0}$					
SA	-1	$\pi_{@_0,@_0}$	$\pi_{0,@_0}$						

(b) Field-centric representation for ground states for 6G bosons (with * denoting participation in one instance of $\kappa_{0,0,0,0}$)

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$	*	*					
SA	-1	$\pi_{@_0,@_0}$	$\pi_{@_0,@_0}$	$\pi_{0,@_0}$					

(c) Field-centric representation for ground states for 8G bosons (with * denoting participation in one instance of $\kappa_{0,0,0,0,0,0}$)

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$	*	*	*				
SA	-1	$\pi_{@_0,@_0}$	$\pi_{@_0,@_0}$	$\pi_{@_0,@_0}$	$\pi_{0,@_0}$				

Table 32: Field-centric representations for gluons (or, 2U bosons)

Side	0	1, 2	3, 4	5, 6	7, 8	$\cdots, \cdots$	o, e	$\cdots, \cdots$
TA	-1	$\pi_{0,@_{-1}}$		$\kappa_{-1,-1}$				
SA	*	$\kappa_{0,-1}$					*	

3.2.10. Simple bosons related to gluons

We explore correlations between ΣU solutions and the pie (or, 0P) and cake (or, 0K) bosons. (Elsewhere, we correlate 0G solutions with all simple bosons except the pie and cake bosons. See table 48 and discussion related to equation (60).)

Table 33 alludes to modeling that correlates the cake and pie particles with U-family forces. Tables 12a and 12d discuss the notion of $SU(3) \uplus I$. Table 33 focuses on the identity operator aspect of the notion of $SU(3) \uplus I$. Discussion related to equation (161) explains the relevant notion of a swap that correlates with the SA-side aspect that the table shows regarding the 0K simple boson. (For this aspect, KS PDE modeling pertains.) Proposed theory suggests that pie particles correlate with the ongoing theory notion of a Yukawa potential that, in atomic nuclei, attracts hadrons to each other. Proposed theory suggests that cake particles correlate with the ongoing theory notion of a Pauli exclusion force that repels hadrons from each other. Whereas, 2U particle interactions correlate with color charges, 0K particles and 0P particles - in effect - interact with clear (or, white) color charge.

Table 34 suggests representations for the 0K and 0P bosons. Each one of the cake simple particle and pie simple particle does not interact with simple fermions.

The mass of the pie simple boson might approximate the masses of pions. We do not explore theory that might correlate with the mass of pie simple bosons.

The effective range of the repulsive force is less than the effective range of the attractive force. The mass of the cake simple boson might exceed the mass of the pie simple boson. (See discussion related to equation (71).) We do not explore theory that might correlate with the mass of the cake boson.

3.2.11. Arc simple fermions and tweak simple bosons

Proposed theory suggests a symmetry regarding ι_Q. The symmetry suggests, regarding non-zero-spin simple particles, that each of the cases $\iota_Q = 2$ and $\iota_Q = 1$ is similar to the case $\iota_Q = 3$.

Table 33: Possible correlations between U-family mathematics and simple bosons that do not belong to the U-family of root forces

Subfamily	Concept	Aspect	KS SA-side aspect	0Φ	0Φ mass	Residual strong force
2U	$SU(3) \uplus I$	I operator	$-(\eta_{TA})^{-2}t^2$	0K	$m \grave{>} 0$	Repulsive
2U	$SU(3) \uplus I$	I operator	$+(\eta_{SA})^{-2}r^2$	0P	$m \grave{>} 0$	Attractive

Table 34: Field-centric representations and interaction-centric representations for 0K and 0P simple bosons

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	0	$\pi_{0,@_{-1}}$							
SA	0	$\kappa_{0,-1}$							

Table 35: Free and unfree simple particles, other than the pie and cake particles

$\iota_S = 2S$	Free $\lvert\iota_Q\rvert\acute{=}3$ $m\grave{>}0$	Free $\lvert\iota_Q\rvert\acute{=}3$ $m\grave{=}0$	Unfree $\lvert\iota_Q\rvert\acute{=}2$ $m\grave{>}0$	Unfree $\lvert\iota_Q\rvert\acute{=}2$ $m\grave{=}0$	Unfree $\lvert\iota_Q\rvert\acute{=}1$ $m\grave{>}0$	Unfree $\lvert\iota_Q\rvert\acute{=}1$ $m\grave{=}0$
0	$0\mathrm{H}^0$:1	$0\mathrm{I}^0$:1				
1	$1\mathrm{C}^3_j$:2	$1\mathrm{N}^0_j$:{1 or 2}	$1\mathrm{Q}^2_j$:2	$1\mathrm{R}^{0''}_j$:{1 or 2}	$1\mathrm{Q}^1_j$:2	$1\mathrm{R}^{0'}_j$:{1 or 2}
2	$2\mathrm{W}^0$:1		$2\mathrm{T}^{0''}$:1		$2\mathrm{T}^{0'}$:1	
2	$2\mathrm{W}^3$:2		$2\mathrm{T}^2$:2		$2\mathrm{T}^1$:2	

Table 35 shows, the free and unfree simple particles - other than the pie and cake particles - that proposed theory suggests. (Compare with table 15 and with table 20.) For the zero-charge unfree particles that table 35 shows, the number of tick marks in a symbol $\Sigma\Phi^0$– equals $|\iota_Q|$.

4. Results: properties of elementary particles and multicomponent objects

This unit interrelates properties of elementary particles and of multicomponent objects.

4.1. Summary: a table of properties of elementary particles and multicomponent objects

Table 36 lists properties that pertain to elementary particles and that may pertain to objects that contain more than one component object. Table 36 correlates with KS modeling.

We anticipate exploring predictions about and correlations among the properties, especially in regard to properties of elementary particles.

Elsewhere, we speculate that aspects of table 36a correlate with the group $SU(17)$ and that people might want to consider the notion that table 36a correlates with - at least a key component of - a so-called theory of everything. (See discussion related to table 83.)

4.2. Modeling regarding properties of elementary particles and multicomponent objects

We discuss concepts and methods that point to results regarding some properties of elementary particles.

4.2.1. Kinematics conservation laws

We explore modeling regarding conservation of energy, momentum, and angular momentum.

In ongoing theory, the electromagnetic field carries information that correlates with events that excited the field. Via de-excitations, people measure energies, momenta, and polarizations. (Also, people measure or infer that the de-excitation event features de-exciting a mode of the electromagnetic field and does not feature de-excitation of a non-electromagnetic field.) People infer information about excitation events.

We want to discuss the extent to which proposed theory models for ΣG (or, G-family) fields reflect encoded information.

We start by exploring modeling related to energy, momentum, and angular momentum.

Ongoing theory discusses models for objects, internal properties (such as spin and charge) of objects, motion-centric properties (such as momentum) of objects, and interactions (or, forces) that affect internal properties of objects or motion of objects.

We discuss symmetries that ongoing theory and proposed theory correlate with conservation laws related to motion. Ongoing theory correlates with KS modeling. PS modeling pertains regarding some aspects of proposed theory. KS modeling pertains regarding some aspects of proposed theory.

Table 37 summarizes symmetries correlating with kinematics conservation laws. Ongoing theory correlates an $S1G$ symmetry with conservation of energy. The one-element term $S1G$ denotes a symmetry correlating with a group for which one generator pertains. Supplementary proposed theory includes KS modeling for motion. Supplementary proposed theory KS modeling for motion includes the kinematics

Table 36: A catalog of properties that pertain to elementary particles and that may pertain to multicomponent objects

(a) The catalog (with DoF abbreviating the three-word phrase degrees of freedom)

XA	SA-side symmetry	Properties	SA-side count	TA-side symmetry (summable and conserved)	Ref
0	-	Positive/zerolike rest energy	-	-	ALG
1, 2	$SU(2)$	Charge	3 $(-,0,+)$	$U(1)$	G
3, 4; 5, 6	$SU(4)$	Rest energy minus freeable energy	-	$U(1)$	G, KS
(5, 6)	$(SU(2))$	(Gens - for simple fermions only)	3 gens	(-)	G
7, 8	$SU(2)$	3LB number	3 $(-,0,+)$	$U(1)$	G
9, 10	$SU(3)$	Color charge	3 (r, b, g)	-	U
11, 12	$SU(2)$	Momentum	3 DoF	$U(1)$	KS
13, 14	$SU(2)$	Angular momentum	3 DoF	$U(1)$	KS
15, 16	$SU(2) \times U(1)$	Isomer (of charge)	6	-	PS

(b) Notes about columns that pertain for the catalog

Notes
• The column labeled XA displays sets of oscillators. Here, XA includes each of TA and SA. A set may refer to two, four, or six oscillators. • The column labeled SA-side symmetry lists SA-side symmetries. • The column labeled properties lists properties. • Numbers in the column labeled SA-side count equal the number of generators for the groups in the column labeled SA-side symmetry. • For a row for which the column labeled TA-side symmetry shows the group $U(1)$, the property is a conserved quantity and the property sums across components of a multicomponent object. • The column labeled with the one-element term Ref alludes to aspects (that this essay discusses) - of modeling - that correlate with the properties. Each of ALG, KS, and PS alludes to a type of modeling. Each of G and U alludes to modeling that pertains to the relevant family of elementary particles. For cases in which G or U pertains, modeling relevant to other families also pertains.

(c) Notes about rows and items that pertain for the catalog

Notes
• The notion of zerolike rest energy pertains for some elementary particles and not for other objects. • Each object has a charge. The charge is an integer multiple of one-third the magnitude of the charge of an electron. The symbol $(-,0,+)$ correlates with the following three possibilities. The integer is negative. The integer is zero. The integer is positive. • For an object that remains intact during an interaction with other objects, the quantity rest energy minus freeable energy remains unchanged by the interaction. The pairs XA3-and-XA4 correlate with rest energy. The pairs XA5-and-XA6 correlate with freeable energy. • The row for which the XA column shows in parentheses the integers five and six is a sub-case of the row immediately above that row and pertains for elementary fermions only. • The one-element item gens abbreviates the word generations. • Each object has a 3LB number. The 3LB number is an integer multiple of the magnitude of the baryon number for a quark. The symbol $(-,0,+)$ correlates with the following three possibilities. The integer is negative. The integer is zero. The integer is positive. • As far as we know, other permuting, among rows, of the items that table 36a shows as correlating with XA9-and-XA10 through XA15-and-XA16 would not make a difference regarding modeling that this essay discusses. • The three-element item (r, b, g) correlates with three color charges - red, blue, and green. • The one-element item DoF abbreviates the three-word phrase degrees of freedom. • The notion of six isomers (of charge and of charged elementary particles) correlates with the astrophysics and cosmology case of PR6IC modeling.

Table 37: Symmetries correlating with kinematics conservation laws

Conservation law	Ongoing theory KS modeling	Proposed theory KS modeling		Proposed theory PS modeling
		TA-side	SA-side	
Conservation of energy	$S1G$	$U(1)$	$SU(4)$	TA-side $SU(5)$
Conservation of momentum	$SU(2)$	$U(1)$	$SU(2)$	SA-side $SU(2)$
Conservation of angular momentum	$SU(2)$	$U(1)$	$SU(2)$	SA-side $SU(2)$

symmetries that table 36 shows. Core proposed theory PS modeling pertains to the existence of elementary particles and multicomponent objects and pertains to interactions between elementary particles and multicomponent objects.

The following concepts pertain regarding proposed theory PS modeling.

- We extend the notion of free to include free objects other than the free simple particles and free root forces to which table 9 alludes. The notion of free correlates with an object having a well-specified definition and with the object modeling, under some circumstances, as if conservation of energy, momentum, and angular momentum pertain for the object.
- Models for the kinematics of free objects need to include the possibility that all three conservation laws pertain. The relevance of all three conservation laws correlates with modeling that correlates with the notion of a distinguishable object and with the notion of a free environment. (Free objects can exist as components of, let us call them, larger objects that are free. For one example, an electron can exist as part of an atom. For another example, a hadron can exist as part of an atomic nucleus that includes more than one hadron. In such contexts, modeling regarding motion of the electron or hadron does not necessarily need to embrace all three conservation laws. The two-word term confined environment can pertain.)
- Models regarding the kinematics of unfree objects do not necessarily need to embrace all three kinematics conservation laws. Unfree objects model as existing in the contexts of larger free objects. The two-word term confined environment pertains.
- For a proposed theory PS ALG model to embrace conservation of momentum and conservation of angular momentum, one, in effect, adds (to a model for an object) four SA-side oscillators and expresses two instances of $SU(2)$ symmetry. Double-entry bookkeeping suggests adding four TA-side oscillators. Proposed theory suggests that, for each of the eight added oscillators, $n\_ = n_{TA0}$.
  - For some modeling, proposed theory suggests combining the four TA-side oscillators with the TA0 oscillator to correlate with an $SU(5)$ symmetry. For such modeling, proposed theory suggests that the TA-side $SU(5)$ symmetry correlates with conservation of energy. (See table 37.)
  - For some modeling, it might be appropriate to use $SU(4)$ plus $S1G$.
- Table 38 shows possible proposed theory PS ALG interaction-centric representations of kinematics conservation laws for free objects. We think that it might not be necessary to designate specific oscillator pairs. (A choice of oscillator pairs XA11-and-XA12 and XA13-and-XA14 correlates with other PS modeling uses for oscillators XA0-through-XA10. A choice of oscillator pairs XA11-and-XA12 and XA13-and-XA14 correlates with the KS modeling that table 36a shows.) For - at least - convenience regarding notation, this essay chooses the oscillator pairs XA11-and-XA12 and XA13-and-XA14. (For field-centric representations, one might want to use oscillator pairs such as XA21-and-XA22 and XA23-and-XA24. Presumably, the pair XA19-and-XA20 would correlate with 10G.)
- Special relativity correlates with boost symmetry, which correlates with an additional $SU(2)$ symmetry. Boost symmetry correlates with KS modeling. PS modeling does not necessarily need to accommodate boost symmetry.
- A contrast between tables 30 and 31 and table 38 pertains. Some information in tables 30 and 31 correlates with symmetries and conservation laws (or with approximate symmetries and somewhat conservation laws) that pertain regarding fields and quantum excitations. Some information in table 38 correlates with interactions and with conservation laws that pertain regarding kinematics.

Table 38: Interaction-centric representation for conservation of energy, momentum, and angular momentum for free objects

(a) The case $n_{TA0} = 0$ (with $\kappa_{0,0,0,0,0}$ spanning the three items showing the symbol *)

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	*						*	*	
SA	0						$\kappa_{0,0}$	$\kappa_{0,0}$	

(b) The case $n_{TA0} = -1$ (with $\kappa_{-1,-1,-1,-1,-1}$ spanning the three items showing the symbol *)

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA	*						*	*	
SA	-1						$\kappa_{-1,-1}$	$\kappa_{-1,-1}$	

- The following PS modeling can pertain regarding combining two free objects to form one free object.
  - Each of the two original objects contributes two SA-side $SU(2)$ symmetries.
  - Two of the original SA-side $SU(2)$ symmetries can pertain regarding modeling for the motion of the new object. The other two SA-side $SU(2)$ symmetries are available for modeling internal aspects of the new object. Neither of the original two objects continues to exhibit both conservation of momentum and conservation of angular momentum. For example, for a system consisting of a star and a planet, neither the star nor the planet exhibits conservation of momentum. In this context, kinematics modeling for each of the two original objects can correlate with unfree modeling. In this context, each leftover internal $SU(2)$ symmetry can correlate with modeling for one of the original objects, for fields that model interactions between the two original objects, for combinations of objects and fields, or for something else. Here, the notion of something else can correlate with, for example, aspects of two-body modeling that features the concept of reduced mass.
  - Similarly, one of the original two TA-side $SU(5)$ symmetries can pertain regarding modeling for the motion of the new object. The other TA-side $SU(5)$ symmetry is available for modeling internal aspects of the new object.

4.2.2. G-family phenomena, including electromagnetism and gravity

We explore aspects regarding G-family forces and regarding components of G-family forces.

In ongoing theory KS modeling, an excitation of a G-family force carries information through which people infer aspects of an event that includes the excitation. For example, people measure the energy of a photon and might use that information to infer information about an atomic transition that excited the photon.

We explore PS modeling that encodes, regarding 2G modes, information about excitations of the overall 2G field. We anticipate that PS modeling points to encoded information to which ongoing theory KS modeling does not point. The additional encoded information correlates with the so-called isomer or isomers that participated in the creation of the photon. (See table 36. See discussion leading to table 62. Perhaps note, for example, discussion - pertaining to isomers and spans - related to equation (129) and discussion related to table 65.)

We consider the left circular polarized mode. Modeling for some excitations correlates with aspects of table 21.

We consider an excitation that models conceptually as combining an excitation of the left circular mode of 4G and the right circular mode of 2G. (This essay de-emphasizes the possible relevance of an actual object that combines a graviton and a photon.) The combination yields a left circular polarization spin-1 excitation. The combination correlates with 2G.

Equation (47) provides notation that we use for such combinations. The symbol ΣG denotes a subfamily of the G-family of solutions to equation (28). The symbol Γ denotes a set of even integers selected from the set $\{2, 4, 6, 8\}$. We use the symbol λ to denote an element of Γ. Each value of λ correlates with the oscillator pair SA($\lambda - 1$)-and-SAλ. (Elsewhere, we discuss aspects correlating with the limit $\lambda \leq 8$. See discussion related to table 40.) For the above example of subtracting spin-1 from spin-2, the notation $\Gamma = 24$ pertains and equation (48) pertains.

Table 39: G-family solutions that may be relevant

Other	Monopole	Dipole	Quadrupole	Octupole
0G∅	2G2	ΣG24	ΣG246	ΣG2468
	4G4	ΣG26	ΣG248	
	6G6	ΣG28	ΣG268	
	8G8	ΣG46	ΣG468	
		ΣG48		
		ΣG68		

$$\Sigma\mathrm{G}\Gamma \tag{47}$$

$$\Sigma = |-2+4| = 2 \tag{48}$$

Table 39 points to possibly relevant solutions. The label monopole correlates with the existence of one mathematical solution for each item in the column labeled monopole. The label dipole correlates with the existence of two mathematical solutions for each item in the column labeled dipole. For example, for $\Gamma = 24$, each one of the solutions 2G24 and 6G24 pertains. The symbol 6G24 correlates with $\Sigma = |+2+4| = 6$. The label quadrupole correlates with the existence of four mathematical solutions for each item in the column labeled quadrupole. G-family physics does not include phenomena that might correlate with the symbol 0G. For each of two quadrupole items, the one 0GΓ mathematical solution is not relevant to G-family physics. (The solutions may be relevant to physics other than G-family physics. See, for example, table 48.) For example, the solution 0G246, which correlates with $|-2-4+6|$, is not relevant to G-family physics. The label octupole correlates with the existence of eight mathematical solutions for the one item in the column labeled octupole. The solution 0G2468 is not relevant to G-family physics. The table notes a conceptually possible 0G∅ solution. The symbol ∅ denotes the empty set.

So far, our discussion of the terms monopole through octupole features numbers of solutions and does not feature physics phenomena.

So far, proposed theory does not depend on choosing a kinematics model. Examples of kinematics models include Newtonian physics and general relativity.

We posit that the words monopole through octupole correlate, for ongoing theory KS Newtonian modeling, with force laws. Ongoing theory correlates the word monopole with a potential energy that varies as r^{-1} and with the RSDF of r^{-2}. (The concept of RSDF correlates with KS modeling.) Here, r denotes the distance from the center of the one relevant object. RSDF abbreviates the five-word term radial spatial dependence of force. Here, we de-emphasize angular aspects of forces. (Discussion related to table 43 shows relationships between some solutions that table 39 lists and aspects of ongoing theory. For example, 2G2 correlates with interactions with charge. 2G24 correlates with interactions with nominal magnetic dipole moment.)

Table 40 shows representations for the G-family solutions that table 39 lists. The solutions correlate with symmetries pertaining to ground states. For the case of Σ being two, excitations comport with the type of ΣG excitations to which table 23 alludes. For the cases of Σ being four, six, or eight, excitations comport with the type of ΣG excitations to which table 31 alludes. In table 40, the rightmost seven columns comport with double-entry bookkeeping. For example, a TA-side $SU(3)$ symmetry alludes to two additional TA-side oscillators for each of which $n_{TA\_} = 0$. Those two oscillators plus the TA0 oscillator correlate with $\kappa_{0,0,0}$ (or, with $SU(3)$ symmetry). The symbol A0+ correlates with an oscillator pair for which, for each of the two oscillators, the symbol $@_0$ pertains. (Perhaps, see table 8.) In table 40a, the column regarding span pertains regarding aspects of dark matter specifically and, generally, aspects of astrophysics and cosmology. (See table 65 and table 40b.) Regarding each $\Sigma > 0$ solution that the table shows, the KS radial behavior of the potential is $r^{n_{SA0}}$. The RSDF is $r^{n_{SA0}-1}$.

Table 41 generalizes from table 40b.

Regarding elementary particle physics, we note four notions that seem to correlate with a limit of $\lambda \leq 8$. Possibly, each one of the notions is relevant.

- The limit might correlate with a scaling law. For the Γ of 2468⟦10⟧, the one-element phrase hexadecimal-pole would pertain. Here, the symbol ⟦10⟧ denotes the number ten. Assuming KS Newtonian modeling, the RSDF (or, radial spatial dependence of force) would be r^{-6}. We consider interactions between two similar, neighboring, non-overlapping, somewhat spherically symmetric

Table 40: Interaction-centric information, including TA-side symmetries, regarding G-family solutions

(a) ΣΦΓ, TA-side symmetries, and other aspects

ΣΦΓ	Span (for $\iota_I \geq 6$)	TA-side $SU(\_)$ symmetry	TA 0	SA 0	SA 1 and 2	SA 3 and 4	SA 5 and 6	SA 7 and 8
0G∅	1	None	-1	-1				
2G2	1	None	0	-1	$\pi_{0,@_0}$			
4G4	6	$SU(3)$	0	-1	A0+	$\pi_{0,@_0}$		
ΣG24	1	None	0	-2	$\pi_{0,@_0}$	$\pi_{0,@_0}$		
6G6	2	$SU(5)$	0	-1	A0+	A0+	$\pi_{0,@_0}$	
ΣG26	6	$SU(3)$	0	-2	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	
ΣG46	6	$SU(3)$	0	-2	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
ΣG246	1	None	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
8G8	1	$SU(7)$	0	-1	A0+	A0+	A0+	$\pi_{0,@_0}$
ΣG28	2	$SU(5)$	0	-2	$\pi_{0,@_0}$	A0+	A0+	$\pi_{0,@_0}$
ΣG48	2	$SU(5)$	0	-2	A0+	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG68	2	$SU(5)$	0	-2	A0+	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG248	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG268	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG468	6	$SU(3)$	0	-3	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG2468	1	None	0	-4	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$

(b) Notes regarding excitations and regarding information that correlates with specific ΣGΓ

Notes
• An excitation of a ΣG field does not (directly) encode information about a relevant ΣGΓ.
• Proposed theory includes so-called PRι_IIC modeling, with ι_I being one of the integers one, six, and 36. The models address aspects of astrophysics and aspects of cosmology. The integer ι_I denotes a number of so-called isomers of charge (or, number of isomers of charged elementary particles).
• In this respect, PR1IC modeling correlates with established ongoing theory. The notion of span is not relevant. (Or, one can say that each simple particle and each component of root forces has a span of one.)
• For PRι_IIC modeling for which $\iota_I \geq 6$, an excitation (for example, of a ΣG field) encodes information that specifies relevant isomers of charge (or, relevant isomers of charged elementary particles). Here, the word relevant denotes relevant to the excitation. The word span denotes the number of relevant isomers.
• For PRι_IIC modeling for which $\iota_I \geq 6$, a de-excitation must correlate with an isomer in the list of isomers that correlates with the relevant excitation.

Table 41: Notes regarding excitations and regarding information that correlates with excitations, plus notes regarding PS modeling and KS modeling

Notes
• An excitation of an elementary particle (or, of a simple particle or a root force) encodes information about the relevant isomer or relevant isomers. The following statements provide examples. For an excitation of an elementary particle with non-zero charge, the list of relevant isomers includes exactly one isomer. For an excitation of a photon (or, 2G mode) via an interaction that correlates with 2G68, the list of relevant isomers includes exactly two isomers.
• An excitation of a root force does not encode information correlating directly with a specific component of the root force.
• A de-excitation must correlate with an isomer in the list of isomers that correlates with the relevant excitation.
• In this essay, PS modeling uses of terms such as the two-element term _pole gravity refer to notions that correlate with isomers. Examples of such terms include the two-word phrase monopole gravity, the two-element term non-monopole gravity, and the four-word term quadrupole component of gravity.
• In this essay, KS modeling uses of terms such as the two-element term _pole gravity refer to notions that an object can have a mass distribution that is not spherically symmetric and can a have a mass distribution that rotates.

Table 42: $\Sigma\gamma$ solutions (or, G-family solutions for which Σ appears in the list Γ)

Σ	Monopole	Dipole	Quadrupole	Octupole
2	2G2	2G24	2G248	
4	4G4	4G48	4G246	4G2468a, 4G2468b
6	6G6		6G468	
8	8G8			8G2468a, 8G2468b

objects. A ΣG2468⟦10⟧ force would scale like $(\upsilon^3\rho)^2/(\upsilon r)^6$, in which υ is a non-dimensional scaling factor that correlates with linear size (or, a length), ρ is the relevant object property for the case for which $\upsilon = 1$, and r is the distance between the centers of the objects. The factor υ^3 provides for scaling for an object that has three spatial dimensions. The force would be independent of υ. That independence might suggest, from a standpoint of physics, that $\varrho = 0$ pertains.

- The limit might correlate with the notion of three eras in the rate of expansion of the universe. (See discussion related to table 74.) Proposed theory correlates those eras with (respectively, working backwards in time from the present era) dipole repulsion, quadrupole attraction, and octupole repulsion. We know of no evidence for an era that would correlate with hexadecimal phenomena.

- The limit might correlate with a TA-side $SU(9)$ symmetry. Based on thinking that leads to table 40, 10G⟦10⟧ correlates with a TA-side $SU(9)$ symmetry. Here, the symbol ⟦10⟧ denotes a Γ that contains just the number ten. We posit that remarks regarding equation (35) pertain. Here, we de-emphasize the notion that 16G⟦16⟧ has relevance to physics. (See discussion related to table 94.) The solution 16G⟦16⟧ would correlate with TA-side $SU(17)$ symmetry.

- The limit might correlate with the notion of channels. Discussion related to table equation (112) and table 57 suggests that a λ that exceeds eight is not relevant regarding G-family physics.

Table 42 lists G-family solutions ΣGΓ for which both Σ does not exceed eight and Σ appears in the list Γ. The expressions $|-2+4-6+8|$ and $|-2-4-6+8|$ show that two solutions comport with the notion of 4G2468. The expressions $|+2+4-6+8|$ and $|-2-4+6+8|$ show that two solutions comport with the notion of 8G2468. We use the symbol $\Sigma\gamma$ to refer to the set of G-family solutions ΣGΓ for which Σ appears in the list Γ. (See equation (49).) We use the symbol $\gamma\lambda$ to refer to the set of G-family solutions ΣGΓ for which λ appears in the list Γ and Σ does not appear in the list Γ. (See equation (50).)

$$\Sigma\gamma = \{\Sigma\mathrm{G}\Gamma | \Sigma \in \Gamma\} \tag{49}$$

$$\gamma\lambda = \{\Sigma\mathrm{G}\Gamma | \lambda \in \Gamma, \Sigma \notin \Gamma\} \tag{50}$$

Table 43: KS-modeling interpretations regarding some components of $\Sigma\gamma$ force components for which $\Sigma \leq 4$

(a) Interactions

Components	Interactions with ...
2G2	Charge
2G24	Magnetic dipole moment
2G248	Magnetic dipole moment for which the axis changes over time
4G4	Mass
4G48	Mass that rotates
4G246	Quadrupole moment of mass
4G2468a, 4G2468b	Quadrupole moments of mass that rotates

(b) An interpretation

Aspect	Interpretation
$8 \in \Gamma$	Rotation

Proposed theory correlates the two-word term monopole gravity (or, the four-word term monopole component of gravity) with the 4G4 solution. (See table 41.) Proposed theory correlates the two-element term non-monopole gravity with the 4G48, 4G246, 4G2468a, and 4G2468b solutions. Solution 4G48 correlates with some effects for which ongoing theory might use the four-word term dark energy negative pressure. Solutions 4G2468a and 4G2468b correlate with some effects for which ongoing theory uses the three-word term inflationary dark energy. Each one of solutions 4G48, 4G246, 4G2468a, and 4G2468b correlates also with - regarding ongoing theory - effects for which people do not use either one of the terms dark energy negative pressure and inflationary dark energy.

Table 43 discusses aspects of table 42. Here, we anticipate possibilities for developing supplementary proposed theory kinematics models. (See, for example, discussion related to table 91 and discussion related to table 94.) Here, we use wording that correlates with KS classical physics Newtonian modeling. Solution 2G248 correlates with interactions with an object for which a non-zero magnetic dipole moment pertains, an axis of rotation pertains regarding the orientation of the axis of the magnetic dipole moment, and the axis of rotation does not match the axis correlating with the magnetic dipole moment. The notion of a vector cross product between a vector correlating with the axis of dipole moment and a vector correlating with the axis of rotation pertains. For the earth, the 2G248 interaction correlates with the non-alignment of the axis of rotation and the axis of the magnetic field. We posit that $8 \in \Gamma$ - or the number eight appearing in the list Γ - correlates with non-zero rotation. One of 4G2468a and 4G2468b interacts - with rotational aspects of quadrupole distributions of mass - based on an axis of maximal moment of inertia. The other one of 4G2468a and 4G2468b interacts - with rotational aspects of quadrupole distributions of mass - based on an axis of minimal moment of inertia.

Statements above regarding 2G and 4G correlate with concepts that equations (51) and (52) symbolize. PS modeling regarding quantum states and excitations does not necessarily involve modeling pertaining to translational motion. Equation (51) pertains. (See table 31.) Equation (52) correlates with linking G-family physics to models for forces and translational motion. (See discussion above regarding 2G and 4G and see, for example, table 40.) Another aspect of such linking correlates with kinematics conservation laws. (See discussion related to table 37.)

$$\Sigma\text{G} \leftrightarrow \text{quantum excitations} \tag{51}$$

$$\Sigma\text{G}\Gamma \leftrightarrow \text{a bridge between quantum excitations and kinematics forces} \tag{52}$$

We explore the extent to which components of G-family forces interact with simple particles. (This exploration correlates with PS modeling.)

We combine aspects of equation (35), table 37, and table 40. We posit that TA-side aspects of table 37 and TA-side aspects of table 40 combine. For example, for 8G8, a TA-side $SU(11)$ symmetry would pertain. (In table 37, seven TA-side oscillators pertain. In table 40, five TA-side oscillators pertain. The tables share their respective $n_{TA0} = 0$ values. Seven plus five minus one is 11.) For example, for 4G4, a TA-side $SU(7)$ symmetry would pertain. For example, for 2G2 or 2G24, a TA-side $SU(5)$ symmetry would pertain. We posit a limit that correlates with aspects of equation (35). We posit that each component that appears in table 40 and has a TA-side symmetry of None or $SU(3)$ can interact with

Table 44: G-family solutions for which $\lambda \leq 4$

Other	Monopole	Dipole
0G∅	2G2	ΣG24
	4G4	

simple particles. (Here, combining the TA-side symmetry that table 40 shows with the conservation of energy symmetry produces, respectively, $SU(5)$ or $SU(7)$.) We posit that each component that appears in table 40 and has a TA-side symmetry of $SU(5)$ or $SU(7)$ does not interact with simple particles. (Here, combining the TA-side symmetry that table 40 shows with the conservation of energy symmetry produces, respectively, $SU(9)$ or $SU(11)$.) We posit that a combined symmetry of either $SU(9)$ or $SU(11)$ correlates with possible interactions with multicomponent objects.

For example, 2G68 can interact with an atom but not with an isolated electron. (Table 40 shows, regarding 2G68, a TA-side $SU(5)$ symmetry.) We correlate 2G68 with at least the 21-centimeter hyperfine interaction with hydrogen atoms. (See discussion related to equation (141).) Generally, $6 \in \lambda$ can correlate with interactions regarding freeable energies of objects. (See discussion related to table 11.) Generally, $8 \in \lambda$ can correlate with interactions regarding rotations of objects or spins of objects. (See discussion related to table 11 and see table 43b.)

We contrast aspects of proposed theory G-family modeling with a possible proposed theory interpretation of aspects of ongoing theory.

Table 44 contrasts with table 39. Regarding table 44, we deploy PEPT techniques, but with an assumption that the maximum λ in any Γ is 4. Ongoing theory does not necessarily include a particle that would correlate with the 0G∅ solution. Ongoing theory includes classical physics modeling and quantum physics modeling that correlate with 2G2 and 2G24. Ongoing theory does not directly include notions that would correlate with 6G24. Ongoing theory includes classical physics models for gravity but does not (yet) include a complete statement regarding a graviton (or, quantum mechanical treatment correlating with 4G4).

4.2.3. Conservation of lepton number minus baryon number

We explore the notion of conservation of lepton number minus baryon number.

Equation (53) shows a quantity, N_{L-B} (or, lepton number minus baryon number). The symbol L correlates with the ongoing theory notion of lepton number. The symbol B correlates with the ongoing theory notion of baryon number. For a matter lepton, $L=+1$ and $B=0$. For an antimatter lepton, $L=-1$ and $B=0$. For a matter quark, $L=0$ and $B=1/3$. For an antimatter quark, $L=0$ and $B=-1/3$. Other than possibly for charged T-family bosons, for simple bosons and root forces, $0=L=B=N_{L-B}$. In ongoing theory, N_{L-B} is a conserved quantity. Equation (53) defines the symbol ι_{3LB}.

$$N_{L-B} = L - B \text{ and } \iota_{3LB} = 3(N_{L-B}) \tag{53}$$

We correlate, with ι_{3LB}, the two-element term 3LB number. The four-element term conservation of 3LB number pertains.

Proposed theory includes the notion of conservation of ι_{3LB}.

Each of equations (54), (55), (56), and (57) shows an interaction that would involve the $2\mathrm{T}^{+1}$ simple particle; transform a matter quark into another simple fermion; and conserve ι_{3LB}, L, and B. Here, for fermions, the notation $1\Phi^{\iota Q}_{\iota_{3LB};3L,3B}$ pertains. Here, for bosons, equations show notation of the form $2\Phi^{\iota Q}_{\iota_{3LB};3L,3B}$ and might suggest that each of L, conservation of L, B, and conservation of B is appropriate. However, discussion related to equation (58) indicates that none of L, conservation of L, B, and conservation of B is relevant to the relevant boson physics. Each of the first three equations correlates with transforming a matter quark into an antimatter simple fermion. Among those equations, the notion of $2\mathrm{T}^{+1}_{-2;\_,\_}$ pertains. There are two forms of $2\mathrm{T}^{+1}_{-2;\_,\_}$, namely $2\mathrm{T}^{+1}_{-2;0,+2}$ and $2\mathrm{T}^{+1}_{-2;-3,-1}$. The two forms, $2\mathrm{T}^{+1}_{-2;0,+2}$ and $2\mathrm{T}^{+1}_{-2;-3,-1}$, show the same ι_{3LB}, but do not correlate with the same L or with the same B. The fourth equation correlates with transforming a matter quark into a matter fermion. Each one of the second, third, and fourth equations might correlate with the ongoing theory notion of leptoquark.

$$1\mathrm{Q}^{+2}_{-1;0,+1} \rightarrow 1\mathrm{Q}^{+1}_{+1;0,-1} + 2\mathrm{T}^{+1}_{-2;0,+2} \tag{54}$$

Table 45: Values, for objects, of ι_{3LB}, L, and B

Concepts
• For free objects, the minimum magnitudes of some non-zero quantities are $\lvert q_\epsilon \rvert$ for charge and three for $\lvert \iota_{3LB} \rvert$.
• For unfree objects, the minimum magnitudes of some non-zero quantities are $\lvert q_\epsilon \rvert/3$ for charge and one for $\lvert \iota_{3LB} \rvert$.
• Each of the quantities charge, ι_{3LB}, L, and B is additive with respect to components of a multicomponent object.

Table 46: Changes, to representations, to reflect conservation of ι_{3LB} and to reflect somewhat conservation laws regarding baryon number and lepton number

(a) Field-centric representation and interaction-centric representation for changes regarding non-zero charge T-family bosons and regarding simple fermions

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA					$\pi_{0,@_{-1}}$				
SA					$\pi_{0,@_{-1}}$				

(b) Field-centric representation and interaction-centric representation for changes regarding other simple particles and regarding root forces

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA					$\pi_{0,@_{-1}}$				
SA									

$$1\mathrm{Q}^{+2}_{-1;0,+1} + 2\mathrm{T}^{+1}_{-2;-3,-1} \rightarrow 1\mathrm{C}^{+3}_{-3;-3,0} \tag{55}$$

$$1\mathrm{Q}^{-1}_{-1;0,+1} + 2\mathrm{T}^{+1}_{-2;-3,-1} \rightarrow 1\mathrm{N}^{0}_{-3;-3,0} \tag{56}$$

$$1\mathrm{Q}^{-1}_{-1;0,+1} + 2\mathrm{T}^{+1}_{+4;+3,-1} \rightarrow 1\mathrm{N}^{0}_{+3;+3,0} \tag{57}$$

More generally, equation (58) shows possible charged 2T simple bosons that convert simple fermions between matter and antimatter. Equation (59) shows possible 2T charged simple bosons that would not convert simple fermions between matter and antimatter. For each of the four possible charged simple bosons, the notation does not show a number $3L$ and does not show a number $3B$.

$$2\mathrm{T}^{\pm1}_{\mp2;} \text{ and } 2\mathrm{T}^{\pm2}_{\pm2;} \tag{58}$$

$$2\mathrm{T}^{\pm1}_{\pm4;} \text{ and } 2\mathrm{T}^{\pm2}_{\mp4;} \tag{59}$$

This essay de-emphasizes the possibilities that equation (59) shows.

Regarding equation (58), each of the four possibilities, of which one possibility is $2\mathrm{T}^{+1}_{-2;}$, correlates with two possible L-and-B pairs. We assume that charged 2T bosons are ambiguous with respect to each of L and B.

Generally, interactions conserve ι_{3LB}, do not necessarily conserve L, and do not necessarily conserve B. Non-conservation of L and B correlates with involvement - in the interactions - of $2\mathrm{T}^{\pm}$ bosons. One might deploy the five-word phrase somewhat conservation of lepton number and the five-word phrase somewhat conservation of baryon number.

Table 45 notes concepts regarding values, for objects, of ι_{3LB}, L, and B. Here, we consider that a proton or other hadron with no more than three quarks can correlate with the notion of free. The following notion also pertains. For a hadron-like particle that includes no more than three quarks and arcs, the restrictions to integer charge and integer baryon number preclude the presence of both quarks and arcs.

Table 46 shows changes, to representations, to reflect conservation of lepton number minus baryon number. Non-zero charge T-family bosons provide the only way to change either the lepton number or the baryon number of a fermion.

Table 47: Field-centric representation and interaction-centric representation aspect that reflects conservation of charge

Side	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16
TA		$\pi_{0,@_{-1}}$							
SA									

Table 48: Possible correlations between 0G solutions and free simple bosons that do not belong to the G-family of forces (with $j_{\lambda\in\Gamma}$ denoting the number of elements in the Γ in $\Sigma\text{G}\Gamma$)

Solution	Boson	Subfamily	$j_{\lambda\in\Gamma}$
0G$\emptyset$	0I (or aye)	0I	0
0G246	W	2W	3
0G268	Z	2W	3
0G2468	H^0 (or, Higgs)	0H	4

4.2.4. Conservation of charge

Table 47 reiterates an aspect, of representations, that reflects conservation of charge. All interactions conserve charge.

4.2.5. Correlations between simple bosons and G-family solutions

Table 48 posits correlations between all free simple bosons and the G-family $\Sigma = 0$ solutions that correlate with table 40. We posit that the W boson correlates with 0G246. (Note the span, which table 64a shows, of one for 4G246.) We posit that the Z boson correlates with 0G268. (Note the span, which table 64b shows, of six for 4G268.) The correlations for the W and Z bosons correlate with the notion of isomers of charged simple particles. (See discussion related to equation (130).) To the extent that table 48 pertains, G-family solutions point to all free simple bosons and all components of G-family forces. The symbol $j_{\lambda\in\Gamma}$ denotes the number of elements in the Γ in $\Sigma\text{G}\Gamma$. Elsewhere, we correlate $j_{\lambda\in\Gamma}$ with mass. (See discussion regarding table 52.)

Each of the $\Sigma = 0$ items that table 40 lists has a TA-side symmetry of none or $SU(3)$. Each one of the aye, W, Z, and Higgs bosons can interact with simple particles.

Table 48 shows all 0G solutions for which the largest value of λ is eight.

The next opportunity for 0G solutions correlates with the range $2 \leq \lambda \leq [\![14]\!]$. For that range, there are four solutions that correlate with 0G. Equation (60) shows the solutions. Here, we do not put brackets around values of λ that exceed eight. Equation (61) shows the same four solutions, but with a different grouping. For each of equation (60) and equation (61), the first item (and, hence the first two solutions) correlates with the expression 0 ± 0.

$$(14-10-6+2) \pm (12-8-4);\;\; 14-12-10+8+6-4-2;\;\; 14-12+10-8-6+4-2 \tag{60}$$

$$(14-12-10+8) \pm (6-4-2);\;\; 14+12-10-8-6-4+2;\;\; 14-12+10-8-6+4-2 \tag{61}$$

Proposed theory suggests that $2\text{T}^{0''}$ and $2\text{T}^{0'}$ correlate with two solutions that equation (60) shows. The other two solutions that the equation shows would correlate with 2T^2 and 2T^1. We use these results to estimate masses for 2T simple bosons. (See discussion related to equation (126).)

4.2.6. Refraction and similar phenomena

We explore modeling regarding contexts in which a zerolike rest mass elementary particle interacts with its surroundings. (This exploration correlates with PS modeling.) Known examples include photons in refractive media. We explore the notion that similar considerations pertain for neutrinos and for gluons.

Table 49 shows four mathematically possible cases. The case of free and $n_{TA0} = 0$ pertains for G-family forces. The case of free and $n_{TA0} = -1$ pertains for (at least) neutrinos. The case of unfree and $n_{TA0} = -1$ pertains for gluons. The case of unfree and $n_{TA0} = 0$ is not necessarily physics-relevant. (Proposed theory does not predict the existence of unfree simple particles for which $n_{TA0} \neq n_{SA0}$.) The equation $n_{SA0} = -1$ correlates with the notion of zerolike rest mass.

We posit that PS ALG modeling extends to include notions of non-isotropic harmonic oscillators.

Table 49: Cases - for zerolike rest mass elementary particles - for modeling regarding refraction and similar phenomena (with the symbol NR denoting the three-word term not physics relevant)

n_{SA0}	n_{TA0}	Free/unfree	Example
-1	0	Free	Photons
-1	-1	Free	Neutrinos
-1	-1	Unfree	Gluons
-1	0	Unfree	NR

Each of equations (62) and (63) offers, based on using the range $-1 < n_{SA0} < 0$, a possible basis for modeling regarding a zerolike rest mass elementary particle. (We contrast $-1 < n_{SA0} < 0$ with $n_{SA0} < -1$. Uses of the expression $n_{SA0} < -1$ pertain for applications related to components of G-family forces, for some modeling regarding gluons, and not necessarily for other purposes. Regarding the applications related to components of G-family forces, see table 40. Regarding the gluon-related modeling, see table 50.) Here in the sense of KS modeling, E denotes energy, $\overrightarrow{P}$ denotes momentum, $\overrightarrow{v}$ denotes velocity, $<\_>$ denotes the expected value of _, $P^2 =< \overrightarrow{P} \cdot \overrightarrow{P} >$, and $v^2 =< \overrightarrow{v} \cdot \overrightarrow{v} >$. Here, double-entry bookkeeping pertains to models for which at least one of the PS ALG TA-side set of harmonic oscillators and the PS ALG SA-side set of harmonic oscillators is not necessarily isotropic.

$$n_{SA0} = -c^2P^2/E^2 \tag{62}$$

$$n_{SA0} = -v^2/c^2 \tag{63}$$

For each of the three physics-relevant cases, each of equations (62) and (63) adds a positive amount to A_{SA}^{ALG}. For each of the three cases, we posit that, for each relevant oscillator, $-1 \leq n_{\_} \leq 0$ pertains.

For the case of free and $n_{TA0} = 0$, for each relevant TA-side oscillator, $n_{TA\_} = 0$. One cannot satisfy double-entry bookkeeping by adding to A_{TA}^{ALG}. Satisfying double-entry bookkeeping correlates with subtracting something positive from at least one of the SA-side oscillators that correlate with $SU(2)$ kinematics symmetries. Proposed theory correlates this subtracting with aspects of refraction. Ongoing theory correlates the expression c/v (or, $(c^2/v^2)^{1/2}$) with the two-word term refractive index (or, with the three-word term index of refraction). This case correlates with refraction of light.

For the case of free and $n_{TA0} = -1$, for each relevant SA-side oscillator, $n_{SA\_} = -1$. One cannot satisfy double-entry bookkeeping by adding to A_{SA}^{ALG}. Satisfying double-entry bookkeeping correlates with adding something positive to at least one of the two TA-side oscillators that correlate with $SU(2)$ somewhat conservation of generation symmetry or to at least one of the TA-side oscillators that correlate with conservation of energy symmetry. This case correlates with neutrino oscillations.

For the case of unfree and $n_{TA0} = -1$, discussion is not as straightforward as is discussion for the other two physics-relevant cases. Discussion related to table 50 and table 51 pertains regarding gluons. (See discussion related to equation (64).)

4.2.7. Gluon interactions

We explore modeling regarding gluons and modeling regarding U-family interactions.

The 2U solutions correlate with gluons. Here, we provide details correlating with PS ALG modeling and with the $\kappa_{-1,-1,-1}$ interaction centric symmetry that correlates with the relevant ongoing theory $SU(3)$ symmetry.

We denote the three relevant oscillators by the symbols SA0, SAo, and SAe. (See table 32.) Here, o denotes a positive odd integer and e denotes the positive even integer that is one greater than o.

Table 50 shows details regarding 2U solutions. The expression $\kappa_{-1,-1,-1}$ correlates with $A_{TA}^{ALG} = -3/2$. Each one of the six SA-side $\pi_{0,-1,-2}$ permutations pertains. Each permutation correlates with $A_{TA}^{ALG} = -3/2$. Table 50 suggests notation for gluon-related solutions. The set of three permutations for which 0, -1, and -2 appear in cyclic order correlates with interactions with one of unfree matter simple fermions and unfree antimatter simple fermions. The set of the other three permutations correlates with the other choice between unfree antimatter simple fermions and unfree matter simple fermions. Regarding unfree matter simple fermions, each of oscillators SAe, SAo, and SA0 correlates with a color charge. Relative to an ongoing theory standard representation for gluons, one of SAe and SAo correlates with the color red, the other of SAe and SAo correlates with the color blue, and SA0 correlates with the color green.

Table 50: Interaction-centric representation for 2U solutions

Solution	SA0	SAo	SAe
2Ue0	0	-1	-2
2Uoe	-1	-2	0
2U0o	-2	0	-1
2Uo0	0	-2	-1
2U0e	-2	-1	0
2Ueo	-1	0	-2

Table 51: Interaction-centric representation for 2U erase or paint ground states

Ground state	SA0	SAo	SAe
2U0 $=$ 2Ue0$\oplus$2Uo0	0	-1	-1
2Ue $=$ 2Uoe$\oplus$2U0e	-1	-1	0
2Uo $=$ 2U0o$\oplus$2Ueo	-1	0	-1

Ongoing theory correlates gluons with zero mass and with phenomena that proposed theory correlates with 2U solutions. We consider 2U phenomena regarding dynamics inside hadron-like particles. In such a frame of reference, proposed theory modeling based on equations (64) and (65) pertains. (Perhaps, compare with discussion, pertaining to refraction, regarding equations (62) and (63).) Here, the notation $a \leftarrow b$ correlates with the three-element phrase a becomes b (or, with the notion that b replaces a). Here, the symbol $\rightarrow$ denotes, in the mathematical sense of a limit, the two-word phrase goes to.

$$(n_{TA0} = -1) \;\leftarrow\; (n_{TA0} = -v^2/c^2 \rightarrow 0^-) \tag{64}$$

$$(n_{SA\_} = -2) \;\leftarrow\; (n_{SA\_} = (-1 - v^2/c^2) \rightarrow (-1)^-) \tag{65}$$

Equations (64) and (65) correlate with boson behavior for gluons. In effect, modeling of excitations and de-excitations correlates with a ground state that correlates with equation (66) and with, for the appropriate $n_{SA\_}$, equation (67). (See tables 50 and 51.) Excitation correlates with erasing a color charge (from, for example, a quark) and de-excitation correlates with painting a color charge (on, for example, a quark). (See discussion related to table 50.) The expressions $n_{TAo} = -1$ and $n_{TAe} = -1$ correlate with a $\kappa_{-1,-1}$ (or, $SU(2)$) symmetry. That symmetry correlates with somewhat conservation of fermion generation. (See discussion - related to the possibility for strong interaction CP violation - in table 85.)

$$n_{TA0} = 0 \tag{66}$$

$$n_{SA\_} = 0 \tag{67}$$

Table 51 shows results of applying, to items in table 50, aspects correlating with equations (66) and (67). Table 51 shows three erase or paint ground states.

A gluon correlates with a weighted sum of two or three erase-and-paint pairs. For each pair, the erase part correlates with, in effect, an ability to erase, from the unfree simple fermion that absorbs the gluon, a color. The paint part correlates with, in effect, an ability to paint, on to the unfree simple fermion that absorbs the gluon, a color. The value $n_{SA\_} = 0$ denotes an ability for a gluon to erase or paint the color charge correlating with the SA_ oscillator. Equation (68) shows an ongoing theory representation for one of the eight gluons. (Out of the eight gluons, this is the only one that involves three erase-and-paint pairs. Each of the other seven gluons involves two erase-and-paint pairs.) Regarding table 51, we make the following correlations. (Alternatively, without loss of generality or results, one might reverse the roles of SAe and SAo.) The symbol r correlates with painting the color red and with a painting application of 2Ue. The symbol $\bar{r}$ correlates with erasing the color red and with an erasing application of 2Ue. The symbol b correlates with painting the color blue and with a painting application of 2Uo. The symbol $\bar{b}$ correlates with erasing the color blue and with an erasing application of 2Uo. The symbol g correlates with painting the color green and with a painting application of 2U0. The symbol $\bar{g}$ correlates with erasing the color green and with an erasing application of 2U0.

$$(r\bar{r} + b\bar{b} - 2g\bar{g})/(6)^{1/2} \tag{68}$$

Table 52: Rest energies for known non-zero-mass simple bosons

Φ	S	Symbol	Name	Experimental mc^2 (GeV)	Calculated N	Calculated mc^2 (GeV)	Difference (standard deviations)
W	1	2W1, 2W2	W	80.379 ± 0.012	7	80.420	≈ 3.4
W	1	2W0	Z	91.1876 ± 0.0021	9	91.1876	-
H	0	0H0	H^0	125.18 ± 0.16	17	125.33	≈ 1.0

4.2.8. A series of formulas for lengths, including the Planck length

We discuss three related formulas that produce lengths. The formulas correlate with aspects pertaining to elementary particles and to other objects.

We suggest a series of formulas for lengths. KS modeling pertains. Equation (69) correlates with the Schwarzschild radius for an object of mass m. Equation (70) correlates with the Planck length and does not depend on m. Equation (71) includes a factor of m^{-1}. When applied to the mass of 2W bosons, equation (71) correlates somewhat with the range of the weak interaction. When applied to the mass of a charged pion, equation (71) correlates somewhat with a range for the component, of the strong interaction, that has bases in gluons. (That component binds the two quarks that exist within the pion.) Equation (72) shows the ratio between successive formulas. Equation (73) shows, for the electron, the ratio correlating with equation (72).

$$R_4(m) = (G_N)^1 m^1 \hbar^0 c^{-2} 2^1 \tag{69}$$

$$R_2(m) = (G_N)^{1/2} m^0 \hbar^{1/2} c^{-3/2} 2^0 \tag{70}$$

$$R_0(m) = (G_N)^0 m^{-1} \hbar^1 c^{-1} 2^{-1} \tag{71}$$

$$(G_N)^{-1/2} m^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \tag{72}$$

$$(G_N)^{-1/2} (m_\epsilon)^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \approx 1.1945 \times 10^{22} \tag{73}$$

4.3. Predictions and correlations regarding properties of elementary particles

We explore masses and other properties of elementary particles.

4.3.1. The masses of the W, Z, Higgs, and aye bosons

We explore relationships between masses of the 2W (or, W and Z), 0H, and 0I bosons.

Table 52 shows, in the column for which the label includes the word experimental, rest energies for the known non-zero-mass simple bosons. (See reference [6].) Notation such as 2W1 and 0H0 extends the notion of Γ - as pertaining to oscillators relevant in ALG models for G-family solutions - to notions of Γ for ALG models relevant to elementary particle families other than the G family. The most accurately known of the three masses is the mass of the Z boson. (Rest energy equals mass times c^2.) The column for which the label includes the word calculated shows results based on equation (74) and on assuming that nine correlates with the square of the mass of the Z boson. Equation (75) shows the size of one unit. The related mass is $\approx 30.396\text{GeV}/c^2$. In table 52, the column for which the label includes the word difference shows the number of standard deviations (regarding the experimental results) by which the calculated mass differs from the nominal experimental mass.

$$(m_{\mathrm{H}^0})^2 : (m_{\mathrm{Z}})^2 : (m_{\mathrm{W}})^2 :: 17 : 9 : 7 \tag{74}$$

$$\approx 9.239 \times 10^2 (\text{GeV}/c^2)^2 :: 1 \tag{75}$$

We discuss approximate ratios for the squares of masses of the Higgs, Z, and W bosons. Based on the ratios (of squares of masses) that equation (74) shows, the possibly least accurately suggested mass is that of the W boson. Equation (74) correlates with a number that is within four standard deviations of the nominal mass of the W boson. (See table 52.) Proposed theory correlates the numbers in equation (74) with, respectively, the expressions $17 = 17$, $9 = 10 - 1 - 0$, and $7 = 10 - 1 - 2$. Each of zero, one, two, 10, and 17 correlates with the value of $D + 2\nu''$ for a PDE solution for which $D'' = 2$. (See table 18e.)

The following correlations pertain regarding relative squares of masses. (See table 48 and table 18e.) For each of the W, Z, and 0H bosons, one positive term pertains. That term correlates with the value of $D+2\nu''$ for which $\sigma'' = -1$ and $S'' = j_{\lambda\in\Gamma}$ pertain. For the W and Z bosons, a negative term - minus one - pertains. That term correlates with the negative of the value of $D+2\nu''$ for which $\sigma'' = -1$ and $S'' = 0$ pertain. That term might correlate with spin-one. For the W boson, another negative term - minus 2 - also pertains. That term correlates with the negative of the value of $D + 2\nu''$ for which $\sigma'' = -1$ and $S'' = 2$ pertain. That term might correlate with the magnitude of a nominal magnetic dipole moment (or that term might correlate with a charge of magnitude equal to the magnitude of the charge of the electron).

To the extent that m_{W} does not exactly comport with equation (74), proposed theory suggests the possibility that an anomalous moment pertains. The W boson has non-zero charge, non-zero nominal magnetic dipole moment, and non-zero mass. We suggest that the anomalous moment might correlate mostly with the 6G24 solution. (Compare with discussion related to equation (176).) The contribution of minus two (compared to the Z boson) that equation (74) implies might correlate with each of 2G24 and nominal magnetic dipole moment.

We explore concepts regarding 0G$\emptyset$.

One might assume that the 0I solution correlates with $S'' = j_{\lambda\in\Gamma} = 0$. (See table 48.) The result $S'' = 0$ correlates with a relative square of mass of one. (See table 18e.) The mass would approximately equal 30.4GeV$/c^2$. We know of no observations that would support the existence of such a particle. We note that, for each of the W, Z, and Higgs bosons, the 0GΓ solution has $n_{TA0} = 0$. (See table 40.) For the 0G$\emptyset$ solution, $n_{TA0} = -1$.

For each $\Sigma \geq 2$ ΣGΓ solution that nature embraces, the mass is zero. We suggest that each solution correlates with $\sigma'' = +1$ and $S'' = 1$. Per table 18e, the relative mass correlates with $D + 2\nu'' = 0$.

We suggest that the 0G$\emptyset$ solution correlates with $\sigma'' = +1$ and $S'' = 1$. The notion of zero mass pertains.

4.3.2. A prediction for the tauon mass

Equation (76) defines the symbol β'. Equation (77) defines β. Here, m denotes mass, τ denotes tauon, ϵ denotes electron, q denotes charge, ε_0 denotes the vacuum permittivity, and G_N denotes the gravitational constant. Equation (78) possibly pertains. Equation (78) predicts a tauon mass with a standard deviation of less than one eighth of the standard deviation correlating with the experimental result. (For relevant data, see reference [7].) Equation (81) shows an approximate value of β that we calculate, using data that reference [7] shows, via equation (77).) Elsewhere, we correlate the numbers four and three in the left-hand side of equation (77) with a notion of channels. (See discussion related to equation (108) and discussion related to equation (111).)

$$\beta' = m_\tau / m_\epsilon \tag{76}$$

$$(4/3) \times \beta^{12} = ((q_\epsilon)^2/(4\pi\varepsilon_0))/(G_N(m_\epsilon)^2) \tag{77}$$

$$\beta' = \beta \tag{78}$$

$$m_{\tau,\ \mathrm{calculated}} \approx (1776.8400 \pm 0.0115)\ \mathrm{MeV}/c^2 \tag{79}$$

$$m_{\tau,\ \mathrm{experimental}} \approx (1776.86 \pm 0.12)\ \mathrm{MeV}/c^2 \tag{80}$$

$$\beta \approx 3477.1891 \pm 0.0226 \tag{81}$$

To the extent that equation (78) correlates with nature, a more accurate experimental determination of G_N or m_τ could predict a more accurate (than experimental results) value for, respectively, m_τ or G_N.

Proposed theory does not, as yet, suggest a relationship - perhaps similar to equation (77) - regarding the ratio m_μ/m_ϵ. Here, μ denotes muon. (See discussion related to equations (95) and (96).)

Table 53: Non-zero charge simple fermions and values of $\log_{10}(m/m_\epsilon)$

Charged lepton and value	Quark and value	Quark and value
electron: 0.0	up: 0.6	down: 1.0
	strange: 2.3	charm: 3.4
muon: 2.3	bottom: 3.9	top: 4.5
tauon: 3.6		

Table 54: Approximate rest energies (in MeV) for quarks and charged leptons

		M'	3	2	1
		Charge	$-1 \cdot \lvert q_\epsilon \rvert$	$+(2/3) \cdot \lvert q_\epsilon \rvert$	$-(1/3) \cdot \lvert q_\epsilon \rvert$
M''	Legend				
0	name		electron	up	down
0	data		$(0.511 \text{ to } 0.511)\times 10^0$	$(1.8 \text{ to } 2.7)\times 10^0$	$(4.4 \text{ to } 5.2)\times 10^0$
0	calculation		$m_\epsilon c^2 \approx 0.511\times 10^0$	$m_u c^2 \approx 2.2\times 10^0$	$m_d c^2 \approx 4.8\times 10^0$
1	name			charm	strange
1	data			$(1.24 \text{ to } 1.30)\times 10^3$	$(0.92 \text{ to } 1.04)\times 10^2$
1	calculation			$m_c c^2 \approx 1.263\times 10^3$	$m_s c^2 \approx 0.938\times 10^2$
2	name		muon	top	bottom
2	data		$(1.06 \text{ to } 1.06)\times 10^2$	$(1.56 \text{ to } 1.74)\times 10^5$	$(4.15 \text{ to } 4.22)\times 10^3$
2	calculation		$m_\mu c^2 \approx 1.06\times 10^2$	$m_t c^2 \approx 1.72\times 10^5$	$m_b c^2 \approx 4.18\times 10^3$
3	name		tauon		
3	data		$(1.777 \text{ to } 1.777)\times 10^3$		
3	calculation		$m_\tau c^2 \approx 1.777\times 10^3$		

4.3.3. The masses of quarks and charged leptons

Table 53 supports the concept that a formula can link the masses of the six quarks and three charged leptons. The table shows values of $\log_{10}(m/m_\epsilon)$. The symbol m denotes an approximate mass. The symbol m_ϵ denotes the mass of the electron. (Discussion regarding table 54 points to the source for relevant data.) For each column, the value increases as one moves downward. For each row that shows more than one value, the value increases as one moves rightward. For each quark column, the charge of the quark in the second row is the same as the charge of the quark in the third row and is not the same as the charge of the quark in the first row.

Table 54 shows, regarding the rest energies of quarks and charged leptons, data that people report and numbers that we calculate via equation (84). Below, we discuss the table and the data before we discuss the equation and the calculations. Equation (84) results from fitting data. This essay does not show theory that would generate equation (84).

Regarding the placement of quarks, some placements in table 54 differ from the respective placements in table 53. In table 54, the variable M' and the columns related to quarks reflect the concept that some aspects regarding mass correlate with charge. In table 54, for each quark column, each of the charge of the quark in the second row and the charge of the quark in the third row is the same as the charge of the quark in the first row.

The data in table 54 reflect information from reference [6].) For each particle other than the top quark, reference [6] provides one estimate. For the top quark, reference [6] provides three estimates. For each quark, table 54 shows a data range that runs from one standard deviation below the minimum nominal value that reference [6] shows to one standard deviation above the maximum nominal value that reference [6] shows. Each standard deviation correlates with the reported standard deviation that correlates with the nominal value. For charged leptons (that is, for $M' = 3$), the table does not completely specify accuracy regarding ranges.

The following concepts pertain regarding developing equation (84). Equation (82) produces a meaningful value for $m(3,1)$. (No elementary particle correlates with $M'' = 3$ and $M' = 1$.) For each $0 \leq M'' \leq 3$, equation (83) produces a meaningful value of $m(M'', 3/2)$. (No elementary particle correlates with $M' = 3/2$. Aspects of equations (84), (88), and (89) correlate with the concept that $m(M'', 3/2)$ values have meaning.) Within each row for which $M'' \neq 3$, the fine-structure constant plays a role regarding linking the masses that pertain for that row. (Aspects of equation (84) comport with this role.)

$$m(3,1)m(3,2) = m(3,0)m(3,3) \tag{82}$$

$$(m(M'',3/2))^2 = m(M'',2)m(M'',1) \tag{83}$$

The following concepts pertain regarding developing and using equation (84). We use equation (77) to calculate β. Equation (84) calculates the same value of m_τ that equation (79) calculates.

Equation (84) shows a formula that approximately fits the masses of the six quarks and three charged leptons. The formula includes two integer variables and seven parameters. One integer variable, M'', correlates somewhat with generation. For the electron and each of the six quarks, the generation equals $M''+1$. For each of the muon and the tauon, the generation equals M''. The other integer variable, M', correlates with magnitude of charge. The seven parameters can be m_ϵ, m_μ (or, the mass of a muon), β, α, $d'(0)$, $d'(1)$, and $d'(2)$. The symbol α denotes the fine-structure constant. (See equation (85).) Here, $d'(k)$ pertains regarding generation-$(k+1)$ quarks. For each generation, the number $d'(k)$ correlates with the extent to which the two relevant quark masses do not equal the geometric mean of the two quark masses. (See equation (83).) Regarding charged leptons, $M'=3$, the term $1-\delta(M',3)$ is zero, and the factor - in equation (84) - that includes the fine-structure constant is one. (See equation (88).)

$$m(M'',M') = m_\epsilon \times (\beta^{1/3})^{M''+(j''_{M''})d''} \times (\alpha^{-1/4})^{(1-\delta(M',3))\cdot((3/2)\cdot(1+M'')+(j'_{M'})d'(M''))} \tag{84}$$

$$\alpha = ((q_\epsilon)^2/(4\pi\varepsilon_0))/(\hbar c) \tag{85}$$

$$j''_{M''} = 0, +1, -1, 0 \text{ for, respectively, } M'' = 0,1,2,3 \tag{86}$$

$$d'' = (2 - (\log(m_\mu/m_\epsilon)/\log(\beta^{1/3}))) \approx 3.840679 \times 10^{-2} \tag{87}$$

$$1-\delta(M',3) \text{ equals } 0, \text{ for } M'=3, \text{ and equals } 1, \text{ otherwise} \tag{88}$$

$$j'_{M'} = 0, -1, 0, +1 \text{ for, respectively, } M' = 3,2,3/2,1 \tag{89}$$

$$d'(0) \sim 0.318 \tag{90}$$

$$d'(1) \sim -1.057 \tag{91}$$

$$d'(2) \sim -1.5091 \tag{92}$$

$$m(1,3) \approx 8.59341 \text{MeV}/c^2 \tag{93}$$

In equation (84), the factor 3/2 correlates with the average of $M'=2$ and $M'=1$ and correlates with equation (83). (Note the appearance of $M'=3/2$ in equation (89). The concepts of $M'=3/2$ and $m(M'',3/2)$ are useful mathematically, though not necessarily directly relevant to physics.) Regarding equations (90), (91), and (92), we choose values that fit data. (The relative signs of the three $d'(\_)$ reflect the differences - regarding the positioning of quarks - between table 53 and table 54.) Regarding each charged lepton, our calculations fit data to more significant figures than the numbers in table 54 show. Regarding the tauon, our calculation correlates with a mass that may be more accurate, and more accurately specified, than the mass that references [6] and [7] show. (See equations (79) and (80).)

Table 55 shows ranges of $d'(M'')$ that fit the data ranges that table 54 shows for quark masses. (See equations (90), (91), and (92).) To the extent that people measure quark masses more accurately, people might find relationships between $d'(0)$, $d'(1)$, and $d'(2)$, and thereby reduce the number of parameters to less than seven.

Table 56 shows possible rest energies for quarks. For each row, we assume the value that the third column shows for the ratio that the second column defines. The value implies the number that the column labeled $d'(M'')$ shows. The six estimated quark rest energies might not be incompatible with

Table 55: Ranges of $d'(M'')$ that fit the data ranges that table 54 shows for quark masses

Symbol	Minimum (approximate)	Nominal (table 54)	Maximum (approximate)
$d'(0)$	0.251	0.318	0.386
$d'(1)$	-1.072	-1.057	-1.042
$d'(2)$	-1.5158	-1.5091	-1.5024

Table 56: Possible estimates for quark rest energies

M''	Ratio	Value	$d'(M'')$	$m_{M'=2}c^2$ (MeV)	$m_{M'=1}c^2$ (MeV)
0	$m_\epsilon m_d/(m_u)^2$	1/2	$\approx$0.31216454	$m_u c^2 \approx 2.203\times 10^0$	$m_d c^2 \approx 4.748\times 10^0$
1	$m(1,3)m_c/(m_s)^2$	1	-1	$m_c c^2 \approx 1.178\times 10^3$	$m_s c^2 \approx 1.006\times 10^2$
2	$m_\mu m_t/(m_b)^2$	1	$-3/2$	$m_t c^2 \approx 1.695\times 10^5$	$m_b c^2 \approx 4.322\times 10^3$

experimental results that table 54 shows. To the extent that table 56 comports with nature, fitting the masses of six quarks and three charged leptons requires at most five parameters. The five parameters can be m_ϵ, m_μ, β , α, and $d'(0)$. To the extent that table 56 comports with nature, equation (94) pertains.

$$(m_s)^2 m_\mu = m_\epsilon m_\tau m_c \tag{94}$$

The charge q_ϵ correlates with β via equation (77). The charge q_ϵ appears in α, via equation (85). Based on equations (74) and (84) and based on modeling for the G-family, proposed theory entangles concepts related to mass and concepts related to charge more deeply than does ongoing theory.

Equations (95) and (96) explore the possibility for a relationship - perhaps similar to equation (77) - regarding the ratio m_μ/m_ϵ or the ratio m_τ/m_μ. Equation (97) shows the result that we compute based on data from reference [6]. Equation (98) shows the result that we compute based on data from reference [7]. The main difference between the two sets of data lies in values of the gravitational constant, G_N. (The two references present the same value for the tauon mass. However, for each result, we use a tauon mass that is based on equation (77).) We do not explore possible significance for the notion that $1+x \approx 10/9$.

$$(1+x)\beta^{1/3} = m_\tau/m_\mu \approx m(1,3)/m_\epsilon \tag{95}$$

$$(1+x)^{-2}\beta^{1/3} \approx m_\mu/m(1,3) \tag{96}$$

$$x \approx 0.110033 \tag{97}$$

$$x \approx 0.110031 \tag{98}$$

4.3.4. The relative strengths of electromagnetism and gravity

We explore concepts that might correlate with the ongoing theory notion that the strength of gravity is much less than the strength of electromagnetism.

We use the expression in equation (99) to denote an interaction in which n_1 elementary fermions and n_2 elementary bosons interact to produce n_3 elementary fermions and n_4 elementary bosons. Here, each $\mathrm{n}\_$ is a non-negative integer.

$$\mathrm{n}_1\mathrm{f} + \mathrm{n}_2\mathrm{b} \to \mathrm{n}_3\mathrm{f} + \mathrm{n}_4\mathrm{b} \tag{99}$$

Below, the symbol 1f correlates with a non-zero-charge non-zero-mass simple fermion that pertains throughout the discussion. We confine our attention to $1\mathrm{f}+\mathrm{n}_2\mathrm{b}\to 1\mathrm{f}+\mathrm{n}_4\mathrm{b}$ interactions such that the exiting simple fermion is the same as the entering simple fermion. The simple fermion correlates (as do all simple fermions) with $S = 1/2$ (or, $\Sigma = 1$). Each symbol 1b denotes a boson. An outgoing boson is not necessarily the same as an incoming boson. Below, in a symbol of the form $1\mathrm{b}(\Sigma = \_)$, the expression $\Sigma = \_$ pertains for the boson.

We explore notions that might correlate with the ongoing theory notion that the strength of gravity is much less than the strength of electromagnetism.

To start this discussion, we assume that we can work within aspects of proposed theory that de-emphasize translational motion and multicomponent objects. We assume that conservation of angular momentum pertains.

The expression that equation (100) shows can correlate with interactions in which effects of the incoming boson correlate with 2G2. The interaction flips the spin orientation of the simple fermion. The exiting 1b correlates with zero spin. The spin-zero boson might be a 0I boson, which has no mass and no charge. (Another possibility might be relevant. The outgoing 1b might correlate with a boson ground state. We de-emphasize further discussion of this possibility.) The expression 1f+1b($\Sigma = 2$)→1f+1b($\Sigma = 4$) can also pertain.

$$\text{1f+1b}(\Sigma = 2) \rightarrow \text{1f+1b}(\Sigma = 0) \tag{100}$$

We extend this thought experiment to consider 4G4. The expression 1f+1b($\Sigma = 4$)→1f+1b($\Sigma = 0$) does not correlate with interactions. Conservation of angular momentum cannot pertain. Equation (101) can pertain. The expression 1f+1b($\Sigma = 4$)→1f+1b($\Sigma = 6$) can pertain.

$$\text{1f+1b}(\Sigma = 4) \rightarrow \text{1f+1b}(\Sigma = 2) \tag{101}$$

Equation (102) shows an analog to equation (100). The notation 2(1b($\Sigma = 0$)) correlates with two spin-zero bosons. In effect, equation (102) includes one use of equation (101) followed by one use of equation (100). Here, the implicit use of equation (100) implies that one needs to void the assumption of no relevance for multicomponent objects. (We de-emphasize the notion of voiding the assumption of no translational motion.)

$$\text{1f+1b}(\Sigma = 4) + \text{1b}(\Sigma = 0) \rightarrow \text{1f+2(1b}(\Sigma = 0)) \tag{102}$$

The notion that 1f+1b($\Sigma = 4$)→1f+1b($\Sigma = 0$) does not pertain for 4G4 might correlate with ongoing theory notions that the strength of gravity is much less than the strength of electromagnetism.

We explore the strengths - for the monopole components of interactions between pairs of charged leptons - of electromagnetism and gravity. We use KS Newtonian modeling.

For each of the three charged leptons, equation (103) characterizes the strength of the 2G2 component of electromagnetism. Here, r denotes the distance between the two particles. Here, F denotes the strength of the force. The equation correlates with a magnitude of the force. The interaction is repulsive. Equation (104) shows notation regarding the masses of charged leptons. (See discussion related to table 54.) Here, ϵ, μ, and τ denote respectively the electron, the muon, and the tauon. Here, the three in $m(M'', 3)$ correlates with charged leptons. (Compare with equation (84), which pertains to the masses of quarks and charged leptons.) Equation (105) repeats equation (76). Equation (106) shows results that reflect data. (We used data that reference [7] shows.) Equation (107) provides a 4G4 analog to the 2G2 equation (103). The symbol G_N denotes the gravitational constant. The equation correlates with a magnitude of the force. Here, the interaction is attractive.

$$r^2 F = (q_\epsilon)^2/(4\pi\varepsilon_0) \tag{103}$$

$$m(M'', 3) = m_x, \text{ for the pairs } M'' = 0, x = \epsilon;\ M'' = 2, x = \mu; \text{ and } M'' = 3, x = \tau \tag{104}$$

$$\beta' = m_\tau/m_\epsilon \tag{105}$$

$$m(M'', 3) = y_{M''}(\beta')^{M''} m_\epsilon, \text{with } y_0 = y_3 = 1 \text{ and } y_2 \approx 0.9009 \tag{106}$$

$$r^2 F = G_N (m(M'', 3))^2 \tag{107}$$

We pursue the concept that a value of M'' can point to a relationship between the strength of electromagnetism and the strength of gravity. Based on the definitions just above, equation (108) pertains within experimental errors regarding relevant data. (Reference [6] provides the data.) Here, in essence, the equation $y_{18} = y_0 = 1$ pertains. Equation (108) echoes equation (77).

$$((q_\epsilon)^2/(4\pi\varepsilon_0))/4 = (G_N(m(18, 3))^2)/3, \text{ with } m(18, 3) = (\beta')^6 m_\epsilon \tag{108}$$

Proposed theory interprets equation (108) as suggesting that the strength of 2G2 correlates with four so-called channels. (See discussion related to equation (111).) The interaction strength for each channel is $((q_\epsilon)^2/(4\pi\varepsilon_0))/4$. The strengths of the four channels combine by addition to yield the 2G2 strength $(q_\epsilon)^2/(4\pi\varepsilon_0)$. Similarly, the expression $G_N(m(M'', 3))^2/3$ characterizes the strength per channel for 4G4. Here, the strengths of the three channels add to yield $G_N(m(M'', 3))^2$.

The following notes pertain.

- Equation (108) links the ratio of two simple particle masses to a ratio of the strengths of two G-family force components.
- Equation (108) links the strength of 2G2 interactions to the strength of 4G4 interactions.
- Equation (109) correlates the fine-structure constant, α, with a function of the tauon mass and the electron mass. (Regarding the fine-structure constant, see equation (85).)

$$\alpha = ((q_\epsilon)^2/(4\pi\varepsilon_0\hbar c)) = (4/3) \times (m_\tau/m_\epsilon)^{12} G_N (m_\epsilon)^2/(\hbar c) \tag{109}$$

- Equation (110) characterizes a per channel ratio that pertains for interactions between two electrons.

$$(((q_\epsilon)^2/(4\pi\varepsilon_0))/4) \,/\, ((G_N(m_\epsilon)^2)/3) \approx 3.124 \times 10^{42} \tag{110}$$

4.3.5. Channels and interactions that involve elementary bosons

The notion of channels pertains to, at least, the relative strengths of the 2G2 component of 2G (or, electromagnetism) and 4G4 component of 4G (or, gravity). (See discussion related to equation (108).) We extrapolate. For 6G6, the number of channels is two. For 8G8, the number of channels is one. For $\Sigma = 10$ and $\Gamma = [\![10]\!]$, ΣGΓ would correlate with zero channels and no interactions.

Each of equation (111) and equation (112) provides a candidate formula for the number of channels that pertain for a G-family solution ΣGΓ.

$$5 - (\Sigma/2) \tag{111}$$

$$5 - (\lambda_{max}/2), \text{ with } \lambda_{max} = \max\{\lambda | \lambda \in \Gamma\} \tag{112}$$

Proposed theory correlates the notion of channels with interaction-centric modeling and not necessarily (especially for G-family physics) with field-centric modeling. Proposed theory uses equation (112) to compute numbers of channels.

Immediately below, we elaborate regarding the selection of equation (112) to compute numbers of channels. Then, we discuss other aspects regarding channels.

Equation (111) would correlate with excitations of the various ΣG. (See, for example, table 31.) Possible G-family forces correlating with $\Sigma \geq 10$ would not be relevant to physics. (See table 9.) Equation (112) provides another possibility. Equation (112) would correlate with tables 40 and 64c. Equation (112) correlates with kinematics symmetries. Possible G-family forces correlating with $\Sigma \geq 10$ could be relevant to physics. (See tables 9 and 64c.)

If we assume that equation (111) pertains regarding numbers of channels, for the purpose of G-family physics, the series 2G, 4G, ... ends with 8G. We would say that $\Sigma_{max} = 8$.

If we assume that equation (112) pertains regarding numbers of channels, for the purpose of G-family physics, the series 2G, 4G, ... can run through 20G. We would say that $\Sigma_{max} = 20$. Each one of 10G, 12G, ..., and 20G would interact with anomalous properties and not with nominal properties. Examples of ongoing theory nominal properties include charge (which correlates with a proposed theory component, 2G2, of 2G), nominal magnetic dipole moment (which correlates with a proposed theory component, 2G24, of 2G), and rest mass (which correlates with a proposed theory component, 4G4, of 4G). An example of an ongoing theory anomalous property is anomalous magnetic dipole moment. Detecting effects of ΣG for which $\Sigma \geq 10$ might be difficult. Interpretations of data do not seem to confirm or rule out 10G, 12G, 14G, 16G, 18G, and 20G bosons.

Table 57 summarizes notions regarding number of channels and regarding an upper limit regarding physics-relevant ΣG. Table 57a lists choices and appraises the choices. Table 57b shows one analysis regarding choices. We do not know of other data that would point to a best choice. The appraisals in table 57a reflect our thoughts, from a standpoint of theory. For one example, the notion that some neutrinos are Dirac fermions and some neutrinos are Majorana fermions seems less than fully appealing. For another example, table 57c explores correlations based on theory related to the G-family. The three-element term PEPT-centric conservation laws refers to, for example, conservation of charge and somewhat conservation of generation. The word fields pertains regarding modeling such as modeling that table 23 and table 31 show. The word interactions pertains regarding modeling such as the modeling that table 40 shows. For another example, discussion related to equation (27) might pertain. Ongoing theory correlates notions of particles with notions of interactions. Regarding table 57c, we embrace that ongoing theory correlation.

We explore notions regarding modeling for aspects of channels.

Table 57: Notions, regarding G-family physics, pertaining to numbers of channels and to an upper limit, Σ_{max}, regarding the series 2G, 4G, ..., Σ_{max}G

(a) Choices and discussion

Channels	Σ_{max}	Seemingly, ...
$5-(\lambda_{max}/2)$	20	The most likely case.
$5-(\lambda_{max}/2)$	8	Too limiting, but hard to distinguish observationally from the previous case.
$5-(\Sigma/2)$	20	Unlikely.
$5-(\Sigma/2)$	8	Not relevant.

(b) Possibilities, based on concepts related to observations and proposed theory pertaining to neutrinos

Two possibilities:
• If we assume that all three neutrinos are Dirac fermions, discussion related to equation (120) and table 59 points to the notion that the number of channels that pertains for each 8G2468x equals the number of channels that pertains for each 4G2468x. (Here, x can be either one of a and b.) Equation (112) would pertain. The number of channels is one. The factor of three in equation (120) correlates with the number of Dirac neutrinos. (See discussion regarding table 59.)
• If we assume that one of the three neutrinos is a Dirac fermion and that the other two neutrinos are Majorana fermions, discussion related to equation (120) and table 59 points to the notion that the number of channels that pertains for each 8G2468x equals one-third of the number of channels that pertains for each 4G2468x. Equation (111) would pertain. The factor of three in equation (120) correlates with a ratio of three 4G channels to one 8G channel.

(c) Aspects correlating with proposed theory

Channels	Σ_{max}	Modeling for PEPT channels correlates with modeling for ...	Modeling for PEPT-centric conservation laws correlates with modeling for ...
$5-(\lambda_{max}/2)$	20	Interactions	Fields
$5-(\lambda_{max}/2)$	8	Interactions	Interactions
$5-(\Sigma/2)$	20	Fields	Fields
$5-(\Sigma/2)$	8	Fields	Interactions

Proposed theory suggests that each channel can correlate with a unique blank (or, $\kappa_{0,-1}$) SA-side oscillator pair in the range from SA1-and-SA2 through SA9-and-SA10. (Perhaps note table 23 and table 31.) For this purpose, isotropic weighting pertains regarding oscillator pairs.

We discuss possible aspects of modeling for an interaction that de-excites a G-family boson. The following notions pertain.

The incoming state de-excites by transferring one unit of excitation to one of the channels. For that channel, equation (113) pertains.

$$\kappa_{0,-1} \to \kappa_{0,0} \tag{113}$$

The new SA-side $SU(2)$ symmetry adds an extra kinematics-conservation-like symmetry that cannot last. (See table 37.) The interaction includes converting the $\kappa_{0,0}$ symmetry to something, pertaining to the outgoing state, such as $\kappa_{0,-1}$. (Discussion above de-emphasizes the notion that, for each SA-side channel, one TA-side channel might exist. Double-entry bookkeeping suggests such a notion. An interaction would feature both a TA-side application of equation (113) and an SA-side application of equation (113). We think that the notion would not adversely impact results to which we allude.)

The above modeling is not incompatible with various proposed theory concepts, including the equal strengths of channels and the linear scaling, by number of channels, of interaction strengths. (See discussion regarding equation (77).)

We discuss elementary bosons other than G-family bosons.

Proposed theory suggests that either one of equation (111) and equation (112) computes the number of channels relevant to each simple boson. (For each of these bosons, equation (112) produces the same result that equation (111) produces.)

4.3.6. The relative strengths of 2G2, 2G24, W-boson, and other spin-one interactions

We explore a possible relationship between the strength of electromagnetism correlating with G-family monopole interactions with charge and the strength of electromagnetism correlating with G-family dipole interactions with nominal magnetic dipole moment.

We look at equation (102) in a context of ongoing theory. In ongoing theory, people can identify the implicit use of equation (100) with the notion of a single virtual photon. The single virtual photon correlates with an interaction strength factor of the fine-structure constant, α. (Elsewhere, we note such. See table 58.) Equation (114) provides one definition of the fine-structure constant. (Compare with equation (85), which provides a more common definition.)

$$\alpha = ((q_\epsilon/\hbar)^2/(4\pi\varepsilon_0 c)) \cdot \hbar \tag{114}$$

Equation (114) provides a link between the strength of 2G2 and the strength of 2G24. The equation includes the term $(q_\epsilon/\hbar)^2$. The Josephson constant K_J equals $2q_\epsilon/h$ (or, $q_\epsilon/(2\pi\hbar)$). Ongoing theory considers that magnetic flux is always an integer multiple of $h/(2q_\epsilon)$.

We explore a concept regarding ongoing theory notions that correlate with relationships between the strengths of the electromagnetic, weak, and strong interactions.

The expression 1f+1b($\Sigma = 2$)→1f+1b($\Sigma = 0$) can pertain for each of the following cases - 1b($\Sigma = 2$) correlates with 2G, 1b($\Sigma = 2$) correlates with 2W, and 1b($\Sigma = 2$) correlates (for a case in which unfree pertains for the 1f particle) with 2U. This notion might correlate with ongoing theory notions that correlate with relationships between the strengths of the electromagnetic, weak, and strong interactions.

4.3.7. The relative strengths of G-family spin-two, spin-three, and spin-four interactions

Equations (115) and (116) parallel equation (102). Equation (114) suggests that a factor of α might pertain regarding modeling the absorbing of a unit of spin. Compared to equation (102), equation (115) requires dissipation - from the incoming boson for which $\Sigma > 0$ - of one more unit - of magnitude $\hbar$ - of spin. For a step from equation (102) to equation (115), a factor of α might pertain. Compared to equation (115), equation (116) requires dissipation - from the incoming boson for which $\Sigma > 0$ - of one more unit - of magnitude $\hbar$ - of spin. For a step from equation (115) to equation (116), a factor of α might pertain.

$$\text{1f+1b}(\Sigma = 6) + 2(\text{1b}(\Sigma = 0)) \to \text{1f+3(1b}(\Sigma = 0)) \tag{115}$$

$$\text{1f+1b}(\Sigma = 8) + 3(\text{1b}(\Sigma = 0)) \to \text{1f+4(1b}(\Sigma = 0)) \tag{116}$$

Table 58: Possible relevance - regarding some interaction strengths - of the fine-structure constant (with the symbol O denoting the two-word term ongoing theory; with the symbol P denoting the two-word term proposed theory; with KS denoting KS modeling; with PS denoting PS modeling; with QED denoting the two-word term quantum electrodynamics; and with the symbol * denoting the expression $(1 - \delta(M', 3)) \cdot ((3/2) \cdot (1 + M'') + (j'_{M'})d'(M'')))$

P/O	Context	Aspect	Factor
O - KS	QED calculations of anomalous magnetic dipole moments	Terms involving j virtual photons (See discussion related to equation (173).)	α^j
P - PS	Relationship between the masses of quarks and the masses of charged leptons	(See equation (84).)	$(\alpha^{-1/4})^*$
P - PS	Possible relationship between the strength of 2G2 and the strength of 2G24	(See discussion related to equation (114).)	α
P - PS	Lepton number and (ongoing theory) perceived masses for neutrinos	Ratio of strengths: 4G2468x to 8G2468x, with x equal to a or b (See discussion related to equation (119). See table 59. See discussion related to equation (116).)	1 to α^2
P - PS	Possible generalization for $\Sigma \geq 4$, $2 \in \Gamma$, and $j > 0$	Ratio of strengths: ΣGΓ to $(\Sigma + 2j)$GΓ (See discussion related to equation (116).)	1 to α^j
P - PS	Possible (speculative) aspects regarding the mass of the W boson.	(See discussion related to table 52.)	?

The factors of α correlate with the notion that some proposed theory modeling suggests $\alpha^2 m_\epsilon$ as the ongoing theory average neutrino mass. (See equation (120).) To the extent that equation (112) pertains (and, thus, equation (111) does not pertain) regarding channels, the various factors of α pertain on a per channel basis. (See discussion regarding table 57a.)

4.3.8. Roles of the fine-structure constant

Table 58 notes some possibilities for relevance of the fine-structure constant regarding ratios of strengths of interactions.

4.3.9. The strengths of ΣG interactions for $\Sigma \geq 10$

For each G-family physics relevant ΣGΓ solution for which $\Sigma \geq 10$, there is a G-family physics relevant Σ'GΓ solution for which Σ' is less than Σ. (Compare table 64c with the combination of table 64a and table 64b.) Equation (117) pertains. Also, each G-family physics relevant ΣGΓ solution for which $\Sigma \geq 10$ correlates with one of the words dipole, quadrupole, or octupole.

$$\Sigma - \Sigma' \geq 4 \tag{117}$$

Equation (118) follows from equation (85).

$$\alpha^2 < 5.33 \times 10^{-5} \tag{118}$$

We assume that the table 58 factor 1 to α^j pertains.

Effects correlating with each G-family physics relevant ΣGΓ solution for which $\Sigma \geq 10$ may be difficult to observe. For each one of those solutions, the word monopole does not pertain and there is a relevant G-family Σ'GΓ solution (for which the same word out of the list dipole, quadrupole, and octupole pertains) that contributes an effect that is at least a factor of 10^4 larger than effects of the ΣGΓ solution.

4.3.10. Ongoing theory estimates of the sum of neutrino masses

Equation (119) provides ongoing theory limits for the sum, across three generations, of neutrino masses. (See reference [6]. Reference [8] provides the lowest of the upper limits that reference [6] lists.) The integer j correlates with generation. Equation (119) comes from interpretations of astrophysics data.

$$0.06\mathrm{eV}/c^2 \lesssim \sum_{j=1}^{3} m_j \lesssim 0.12\mathrm{eV}/c^2 \tag{119}$$

Table 59: Interpretations regarding some aspects of G-family solutions

Aspect	Interpretation
8G	Interacts with lepton number minus baryon number
8G2468a and 8G2468b	Interact with individual neutrinos
8G2468a and 8G2468b	Catalyze neutrino oscillations
8G2468a and 8G2468b	Catalyze effects that people interpret as implying (via ongoing theory) that at least one generation of neutrino has non-zero mass

Independent of results of observations and of assumptions about modeling, equation (120) pertains.

$$3\alpha^2 m_\epsilon \approx 0.0816 eV/c^2 \tag{120}$$

We anticipate exploring notions that the following sentences state. The number $3\alpha^2 m_\epsilon$ might predict an upper bound for the lower limit of the range that people derive from the types of observations that underlie equation (119). The number $3\alpha^2 m_\epsilon$ might predict a lower bound for the upper limit of the range that people derive from the types of observations that underlie equation (119). The factor of three might correlate with the range $1 \leq j \leq 3$ in equation (119).

4.3.11. Models that might estimate an ongoing theory sum of neutrino masses

We explore possibilities for developing models that would estimate a non-zero ongoing theory sum of neutrino masses.

One possibility has bases in the notion that one can extrapolate, based on equation (84), to results that pertain to neutrino masses. We do not find a seemingly useful method. We de-emphasize this possibility.

One possibility assumes the ongoing theory notion that neutrino oscillations correlate with interactions that we correlate with the 4G subfamily. Table 31a correlates 4G with somewhat conservation of fermion generation. Neutrino oscillations might correlate with multiple close-by interactions. (People might, therefore, correlate neutrino oscillations with notions of CP violation. See discussion related to table 25.) However, such interactions might not account for observed magnitudes of neutrino oscillations. (Also, ongoing theory seems not to propose a correlation between CP violation and neutrino oscillations.) We de-emphasize the possibility that quantum interaction with 4G accounts for most of the effects that people correlate with neutrino oscillations.

One possibility has bases in the notion that modeling regarding neutrino oscillations might feature notions of indices of refraction. (See discussion related to equation (62).) Some refraction might correlate with ongoing theory notions of classical physics interactions with gravity. As far as we know, people have yet to detect (gravitational lensing or) gravitational refraction of neutrinos. (See discussion related to table 60.) Proposed theory suggests that interactions mediated by 8G bosons play significant roles regarding refraction of neutrinos.

Matter charged leptons, including the electron, and matter neutrino simple particles correlate with the same 3LB number - $\iota_{3LB} = 3$. We assume that neutrinos are Dirac fermions and not Majorana fermions.

Table 59 posits modeling that reconciles discussion above, equation (119), and equation (120). Table 59 extends table 43. Here, we assume the factor that a row in table 58 shows. We think that discussion related to equations (115) and (116) supports this assumption.

We discuss possible implications regarding ongoing theory modeling.

Ongoing theory astrophysics modeling does not include modeling that proposed theory correlates with 6G and 8G. We posit one or two conceptual mapping steps. First, in the context of proposed theory, modeling for 8G octupole components of force maps to modeling for octupole components of 4G forces. Perhaps that step suffices. In this context, ongoing theory modeling paralleling aspects of proposed theory 4G2468a and 4G2468b interprets 8G effects on neutrinos as correlating with non-zero neutrino mass. The following (or, second) step pertains to the extent that relevant ongoing theory modeling does not correlate adequately well with proposed theory non-monopole components of 4γ. Second, in the context of proposed theory, modeling for 4G octupole components of force maps to modeling involving 4G4. In this context, ongoing theory modeling based on only proposed theory 4G4 would interpret 8G effects on neutrinos as correlating with non-zero neutrino mass.

We perform a check regarding reasonableness of proposed theory regarding interactions that couple to lepton number. (Here, KS modeling pertains.)

Table 60: Aspects that might correlate with the extent to which neutrinos have non-zero masses

Aspects
• Limits regarding neutrino masses, as inferred from astrophysics data.
• The existence of neutrino oscillations.
• Neutrino speeds.
• Effects of neutrino lensing (which would be based on gravity).
• Other.

We consider our interpretation of aspects of ongoing theory. We consider gravitational interactions between two electrons. Equation (121) describes results based just on the component that correlates with proposed theory 4G4 effects. Equation (122) assumes that ϵ' correlates with one standard deviation regarding the mass of an electron. (Reference [6] provides the data that we use for these calculations.) The lepton number for an electron equals the lepton number for a matter neutrino. Equation (123) correlates with results based just on the component that correlates with proposed theory 8G effects. (One exponent of two correlates with the exponent of two pertaining, in essence, to equation (120). One exponent of two correlates with the notion that the interaction involves two simple fermions.) The result that equation (123) shows is less than the result that equation (122) shows. In this context of ongoing theory, the interaction, between two electrons, based on lepton number is not incompatible with measurements of electron masses.

$$G_N(m_\epsilon(1+\epsilon'))^2/r^2 \approx G_N(m_\epsilon)^2(1+2\epsilon')/r^2 \tag{121}$$

$$|\epsilon'| \approx 1.2 \times 10^{-8} \tag{122}$$

$$(\alpha^2)^2 \approx 2.8 \times 10^{-9} \tag{123}$$

Proposed theory suggests that, for KS Newtonian modeling, the strength of interactions with lepton number scales as r^{-5}. The strength of interactions with charge scales as r^{-2}. People might want to estimate a minimum energy for which the interaction between two charged leptons exhibits measurable effects of 8G octupole components.

Discussion above assumes that neutrinos are Dirac fermions and not Majorana fermions. Table 57 suggests the possibility that proposed theory can suggest a nexus between equation (119) and equation (120) under the assumption that exactly one of the three neutrinos is a Dirac fermion.

We summarize proposed theory suggestions about ongoing theory statements about the sum of neutrino masses.

The following statements pertain. The dominant contribution to the relevant astrophysics data correlates with neutrino refraction based on interactions mediated by the 8G2468a and 8G2468b components of 8G. Contributions correlating with trajectory bending via classical physics refractive interactions with gravity might pertain. Contributions correlating with CP-violating interactions with gravity might pertain. Contributions correlating with non-zero neutrino masses might pertain. Each one of the three neutrinos might have zero mass.

4.3.12. Neutrino masses

Discussion related to table 59 suggests that proposed theory can be compatible with modeling that is compatible with either one of the following two statements. All neutrinos have zero mass. Some neutrinos have non-zero mass.

We explore the notion that all neutrinos have zero mass, even though people interpret data as suggesting that at least one flavor of neutrino correlates with non-zero mass.

Table 60 lists aspects that might correlate with the extent to which neutrinos have non-zero masses.

We discuss inferences from astrophysics data.

Discussion related to table 59 and to equation (120) suggests modeling that would be compatible with data and with elementary particle Standard Model ongoing theory aspects that suggest that all neutrinos have zero rest masses.

We discuss aspects related to neutrino oscillations.

Ongoing theory hypothesizes that gravity catalyzes neutrino oscillations. This hypothesis might correlate with a process of elimination. Ongoing theory suggests that each known simple particle does not catalyze neutrino oscillations. Ongoing theory suggests that photons do not catalyze neutrino oscillations.

Ongoing theory suggests that the strong interaction does not catalyze neutrino oscillations. The only ongoing theory catalyst for neutrino oscillations might be gravity.

Proposed theory suggests that 4G correlates with somewhat conservation of fermion generation. Proposed theory suggests that interactions mediated by 4G bosons might be insufficient to catalyze known amounts of neutrino oscillations. Proposed theory suggests that 8G bosons catalyze observed neutrino oscillations. (See discussion related to table 59.)

We know of no data about neutrino speeds that would settle the question as to the extent to which neutrinos have non-zero masses.

As far as we know, observations of impacts of possible neutrino lensing have yet to produce relevant results.

As far as we know, other possibly relevant experiments and observations do not provide additional insight about the extent to which neutrinos have non-zero masses. (See, for example, references [9] and [10].)

Proposed theory suggests that each neutrino might correlate with zero rest mass.

4.3.13. Possible masses of the tweak bosons

We explore possibilities regarding masses of T-family bosons.

The 0G$\emptyset$ solution correlates with the possible 0I (or, aye) boson. The 0I boson would have zero mass. Zero mass correlates with $\sigma'' = +1$ and $S'' = 1$. (See, in table 18e, the column labeled $D + 2\nu''$.) We try to extrapolate from $\sigma'' = +1$ and $S'' = 1$ for the 0I boson, $\sigma'' = -1$ and $S'' = 3$ for W-family physics, and $\sigma'' = -1$ and $S'' = 4$ for H-family physics. The equation $S'' = 7$ provides the first possibility (beyond the limit $\lambda \leq 8$) to have G-family-like solutions for which $\Sigma = 0$. The equation $S'' = 7$ would correlate with allowed values of λ of two, four, six, eight, 10, 12, and 14. For $S'' = 7$, $D + 2\nu'' = 50$. Proposed theory suggests that equations (124) and (125) might pertain regarding the masses of T-family bosons. (Here, $\mathrm{T}^{\pm}$ denotes each of $\mathrm{T}^{\pm 2}$ and $\mathrm{T}^{\pm 1}$. Here, T^0 denotes each of $\mathrm{T}^{0''}$ and $\mathrm{T}^{0'}$.) Here, we allow for the possibilities of adding or subtracting the integers correlating with $\sigma'' = +1$ and $S'' = 1$, $S'' = 0$, and $\sigma'' = -1$ and $S'' = 1$. Based on data from reference [6] regarding the Higgs boson, the rest energies of the T-family bosons would comport with equation (126).

$$47/17 \leq (m_{\mathrm{T}^{\pm}})^2/(m_{\mathrm{H}^0})^2 \leq 53/17 \tag{124}$$

$$49/17 \leq (m_{\mathrm{T}^0})^2/(m_{\mathrm{H}^0})^2 \leq 51/17 \tag{125}$$

$$208\mathrm{GeV} \lesssim (m_{\mathrm{T}^{\cdots}})c^2 \lesssim 221\mathrm{GeV} \tag{126}$$

Proposed theory suggests that equation (126) correlates with lowest possible rest energies for tweaks. (Possibly, for example, the mass range correlates with, for example, $S'' = 7$, $S'' = 8$, $S'' = 11$, or $S'' = 12$.)

4.3.14. A possible lack of electric dipole moments for elementary particles

Table 40 points to no G-family solutions that would correlate with a non-zero electric dipole moment for a point-like elementary particle. The lack of such G-family solutions might correlate with nature not including elementary particles that have non-zero electric dipole moments.

4.3.15. A possible lack of neutrino asymmetry

Reference [11] suggests that people might be on the verge of finding an asymmetry, which would correlate with CP violation, between matter neutrinos and antimatter neutrinos. The article suggests that ongoing theory interpretation of data seems to point toward such an asymmetry and that it might be reasonable to anticipate that, with more data, people will conclude that the asymmetry exists.

Proposed theory offers an alternative explanation for such data. People produce the relevant neutrinos 295 kilometers from where the measurements take place. Between production and detection, the neutrinos pass through earth. Along the path, if one just considers protons in atomic nuclei and electrons in materials, ι_{3LB} is essentially zero. If one considers also the neutrons in atomic nuclei, ι_{3LB} is negative. Core proposed theory suggests that, via ongoing theory virtual interactions, relevant neutrinos interact via 8G interactions with an ι_{3LB} that is negative everywhere along the relevant path. (Some aspects of the virtual interactions might correlate with 8G2468a and 8G2468b. To the extent that 8G8 pertains, the 8G8 component of the virtual interactions might have a magnitude that correlates with α^2 times the strength of interactions between electrons and gravity.)

Table 61: Aspects of nature - that ongoing theory discusses or suggests - for which proposed theory seems to provide insight that augments insight that ongoing theory suggests

Aspect
• Details regarding the fundamental components of dark matter.
• Eras during which the rate of expansion of the universe increases or decreases.
• Ratios of dark matter amounts or effects to ordinary matter amounts or effects.
• Details regarding the inflationary epoch.
• Details regarding just after the inflationary epoch.
• Details regarding mechanisms leading to baryon asymmetry.
• An additional source of acoustic oscillations that influenced the formation of filaments.
• Details regarding some aspects of galaxy formation.
• Details regarding dark matter objects that would be smaller than galaxies.

This explanation suggests that the would-be asymmetry might correlate with the material through which the neutrinos pass. This explanation suggests that the would-be asymmetry would not necessarily correlate with a CP violation asymmetry pertaining to neutrinos themselves.

5. Results: astrophysics and cosmology

This unit describes dark matter particles. This unit predicts and explains data about dark matter, galaxy formation, other aspects of astrophysics, and the cosmos.

5.1. Summary: a table of predictions and explanations re astrophysics and cosmology

We discuss aspects of nature - correlating with the terms dark matter, dark energy, astrophysics, and cosmology - for which proposed theory might provide, relative to ongoing theory, new details or better-defined explanations.

Table 61 lists some topics for which proposed theory seems to provide insight that augments insight that ongoing theory suggests.

We discuss immediately below some, but not all, of the items that table 61 lists.

Ongoing theory explores various hypotheses regarding the fundamental components of dark matter. Proposed theory suggests specific components for dark matter. Proposed theory uses its description of dark matter fundamental components to explain data that ongoing theory seems not to explain.

Ongoing theory suggests notions regarding three known eras in the rate of expansion of the universe. One era features an accelerating (or, increasing) rate and correlates with the so-called inflationary epoch. A later multi-billion-year era features a decelerating (or, decreasing but still positive) rate. The current multi-billion-year era features an accelerating rate. Proposed theory suggests an explanation that has bases in components of 4G forces. (This explanation correlates with PS modeling. See table 41.) The explanation does not necessarily depend on ongoing theory notions of dark energy negative pressure or on ongoing theory modeling based on general relativity. The proposed theory explanation might be generally compatible with ongoing theory models. The proposed theory explanation points to some subtleties that ongoing theory modeling might miss.

Ongoing theory seems not to explain patterns regarding ratios of dark matter to ordinary matter. Observations point to ratios of five-plus to one regarding densities of the universe and regarding amounts in galaxy clusters. Observations regarding ratios of amounts in early galaxies seem to cluster around zero-plus to one and four to one. Observations regarding ratios of amounts in later galaxies seem to cluster around zero-plus to one, four to one, and one to zero-plus. Observations regarding depletion, via hyperfine interactions with hydrogen atoms, of cosmic microwave background radiation (or, CMB) may point to a ratio of one to one. Proposed theory suggests explanations for each of these ratios. (See discussion regarding table 68 and see, for example, table 77.) The explanations have bases in proposed theory specifications for dark matter and in effects correlating with PS modeling and with components of 4G forces. (See table 41.) Proposed theory does not seem to point to possible directly observable, widely applicable, easily explained approximate ratios of, for example, three to one or six to one. We do not know of observations that would point to directly observable, adequately widely applicable approximate ratios of, for example, three to one or six to one.

Ongoing theory suggests that the early universe includes an inflationary epoch. Ongoing theory proposes a role, during that epoch, for a so-called inflaton particle. Proposed theory suggests that the aye (or, 0I) simple particle correlates with the notion of an inflaton. Proposed theory suggests that octupole components of 4G forces provided for rapid expansion.

Ongoing theory suggests that the achievement of baryon asymmetry occurred after the formation of the universe. Ongoing theory proposes mechanisms that might have catalyzed baryon asymmetry. Ongoing theory does not necessarily point to the tweak simple bosons that proposed theory suggests exist. Proposed theory suggests that tweak bosons might have catalyzed the achievement of baryon asymmetry.

Ongoing theory provides hypotheses regarding the possibilities for substantial objects that might be significantly smaller than galaxies and contain mostly dark matter. Proposed theory suggests some specifics regarding some objects that would be significantly smaller than galaxies and would contain mostly dark matter.

5.2. Modeling pertaining to astrophysics and cosmology

We discuss concepts and methods that lead to proposed theory results regarding astrophysics and cosmology.

5.2.1. Modeling that describes dark matter particles

We discuss one type of dark matter.

We introduce the symbols that equations (127) and (128) show. The symbol 1Q⊗2U denotes a particle that includes just quarks and gluons. The word hadron pertains for the particle. The one-element term hadron-like pertains for the particle. Examples of such particles include protons, neutrons, and pions. The symbol 1R⊗2U denotes a particle that includes just arcs and gluons. The one-element term hadron-like pertains for the particle. The particle does not include quarks.

$$\mathrm{1Q} \otimes \mathrm{2U} \tag{127}$$

$$\mathrm{1R} \otimes \mathrm{2U} \tag{128}$$

A 1R⊗2U hadron-like particle contains no charged simple particles. The 1R⊗2U hadron-like particles do not interact with 2γ. The 1R⊗2U hadron-like particles measure as being dark matter.

The existence of 1R⊗2U hadron-like particles seems insufficient to explain ratios of dark matter effects to ordinary matter effects of (for example) five-plus to one, four to one, and maybe one to one.

We correlate work above with the two-element term PR1IC modeling.

We explore the notion that some five-plus to one ratios reflect something fundamental in nature. We correlate some results from this exploration with so-called PR6IC modeling. Here, dark matter includes the above-mentioned 1R⊗2U hadron-like particles and other particles.

The symbol element PR denotes the one-element term physics-relevant. The symbol element IC correlates with the three-word term isomers of charge (or, with the five-word term isomers of charged elementary particles). Here, the notion of isomer correlates with PS symmetries and not necessarily with KS symmetries. Discussion related to table 73 posits PS symmetries that correlate with differences between relevant isomers. (This PS notion of isomers does not necessarily correlate with ongoing theory notions of isomers. The PS notion of isomers does not necessarily parallel the nuclear physics notion - same numbers of protons and neutrons, but different energy states - of isomer. The PS notion of isomer does not necessarily correlate with the chemistry notion - same numbers of various atoms, but different spatial arrangements - of molecular isomers.)

PS modeling correlates interactions with charge with the 2G2 component of the 2G force. We posit that nature includes six isomers of charge. PS modeling correlates interactions with nominal magnetic dipole moment with the 2G24 component of the 2G force. We posit that each isomer of charge correlates with one isomer of nominal magnetic dipole moment. We posit that each of the six pairings of one isomer of charge and one isomer of nominal magnetic moment correlates with its own isomer of all the elementary particles that exhibit non-zero charge or non-zero nominal magnetic dipole moment. One isomer of charge, nominal magnetic dipole moment, and related elementary particles measures as ordinary matter. (The previous sentence also pertains regarding PR1IC modeling.) We posit that each of the other five isomers of charge, nominal magnetic dipole moment, and related elementary particles measures as dark matter. (PR1IC modeling does not include these five isomers.) We posit that one isomer of 4G4 interacts with each one of the one ordinary matter isomer and five dark matter isomers. Each one of 4G4, neutrinos, and the 1R⊗2U hadron-like particles does not correlate with just one isomer of charge.

Table 62: Perspective regarding PR6IC modeling

PR6IC modeling ...
• Explains observed dark matter to ordinary matter ratios of five-plus to one, four to one, one to one, zero-plus to one, and one to zero-plus. (PR36IC modeling offers a different explanation for the one known ratio of one to one. See discussion regarding equation (129) and discussion regarding equation (149).)
• Echoes the notion that PS modeling intertwines 2G-related aspects and 4G-related aspects in ways that ongoing theory does not. (See, for example, equation (84).)
• Echoes the exponent of six that equation (108) discusses.
• Echoes the six ranges that equation (132) and table 70 feature.
• Correlates with information that table 36 shows.
• Might correlate with a TA-side $SU(7) \supset SU(5) \times SU(2) \times U(1)$ relationship. Here, $SU(5)$ correlates with conservation of energy. Here, $SU(2) \times U(1)$ correlates with the six ranges that equation (132) and table 70 feature. (PS ALG modeling might correlate the $SU(2)$ symmetry with oscillators TA15 and TA16.)
• Seems to correlate with aspects of unverified ongoing theory.

We posit that the next two sentences pertain. The six-isomer notion explains the five that pertains regarding five-plus to one ratios of amounts of dark matter to ordinary matter. The existence of 1R⊗2U hadron-like particles explains the plus that pertains regarding five-plus to one ratios of amounts of dark matter to ordinary matter. Such five-plus to one ratios pertain regarding densities of the universe and regarding the compositions of (perhaps most) galaxy clusters.

Additionally, the following sentences pertain. PR6IC modeling explains other observed ratios of dark matter effects to ordinary matter effects. PR6IC modeling correlates with various mathematics modeling aspects of PS modeling that pertain regarding PR1IC modeling.

Table 62 provides perspective regarding PR6IC modeling. The following sentences illustrate the last item in the table. People suggest that dark matter could have characteristics similar to ordinary matter. (See, for example, reference [12].) People suggest that dark matter might include components that include quarks or that might experience Yukawa-like potentials. (See, for example, references [13] and [14].) People suggest that nature might include dark matter photons. (See, for example, reference [15].)

Regarding each one of the six PR6IC isomers, we suggest that each combination - that table 54 shows - of magnitude of charge and magnitude of mass pertains to a simple fermion that correlates with the isomer. For example, each isomer includes a charged lepton for which the magnitude of charge equals the magnitude of the charge of the ordinary matter electron and for which the rest energy equals the rest energy of the electron. However, regarding charged leptons, the combination of mass and generation number does not necessarily match across isomers. (See table 70.) For example, for so-called isomer one, the generation three charged lepton may have the same mass as the ordinary matter electron. (See table 54.) The ordinary matter electron has a generation number of one.

Table 13d discusses the symbol ι_I. Discussion just above pertains regarding PRι_IIC, with ι_I being one or six. Within any one PRι_IIC, equation (129) pertains for each free simple particle, for each component of G-family force, and for each hadron-like particle. For example, for PR6IC modeling, for the electron, the number of isomers is six and the span of each isomer is one. For PR6IC modeling, for the 4G4 component of 4G, the number of isomers is one and the span of each isomer is six.

$$(\text{number of isomers}) \times (\text{span of one isomer}) = \iota_I \tag{129}$$

PR6IC modeling suggests that 2G248 has a span of six isomers of charged simple particles.

PR6IC modeling assumes that the span of six for 2G248 embraces the same six isomers of charged simple particles as does the span of six for 4G4.

We explore the notion that nature might include 36 isomers.

PR36IC modeling embraces the possibility that the span of six for 2G248 is, in effect, orthogonal (or, perpendicular) to the span of six for 4G4. Here, six isomers of 4G4 pertain. Each of those six isomers of 4G4 spans a different (from the other five isomers of 4G4) six isomers of charged simple particles. We use the two-element term doubly-dark matter to correlate with the 30 isomers of charged simple particles that do not interact with the ordinary matter isomer of charged particles via 4G4. Doubly dark matter does not interact with ordinary matter via 2G2, 2G24, 4G4, or other components of 4G. Five doubly dark matter isomers of charged simple particles interact with the ordinary matter isomer of charged simple particles via 2G248.

Table 63: Cumulative features of various types of modeling

(a) Featured modeling

Modeling	ι_I	New descriptions and new explanations	New subtleties
Ongoing theory	NR	• (Baseline)	-
PR1IC	1	• New simple particles and root forces • Baryon asymmetry • Some dark matter	• Dark energy negative pressure • Ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter
PR6IC	6	• More dark matter • Ratios of dark matter effects to ordinary matter effects • Objects, smaller than galaxies, that feature dark matter.	• Spans • Dark energy negative pressure

(b) Possibly useful modeling

Modeling	ι_I	New descriptions and new explanations	New subtleties
PR36IC	36	-	• Ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter

From the perspective of each one of the 36 isomers of charged simple particles, the following statements pertain. The isomer correlates with its own isomers of 2G2, 2G24, 4G246, 4G2468a, and 4G2468b. The isomer of charged simple particles interacts via 2G248 with five other isomers of charged simple particles. The isomer of charged simple particles interacts via 4G4 with five other isomers of charged simple particles. None of the first five other isomers is one of the second five other isomers. The first five other isomers are - from the perspective of the one isomer - doubly dark matter isomers. The second five other isomers are - from the perspective of the one isomer - dark matter isomers.

Compared to PR6IC modeling, PR36IC modeling adds a six-generator PS ALG symmetry. PS ALG modeling might correlate a $SU(2) \times U(1)$ symmetry with oscillators TA15 and TA16. (Note table 36a.)

We preview features of each of PR1IC, PR6IC, and PR36IC modeling.

Table 63 discusses cumulative features of various types of modeling. Generally, each row augments the rows above that row. Regarding ongoing theory, the symbol NR denotes the concept that the notion of isomers is not relevant. We think that PR6IC provides useful insight about nature. Regarding ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter, PR36IC offers an alternative (to PR6IC) explanation of dark energy density. (See discussion related to equation (149).) Otherwise, regarding bases for aspects that table 63 lists, PR36IC is similar to PR6IC. Discussion related to equation (149) suggests that PR6IC modeling might suffice to explain known phenomena and that it might not be necessary to consider PR36IC modeling. From a standpoint of observations, distinguishing between the case of PR6IC and the case of PR36IC might prove difficult.

5.2.2. Spans for simple particles, components of root forces, and some objects

We consider PR6IC modeling.

We start from the span of six that we posit for 4G4. We consider TA-side symmetries for G-family solutions. (See table 40.) We aim to develop numbers that belong in the table 40 column that has the label span (for $\iota_I \geq 6$). The number of generators of each of $SU(3)$, $SU(5)$, and $SU(7)$ divides evenly the integer 48, which is the number of generators of $SU(7)$. Regarding 4G4, we posit that the expression $6 = g_7/g_3$ is relevant. (Regarding notation, see equation (35).) We generalize. We assert that, for each G-family solution for which a TA-side symmetry of $SU(j)$ pertains, equation (130) provides the span. We assume that we can generalize from the assumption that the span of 2G2 is one. For each G-family solution with no TA-side symmetry, the span is one. The W boson has non-zero charge. We assume that the span of the W boson is one. A span of one comports with information that tables 40 and 48 show. The following sentences pertain. A span of six pertains for the Z boson. A span of one pertains for the Higgs boson.

$$g_7/g_j \tag{130}$$

We discuss spans for simple particles and other objects that we do not correlate directly with G-family solutions.

Each charged simple fermion has a span of one. We assume that the span for 2U parallels the span for the Z boson. The span for 2U is six. We assume that the spans for 0K and 0P equal the span for 2U. The span for 1Q⊗2U is one, based on the non-zero charges of 1Q particles. We assume that a span of six pertains for each zero-charge simple fermion. We assume that the span of 1R⊗2U is six.

Equation (131) shows notation for denoting the span, s, for a simple particle or for a component of a root force.

$$\Sigma(\mathrm{s})\Phi \quad \text{or} \quad \Sigma(\mathrm{s})\Phi\Gamma \tag{131}$$

For each of each simple particle, each hadron-like particle, and each component of G-family forces, the one-word term span denotes the number of isomers of a set of, at least, non-zero-charge simple particles with which an isomer of the particle or force component interacts. The set includes all non-zero-charge simple particles and the ongoing theory photon 2(1)G.

Table 64 shows the span for each component of G-family forces. The table pertains for each of PR6IC modeling and PR36IC modeling. Rows in table 64a list all $\Sigma\gamma$ components. Table 64a lists 2(6)G248 and does not list 2(1)G248. Rows in table 64b list $\Sigma \leq 8$ G-family force components that do not correlate with $\Sigma\gamma$. Table 64c lists some solutions that might correlate with G-family force components. These solutions likely correlate with G-family force components. (See discussion related to table 57.)

We consider all three of PR1IC modeling, PR6IC modeling, and PR36IC modeling.

Table 65 summarizes information regarding spans for simple particles, for hadron-like particles, and for some components of root forces. The table summarizes information regarding types of objects with which boson simple particles and some root force components interact. The table separates, based on a proposed theory view, elementary particle Standard Model aspects from aspects that the elementary particle Standard Model does not embrace. The magnitude of charge for the $\mathrm{T}^{\pm 1}$ boson is one-third the magnitude of the charge for each of the $\mathrm{W}^{\pm 3}$ boson and the electron. The magnitude of charge for the $\mathrm{T}^{\pm 2}$ boson is two-thirds the magnitude of the charge for each of the $\mathrm{W}^{\pm 3}$ boson and the electron. The symbol 1Q⊗2U correlates with known and possible hadrons. The symbol 1R⊗2U correlates with possible hadron-like particles. Regarding the PR36IC case, the notation (‖2G) denotes a span that couples ordinary matter and doubly dark matter. The symbol ‖2G correlates with the 3-element phrase parallel to 2G248. Regarding the PR36IC case, the notation (‖4G) denotes a span that couples ordinary matter and dark matter. The symbol ‖4G correlates with the 3-element phrase parallel to 4G4. Table 65a does not include G-family components that do not correlate with$\Sigma\gamma$ solutions. Regarding the PR6IC case, the span for 2G68 is two. (See table 65b.) Regarding the PR36IC case, the span for 2G68 is two and the notion of ‖2G pertains. Regarding the PR6IC case, the pairings of isomers that isomers of 4G48 span might not equal the pairings of isomers that isomers of 2G68 span. The symbols :4G and :2G correlate with this possible mismatch regarding pairings. Table 65 shows the extent to which each of the simple bosons and some of the root force components interacts directly with each of at least some simple fermions and with each of at least some multicomponent objects. The word Yes denotes that interactions occur. The symbol † denotes that somewhat conservation of fermion generation pertains for 1f+1b→1f+1b interaction vertices. The word No denotes that interactions do not occur. Proposed theory suggests the possibility that neither the 0H boson nor the 0I boson interacts directly with multicomponent objects. Proposed theory suggests that G-family solutions for which the TA-side symmetry is $SU(5)$ or $SU(7)$ do not correlate with direct interactions with simple fermions. (See discussion related to table 37 and discussion related to table 40.) For each unfree simple boson for which table 65 shows a non-one span, the non-one span numbers result from mathematics underlying assumed modeling. The effective span depends on the span correlating with the object (such as a hadron-like object) in which the simple boson exists. Tables 65c and 65d summarize some concepts relevant to tables 65a and 65b.

In table 65, the items for which free pertains and the PR36IC span might be 36 are 1N, 1R⊗2U, and 0I. The 1N simple particles (or, neutrinos) have zerolike mass and zero charge. For 1R⊗2U, the component simple particles have zerolike or zero mass and zero charge. The 0I simple particle (or, aye) would have zerolike mass and zero charge.

Table 64: A catalog of components of G-family forces

(a) G-family force components for which $\Sigma \in \Gamma$

$\Sigma\Gamma$ ($\Sigma \in \Gamma$)	S	Monopole (RSDF $= r^{-2}$)	Dipole (RSDF $= r^{-3}$)	Quadrupole (RSDF $= r^{-4}$)	Octupole (RSDF $= r^{-5}$)
Yes	1	2(1)G2	2(1)G24	2(6)G248	
Yes	2	4(6)G4	4(2)G48	4(1)G246	4(1)G2468a
Yes	2				4(1)G2468b
Yes	3	6(2)G6		6(6)G468	
Yes	4	8(1)G8			8(1)G2468a
Yes	4				8(1)G2468b

(b) G-family force components for which $\Sigma \notin \Gamma$ and $\Sigma \leq 8$

$\Sigma\Gamma$ ($\Sigma \in \Gamma$)	S	Monopole (RSDF $= r^{-2}$)	Dipole (RSDF $= r^{-3}$)	Quadrupole (RSDF $= r^{-4}$)	Octupole (RSDF $= r^{-5}$)
No	1		2(6)G46	2(6)G468	
No	1		2(2)G68		
No	2		4(6)G26	4(6)G268	
No	3		6(1)G24	6(6)G248	
No	3		6(2)G28		
No	4		8(6)G26	8(1)G246	

(c) Some G-family solutions for which $\Sigma \geq 10$

$\Sigma\Gamma$ ($\Sigma \in \Gamma$)	S	Monopole (RSDF $= r^{-2}$)	Dipole (RSDF $= r^{-3}$)	Quadrupole (RSDF $= r^{-4}$)	Octupole (RSDF $= r^{-5}$)
No	5		10(2)G28	10(6)G248	
No	5		10(6)G46	10(6)G468	
No	6		12(2)G48	12(1)G246	12(1)G2468
No	6			12(6)G268	
No	7		14(2)G68	14(6)G248	
No	8			16(6)G268	16(1)G2468
No	9			18(6)G468	
No	10				20(1)G2468

Table 65: Particles and solutions that correlate with one isomer and particles and solutions that might correlate with more than one isomer; plus, the extent to which simple bosons and some root force components interact with simple fermions and with multicomponent objects (with the symbol MCO denoting multicomponent objects; and with the symbol † denoting that somewhat conservation of fermion generation pertains)

(a) Particles and solutions, other than G-family components that are not $\Sigma\gamma$ components

Standard Model entities	Possible entities	PR1IC span	PR6IC span	PR36IC span	1b interact w/ 1f	1b interact w/ MCO
1C	-	1	1	1	-	-
1N	-	1	6	6 (‖2G) or 36	-	-
1Q	-	1	1	1	-	-
-	1R	1	6	6 (‖2G)	-	-
2U	-	1	6	6 (‖2U)	Yes†	No
2W: Z		1	6	6 (‖2G)	Yes†	No
	2T: $2T^{0''}$, $2T^{0'}$	1	6	6 (‖2G)	Yes†	No
2W: $W^{\pm 3}$	2T: $2T^{\pm 2}$, $2T^{\pm 1}$	1	1	1	Yes†	No
1Q⊗2U	-	1	1	1	-	-
-	1R⊗2U	1	6	6 (‖2G) or 36	-	-
0H	-	1	1	1	Yes	No
-	0I	1	1, or 6	1, 6 (‖?), or 36	Yes	No
-	0K	1	6	6 (‖2G)	No	Yes
-	0P	1	6	6 (‖2G)	No	Yes
2G2	-	1	1	1	Yes	Yes
2G24	-	1	1	1	Yes	Yes
2G248	-	1	6	6 (‖2G)	Yes†	Yes
-	4G4	1	6	6 (‖4G)	Yes†	Yes
-	4G48	1	2(:4G)	2 (‖4G)	No	Yes
-	4G246	1	1	1	Yes†	Yes
-	4G2468a	1	1	1	Yes†	Yes
-	4G2468b	1	1	1	Yes†	Yes
-	6G6	1	1	1	No	Yes
-	6G468	1	1	1	Yes	Yes
-	8G8	1	1	1	No	Yes
-	8G2468a	1	1	1	Yes	Yes
-	8G2468b	1	1	1	Yes	Yes

(b) Selected G-family component that is not a $\Sigma\gamma$ component

Standard Model entities	Possible entities	PR1IC span	PR6IC span	PR36IC span	1b interact w/ 1f	1b interact w/ MCO
-	2G68	1	2(:2G)	2 (‖2G)	No	Yes

(c) Notes regarding the case PR6IC

Notes
• For any $\Sigma\Phi$ and non-zero charge, the span is one.
• For 1Φ and 2Φ; $\Phi \neq$ G; and zero charge, a span of six correlates with somewhat conservation of generation.
• For 0K and 0P, the spans equal the span for 2U.
• For 0H, we assume that the span is one. (See table 48 and note that ΣG2468 correlates with a span of one.)
• For 0I, we assume that the span is one of one or six.
• For one of $4\text{G}\Gamma$ and $2\text{G}\Gamma$ with a span of two (and for a numbering system that numbers isomers using the integers zero through five), the pairings 0-and-3, 1-and-4, and 2-and-5 might pertain. For the other one of the two ($4\text{G}\Gamma$ and $2\text{G}\Gamma$), different pairings might pertain. (Note the notation :4G and :2G.)

(d) Notes regarding the case PR36IC

Notes
• For each $\Sigma\Phi$ with $\Phi \neq$ G or I and with a PR6IC span of six or two, we assume that ‖2G pertains.
• For each $4\text{G}\Gamma$ with a PR6IC span of six or two, we assume that ‖4G pertains.
• For 0I, we assume that the span is one of one, six, or 36.

Table 66: Maximal possible spans for elementary particles other than G-family elementary particles

Elementary particle charge	Elementary particle mass	PR1IC	PR6IC	PR36IC
Not zero	Not zerolike	1	1	1
Zero	Not zerolike	1	6	6
Zero	Zerolike	1	6	36

Table 67: Aspects regarding information - centric to isomers - that proposed theory fields carry

Aspect
• Compared to ongoing theory modeling regarding fields, proposed theory adds - to the set of information that an excitation carries - information about the isomer(s) correlating with the excitation.
• For PR1IC modeling, only one isomer pertains. The information correlates with a list of the one isomer that correlates with creating the excitation. In effect, there is no added (compared to ongoing theory) information.
• For PR6IC modeling, the information correlates with a list of the one, two, or six isomers that correlate with creating the excitation. The number of isomers in the list equals the span for the relevant particle or component. (See for example, table 65.)
• For PR36IC modeling, the information correlates with a list of the one, two, six, or 36 isomers that correlate with creating the excitation. The number of isomers in the list equals the span for the relevant particle or component. (See, for example, table 65.)
• For each of PR1IC modeling, PR6IC modeling, and PR36IC modeling, the excitation does not necessarily carry information about the simple particles or force components that participated in creating the excitation.
• For each of PR1IC modeling, PR6IC modeling, and PR36IC modeling, de-excitation of an excitation of a field must correlate with a set of isomers that includes an isomer that the excitation-centric list includes.

Excitation of a boson encodes information specifying, in effect, the isomer or isomers that correlate with the excitation.

Table 66 shows maximal possible spans for elementary particles other than G-family elementary particles. (See table 65a.) Each elementary particle for which the charge is not zero has a mass that is not zerolike.

Table 67 summarizes aspects regarding information - centric to isomers - that proposed theory fields carry. (Table 67 illustrates concepts that table 41 discusses.) In ongoing theory, the electromagnetic field carries information that correlates with events that excited the field. Via de-excitations, people measure energies, momenta, and polarizations. People infer information about excitation events. (See discussion related to table 37.) Table 67 discusses additional information (compared to information that ongoing theory fields carry) that proposed theory fields carry.

We discuss concepts regarding the 2(2)G68 solution.

The 2(2)G68 solution does not belong to the set of 2γ solutions and does not belong to the set of $\gamma2$ solutions. The 2(2)G68 solution does not correlate with interactions with individual simple fermions. Table 59 correlates $\lambda = 8$ with leptons and baryons. Each of table 43b and discussion related to table 11 correlates $\lambda = 8$ with rotation or spin. Table 36 correlates $\lambda = 6$ with changes of internal states for multicomponent objects. We posit that 2(2)G68 correlates with some electromagnetic (or, $\Sigma = 2$) interactions with atoms and other objects. We posit that those interactions include so-called hyperfine interactions.

Each of 2(1)G2 and 2(1)G24 correlates with some electromagnetic (or, $\Sigma = 2$) interactions with atoms and other objects that include both baryons and leptons.

Unlike for the cases of electromagnetic interactions that correlate with 2(1)G2 and 2(1)G24, 2G produced by ordinary matter objects interacts with dark matter objects (for the case in which PR6IC pertains to nature) or doubly dark matter objects (for the case in which PR36IC pertains to nature) via 2(2)G68. Unlike for the cases of electromagnetic interactions that correlate with 2(1)G2 and 2(1)G24, 2G produced by some dark matter objects (for the case in which PR06IC pertains to nature) or by some doubly dark matter objects (for the case in which PR36IC pertains to nature) interacts with ordinary matter via 2(2)G68.

Table 68: Approximate ratios of dark matter effects to ordinary matter effects (with DM denoting dark matter; with OM denoting ordinary matter; with A denoting amount; with OM CMB denoting cosmic microwave background radiation; and with * denoting that proposed theory also suggests an explanation - correlating with PR36IC modeling - that correlates with doubly-dark matter and does not correlate with dark matter)

Approximate DMA:OMA	Amounts
5^{+}:1	Density of the universe
5^{+}:1	Amount of stuff in galaxy clusters
1:1 or 1^{+}:1	Amount of absorption of OM CMB via interactions with DM* atoms or OM atoms.
0^{+}:1	Amount of stuff in some early galaxies
$\approx$4:1	Amount of stuff in some early galaxies
1:0^{+}	Amount of stuff in some early galaxies
0^{+}:1	Amount of stuff in some later galaxies
$\approx$4:1	Amount of stuff in some later galaxies
1:0^{+}	Amount of stuff in some later galaxies
$\approx$3:2 to $\approx$4:1	Amount of stuff in dark matter halo to amount of stuff near galaxy center (for some later galaxies)

Table 69: Modeling pertaining to the one ordinary matter isomer and the five dark matter isomers

n	Formula	Interpretation
0, 1, 2, 3, 4, or 5	$M'' = 3n + 1$	No particle
0 or 3	$M'' = 3n$	Generation 1
1 or 4	$M'' = 3n$	Generation 3
2 or 5	$M'' = 3n$	Generation 2

5.2.3. Dark matter to ordinary matter ratios that modeling might predict or explain

We discuss ratios that PR6IC modeling or PR36IC modeling might predict or explain.

Table 68 lists some approximate ratios of dark matter effects to ordinary matter effects that PR6IC modeling might explain. We designed PR6IC modeling to explain the five-plus to one ratios that people observe regarding densities of the universe. Here, the five correlates with dark matter isomers of charged elementary particles and the plus correlates with hadron-like particles that do not interact with 2γ force components. Galaxy clusters seem to be sufficiently large to comport with similar ratios. Discussion just above regarding 2(2)G68 correlates with the approximately one to one ratio. (See, also, discussion related to equation (141).) Ratios of zero-plus to one, four to one, and one to zero-plus comport with roles of non-monopole gravity in scenarios regarding galaxy formation. (See discussion related to table 77.) The DMA:OMA ratios of zero-plus to one, the DMA:OMA ratio of four to one, and the DMA:OMA ratios of one to zero-plus comport with scenarios regarding some galaxies for which observations correlate with times well after galaxy formation. (See other discussion related to table 77.) Regarding the last row in table 68, see AX in table 77a and B0, B3, and BY in table 77b and note that only one of table 77a and table 77b pertains to nature. Generally, we do not expect directly observable, widely applicable, easily explained approximate ratios of, for example, three to one or six to one.

5.2.4. Some properties of isomers of quarks and charged leptons

We consider PR6IC modeling and PR36IC modeling.

We explore the notion that the exponent of six in equation (108) correlates with the notion of six isomers, one of which correlates with ordinary matter and five of which correlate with dark matter. (See also, discussion related to equation (84).)

We explore modeling that correlates each of the six relevant isomers with a range of M''. In equation (132), the integer n numbers the isomers. Here, the ordinary matter isomer correlates with $n = 0$.

$$\text{isomer } n \leftrightarrow 3n \leq M'' \leq 3n + 3, \text{ for } 0 \leq n \leq 5 \tag{132}$$

Table 69 shows interpretations regarding modeling for the six isomers. (Compare with table 54.) Here, for $n \geq 1$, the $M'' = 3n$ generation relevant to isomer n equals the $M'' = 3(n-1) + 3$ generation relevant to isomer $n-1$. Within an isomer, an overall result correlates with the same cyclic ordering, for generations, that table 54 shows.

We de-emphasize the following notions. Dark matter lepton masses might correlate with $m(M'', 3)$ and $M'' > 3$. Mathematics - such as for $M'' < 0$ - related to equation (84) might help estimate ongoing

Table 70: Relationships between quark generation and lepton aspect

M''	Quark n	Quark generation	Lepton n (for n even)	Lepton aspect (even n)	Lepton n (for n odd)	Lepton aspect (odd n)
0	0	1	0	1	-	-
1	0	2	0	-	-	-
2	0	3	0	2	-	-
3	1	1	0	3	1	3
4	1	2	-	-	1	-
5	1	3	-	-	1	1
6	2	1	2	2	1	2
7	2	2	2	-	-	-
8	2	3	2	3	-	-
9	3	1	2	1	3	1
10	3	2	-	-	3	-
11	3	3	-	-	3	2
12	4	1	4	3	3	3
13	4	2	4	-	-	-
14	4	3	4	1	-	-
15	5	1	4	2	5	2
16	5	2	-	-	5	-
17	5	3	-	-	5	3
18	-	-	-	-	5	1

Table 71: Choices for models regarding aspects pertaining to dark matter leptons

Theme	Can differ by generation	The notion of mimics OM generation pertains for $n = \ldots$	Can differ by mass	The notion of mimics OM mass pertains for $n = \ldots$
Sameness	No	1, 2, 3, 4, 5	No	1, 2, 3, 4, 5
Differ by mass	No	1, 2, 3, 4, 5	Yes	3 only
Differ by generation	Yes	3 only	No	1, 2, 3, 4, 5
Differ by both	Yes	3 only	Yes	3 only

theory values for neutrino masses. Results that correlate with $M'' < 0$ might be useful for estimating magnitudes of ordinary matter 2G interactions with dark matter analogs to ordinary matter charged leptons.

Table 70 shows, for each value of n, relationships between quark generation and lepton aspects. Table 70 extends table 69 and includes quarks. For each n, the order for quarks is generation one, generation two, and then generation three.

Table 71 lists choices that pertain regarding the two-word term lepton aspect, as defined by table 70. The one-word term sameness denotes the notion that each of the five dark matter isomers echoes - regarding lepton generation and lepton mass - the ordinary matter isomer. For example, for $n = 1$, for the M''=3 lepton, the generation is one and the mass is the mass of the ordinary matter electron. (Here, we do not discuss the signs of the charges for dark matter leptons.) The following sentence provides an example for the case for which the four-word phrase can differ by mass pertains. For the lepton for which $n = 1$ and M''=3, the generation is one and the mass equals the mass of the ordinary matter tauon. (For ordinary matter, the tauon correlates with generation three.) For the lepton for which $n = 3$ and M''=9, the generation is one and the mass equals the mass of the ordinary matter electron. The following sentence provides an example for the case for which the four-word phrase can differ by generation pertains. For the lepton for which $n = 1$ and M''=3, the generation is three and the mass equals the mass of the ordinary matter electron. The two-word phrase by both denotes the five-word phrase by mass and by generation. From a standpoint of physics, the differ by both choice might be identical to the sameness choice.

This essay de-emphasizes the possibility that dark matter quarks correlate with a theme of differ by mass or with a theme of differ by generation. This essay de-emphasizes the possibility that the masses of dark matter quarks correlate with changes of signs regarding the various $d'(\_)$. (See equations (90), (91), and (92).) We assume that, for each of the six ranges that equation (132) specifies, the masses of the

Table 72: Ordinary matter, four cool dark matter isomers, and the one other dark matter isomer

Isomers (n)	Aspect - regarding each isomer
0	Is ordinary matter.
3	Evolves similarly to ordinary matter.
1, 2, 4, and 5	Evolves into cool dark matter.

Table 73: More choices for models regarding aspects pertaining to dark matter leptons

Theme	Can differ by lepton handedness	The notion of mimics OM lepton handedness pertains for $n = \ldots$
Sameness	No	1, 2, 3, 4, 5
Differ by lepton handedness	Yes	2 and 4 only

relevant quarks match the masses that table 54 would show if the masses in table 54 comported exactly with nature. For example, for each isomer, the mass of the generation-one quark with a magnitude of charge of $|q_\epsilon|/3$ equals the mass of each other generation-one quark with a magnitude of charge of $|q_\epsilon|/3$.

5.2.5. Possible differences regarding the evolution of dark matter isomers

We explore possible differences regarding the evolution of various dark matter isomers.

We explore the theme of differ by mass. (See table 71.)

We compare isomer one and isomer zero. For isomer one, the generation one charged lepton has a mass that is equal to the mass of an ordinary matter tauon. The isomer one generation one charged lepton has more mass than does the isomer zero generation one lepton (which is the electron). The isomer one generation two charged lepton has a mass that is equal to the mass of the isomer zero electron. The isomer one generation three charged lepton has a mass that is equal to the mass of the isomer zero muon. Regarding isomer one, each one of the generation two and generation three charged leptons has a mass that is less than the mass of the respective isomer zero charged lepton.

We discuss times for which the temperature suffices to catalyze tweak-based interactions that do not conserve fermion generation. Regarding generation one quarks, more transitions to higher generations occur for isomer one than for isomer zero. Regarding generation two and generation three quarks, fewer transitions to lower generations occur for isomer one than for isomer zero.

The formation of hadron-like particles based on generation one quarks occurs later for isomer one than for isomer zero.

Isomer one phenomena such as star formation and nuclear fusion start later and at lower densities of atoms than do similar ordinary matter (or, isomer zero) phenomena. Similar results - of later start and lower densities, compared to the ordinary matter isomer - pertain for isomers two, four, and five. (Details regarding isomer four have similarities to details regarding isomer one. Details regarding isomer five have similarities to details regarding isomer two. Details regarding isomer two and five differ from details regarding isomers one and four.) Details regarding isomer three have similarities to details regarding isomer zero.

Each one of the four isomers that exhibit reduced star formation and reduced fusion somewhat rapidly features mainly non-zero mass objects and dark matter photons. From that time forward, the dominant effects are clumping of the objects and cooling of the dark matter photons. The clumping has bases in 4G interactions. We correlate the three-word term cool dark matter with this dark matter state of mainly non-zero mass objects and dark matter photons. (We do so to denote scientific similarity to, but not necessarily linguistic equality with, ongoing theory uses of the three-word term cold dark matter.)

Table (72) pertains.

We anticipate that notions that table 72 summarizes explain aspects of the Bullet Cluster and aspects regarding galaxy dark matter halos. (Regarding the Bullet Cluster, see discussion related to table 75. Regarding dark matter halos, see, for example, discussion related to table 77.)

5.2.6. Symmetries that characterize the six DM and OM isomers

We explore a characterization for symmetries that might correlate with the notion of six isomers, one of which correlates with ordinary matter and five of which correlate with dark matter.

Table 73 suggests a parallel to table 71.

One possible interpretation of the word differ in table 73 is the notion of dominance with respect to handedness of leptons. For the ordinary matter isomer, the number of left-handed (or, matter) leptons greatly exceeds the number of right-handed (or, antimatter) leptons. We know of no data that would support or refute the relevance to nature of the notion - that table 73 suggests - of differ by lepton handedness. (Aspects of this discussion contrast with a notion of dominance with respect to generation of leptons. Dominance with respect to generation correlates with the notion of decay into lowest energy - or lowest mass - states.) Proposed theory does not necessarily suggest that the notion of differ by lepton handedness correlates with baryon asymmetry. (See discussion related to equation (146).)

We de-emphasize the topic of the extent to which the notion of differ by lepton handedness extends to a notion of differ by handedness regarding quarks and arcs.

Nevertheless, we suggest that the combination of the differ-by-mass row in table 71 and the differ-by-lepton-handedness row in table 73 correlates with symmetries that people can use to characterize the relevant six isomers of charge (or, of charged elementary particles).

Discussion immediately above pertains regarding PR6IC modeling and regarding PR36IC modeling. Compared with PR6IC modeling, the additional factor of six - regarding the number of isomers - that characterizes PR36IC modeling correlates with the span, six, of 2(6)G248.

5.3. Predictions and explanations regarding astrophysics and cosmology

We explore aspects of astrophysics and cosmology.

5.3.1. A specification for dark matter and ordinary matter

We summarize a combined description of dark matter and ordinary matter. (See, for example, table 65a.) This description correlates with PR6IC modeling.

Nature includes two sets of simple particles and hadron-like particles. One set features particles that interact via 2G2. Each simple particle has non-zero charge. Each hadron-like particle includes quarks. One set features particles that do not interact via 2G2. Each simple particle has zero charge. Each hadron-like particle includes arcs and does not include quarks.

PR6IC modeling correlates with one isomer of particles that do not interact via 2G2. These particles include neutrinos, 1R⊗2U hadron-like particles, and ayes. The 1R⊗2U hadron-like particles measure as being dark matter.

PR6IC modeling correlates with six isomers of particles that interact via 2G2. Here, each of the six isomers of particles correlates with its own isomer of 2G2. From the perspective of observations that people make, one isomer measures as being ordinary matter and the other five isomers measure as being dark matter.

Regarding each ordinary matter simple particle, each one of the five dark matter isomers includes a simple particle that has the same spin, the same magnitude of charge, and the same mass. If the ordinary matter simple particle is a charged lepton, for each of four of the five dark matter isomers the respective same-spin, same-magnitude-of-charge, and same-mass charged lepton correlates with a generation number that differs from the generation number that pertains for the ordinary matter charged lepton.

For each one of those four dark matter isomers, evolution regarding objects differs from the evolution regarding ordinary matter objects. Those four isomers evolve into cool dark matter.

Regarding pie and cake simple particles, one isomer pertains. Nature might form atomic nuclei or neutron stars that include both ordinary matter hadron-like particles (that is, hadrons) and dark matter hadron-like particles.

5.3.2. Densities of the universe

Ongoing theory discusses five partial densities of the universe. The symbol Ω_ν denotes neutrino density of the universe. The symbol Ω_{c} denotes dark matter (or, cold dark matter) density of the universe. The symbol Ω_{b} denotes ordinary matter (or, baryonic matter) density of the universe. The symbol Ω_γ denotes photon density of the universe. The symbol Ω_Λ denotes dark energy density of the universe. Each of the five densities correlates with data. Equation (133) pertains regarding the total density of the universe, Ω.

$$\Omega = \Omega_\nu + \Omega_{\mathrm{c}} + \Omega_{\mathrm{b}} + \Omega_\gamma + \Omega_\Lambda \tag{133}$$

In ongoing theory, the symbol Ω_{c} correlates with all dark matter. To the extent that proposed theory PR6IC modeling or PR36IC modeling comports with nature, the symbol Ω_{c} correlates with all of the three aspects - 1R⊗2U hadron-like particles, the four dark matter isomers that we correlate above with the word cool, and the one dark matter isomer that we do not necessarily correlate above with the word cool - that proposed theory correlates with the term dark matter.

Proposed theory suggests equation (134). The symbol Ω_{1R2U} denotes 1R$\otimes$2U density of the universe. The symbol Ω_{ib} denotes dark matter baryonic density of the universe. (The letter i symbolizes the word isomer.) The symbol $\Omega_{\mathrm{i}\gamma}$ denotes dark matter photon density of the universe.

$$\Omega_{\mathrm{c}} = \Omega_{\mathrm{1R2U}} + \Omega_{\mathrm{ib}} + \Omega_{\mathrm{i}\gamma} \tag{134}$$

We interpret data regarding recent states of (ordinary matter) CMB (or, cosmic microwave background radiation) as correlating with equation (135). The symbol Ω_{1R2U} correlates with the plus in the ratio five-plus to one. The relationship $\Omega_{\mathrm{b}} \gg \Omega_{\gamma}$ pertains regarding data. (Reference [6] provides data regarding $\Omega_{\mathrm{b}} \gg \Omega_{\gamma}$.)

$$\Omega_{\mathrm{ib}} \approx \Omega_{\mathrm{ib}} + \Omega_{\mathrm{i}\gamma} \approx 5(\Omega_{\mathrm{b}} + \Omega_{\gamma}) \approx 5\Omega_{\mathrm{b}} \tag{135}$$

Equation (139) estimates Ω_{1R2U} for the current state of the universe. (Reference [6] provides the data that equations (136), (137), and (138) show.)

$$\Omega_{\mathrm{b}} \approx 0.0484 \pm 0.001 \tag{136}$$

$$\Omega_{\mathrm{c}} \approx 0.258 \pm 0.011 \tag{137}$$

$$\Omega_{\gamma} \approx 0.0000538 \pm 0.0000150 \tag{138}$$

$$\Omega_{\mathrm{1R2U}} \approx \Omega_{\mathrm{c}} - 5\Omega_{\mathrm{b}} \approx 0.016 \tag{139}$$

Reasons exist for not taking the results that equation (139) shows to be exact. For example, we note the size of the standard deviation in equation (137).

5.3.3. DM to OM density of the universe ratios inferred from data regarding CMB

People use data from observations of CMB (or, cosmic microwave background radiation) to infer ratios of dark matter density of the universe to ordinary matter density of the universe. (See discussion that leads to table 63 and includes equation (130).) A ratio of five-plus to one seems to pertain for billions of years. (See discussion related to equation (135) and discussion related to equation (140).) We use that ratio to posit the six-isomer basis for PR6IC modeling.

5.3.4. Constancy of actual density of the universe ratios re DM and OM

We discuss theory regarding the ratio of actual dark matter density of the universe to actual ordinary matter density of the universe.

Elsewhere, we discuss possible threshold energies pertaining to reactions that might produce 1R$\otimes$2U hadron-like particles. (See, for example, discussion regarding equations (186) and (187).) The relative densities of the universe of 1R$\otimes$2U hadron-like particles and ordinary matter 1Q$\otimes$2U hadron particles might be essentially constant after the universe cools to a temperature correlating with an energy of 81 GeV. (See discussion regarding equations (186) and (187).) Regarding PR6IC modeling and PR36IC modeling, proposed theory does not necessarily include interactions that would directly convert ordinary matter 1Q$\otimes$2U to dark matter 1Q$\otimes$2U or interactions that would directly convert dark matter 1Q$\otimes$2U to ordinary matter 1Q$\otimes$2U.

The actual ratio of dark matter density of the universe to ordinary matter density of the universe might not much change after the cooling to the temperature correlating with the energy 81 GeV. That energy correlates with a temperature of about 10^{15} degrees Kelvin. That temperature correlates with a time that is less than 10^{-4} seconds after the Big Bang. (Reference [16] notes that a temperature of 10^{13} degrees Kelvin correlates with a time of 10^{-4} seconds after the Big Bang.)

Measured ratios of dark matter density of the universe to ordinary matter density of the universe would not much change regarding times for which equation (140) pertains. (Perhaps, see equations (136) and (138).) That time range starts somewhat after 380,000 years after the Big Bang and continues through now.

$$\Omega_{\gamma} \ll \Omega_{\mathrm{b}} \tag{140}$$

5.3.5. A possibly DM effects to OM effects ratio inferred from data regarding CMB

People measure specific depletion of CMB and attribute some of that depletion to hyperfine interactions with (ordinary matter) hydrogen atoms. (See reference [17].) The amount of depletion is twice or somewhat more than twice the amount that people expected. At least one person speculates that the amount above expectations correlates with effects of dark matter. (See reference [18].)

Proposed theory suggests the following explanation. Solution 2(2)G68 has a span of two. 2(2)G68 interactions are 2(2)GΓ interactions. Equation (141) pertains. Solution 2(2)G68 does not correlate with interactions with individual simple fermions. (The TA-side symmetry is $SU(5)$. See table 40 and table 65b.) Solution 2(2)G68 might correlate with hyperfine interactions. (Note, for example, that the six in Γ might correlate with aspects of multicomponent objects. The eight in Γ might correlate with at least one of lepton number and spin.) Half or somewhat less than half of the observed absorption correlates with the ordinary matter isomer of hydrogen atoms. An equal amount of the observed effect correlates with hydrogen-atom isomers that correlate with one dark matter isomer or with one doubly dark matter isomer. The dark matter case correlates with PR6IC modeling. The doubly dark matter case correlates with PR36IC modeling.

$$2\mathrm{G}68 \notin 2\gamma,\ \ 2\mathrm{G}68 \notin \gamma 2 \tag{141}$$

To the extent that the absorption by ordinary matter is less than half of the total absorption, the following explanations might pertain. One explanation correlates with the notion that the evolution of the relevant non-ordinary-matter isomer might differ from the evolution of the ordinary matter isomer. The non-ordinary-matter isomer might have more hydrogen-atom-like objects than does the ordinary matter isomer. One explanation correlates with 2GΓ solutions with spans of at least two. Each one of solutions 2(6)G46 and 2(6)G468 might pertain. The number six appears in both the Γ for 2(2)G46 and the Γ for 2(6)G468. Solution 2(2)G46 correlates with a dipole effect. Solution 2(6)G468 correlates with a quadrupole effect.

Proposed theory might contribute to credibility for assumptions and calculations that led to the prediction for the amount of depletion that correlates with ordinary matter hydrogen atoms. (Regarding the assumptions and calculations, see reference [19].)

5.3.6. The rate of expansion of the universe

Two thought experiments set the stage for discussing aspects regarding the rate of expansion of the universe.

We consider one thought experiment. We consider two similar neighboring clumps of stuff. We assume that the clumps are moving away from each other. We assume that the clumps will continue to move away from each other. We assume that, initially, interactions correlating with RSDF $r^{-(n+1)}$ dominate regarding interactions between the two clumps. We assume that the two clumps interact via interactions correlating with RSDF r^{-n}. We assume that no other forces have adequate relevance. We assume that the distance between the objects increases adequately. Eventually, the RSDF r^{-n} force dominates the RSDF $r^{-(n+1)}$ force.

We consider a similar thought experiment. We consider two similar neighboring clumps. We assume that these clumps are less interactive (for example, less massive) than the two clumps in the first thought experiment. Generally, dominance of the RSDF r^{-n} force over the RSDF $r^{-(n+1)}$ force occurs sooner for the two clumps in the second thought experiment than it does for the two clumps in the first thought experiment.

Table 74 summarizes, regarding the rate of expansion of the universe, eras and 4G force components. In this context, the eras pertain to the largest objects that people can directly infer. Early acceleration pertains for some time after the Big Bang. Then, deceleration pertains for some billions of years. (Regarding observations that correlate with the eras that correlate with deceleration and recent acceleration, see references [20], [21], [22], and [23].) Acceleration pertains for the most recent some billions of years. Regarding smaller objects, dominant forces within objects and between neighboring objects have, at least conceptually, generally transited parallels to the above-mentioned eras and now generally exhibit behavior correlating with RSDF of r^{-2}. (Discussion regarding table 91 notes that high-outflow phenomena related to black holes or neutron stars might provide exceptions regarding the notion of complete dominance correlating with an RSDF of r^{-2}. For some aspects of these cases, r^{-3} net repulsion might pertain.) In table 74, the column labeled A/R notes net effects, across force components dominating for each era. The column labeled components of 4γ lists solutions that might correlate with significant forces. (See table 42. Proposed theory suggests that, for the purposes of this discussion, neither 4(1)G268 nor 4(2)G26 correlates with significant effects.) Proposed theory suggests (but does not necessarily require)

Table 74: Eras and components of 4G forces, regarding expansion of the universe

Era	A/R	RSDF	Components of 4γ	Other components of 4G	Span (PR6IC or PR36IC)
early acceleration	net repulsive	r^{-5}	4(1)G2468a, 4(1)G2468b		1
deceleration	net attractive	r^{-4}	4(1)G246	4(1)G268	1
recent acceleration	net repulsive	r^{-3}	4(2)G48	4(2)G26	2
(recent, for smaller objects)	attractive	r^{-2}	4(6)G4		6

that, for the components of 4γ that table 74 lists, the two-word term net repulsive correlates with a notion of essentially always repulsive (though perhaps sometimes not significantly repulsive). Proposed theory suggests (but does not necessarily require) that, for the components of 4γ that table 74 lists, the two-word term net attractive correlates with a notion of essentially always attractive (though perhaps sometimes not significantly attractive).

Proposed theory suggests that the ongoing theory notion of dark energy negative pressure correlates with the 4(2)G48 component (and possibly with the 4(1)G2468a and 4(1)G2468b components) of 4γ.

A better characterization than the six-word term rate of expansion of the universe might feature a notion of the rates of moving apart of observed very large astrophysical objects.

5.3.7. Phenomena during and just after inflation

Ongoing theory suggests that an inflationary epoch might have occurred. Ongoing theory suggests that the epoch ended around 10^{-33} seconds to 10^{-32} seconds after the Big Bang. We are not certain as to the extent to which data confirms the occurrence of an inflationary epoch.

Ongoing theory includes models that people claim would support notions of inflation. The models point to states of the universe, at and somewhat after the inflationary epoch, that would provide bases for evolution that would be consistent with observations about later phenomena and would be consistent with aspects of ongoing theory. (Reference [24] summarizes aspects related to inflation, points to references regarding ongoing theory, and discusses some ongoing theory work.)

Reference [25] suggests the possibility that a repulsive aspect of gravity drove phenomena correlating with the inflationary epoch. The reference suggests that the composition of the universe was nearly uniform spatially. The reference suggests the importance of a so-called inflaton field.

Proposed theory suggests the possibility that, during the inflationary epoch, aye particles (or, 0I particles) provided a major non-root-force component of the universe. The aye particle matches ongoing theory notions of a boson with zero spin. (See reference [24].) Ongoing theory uses the word inflaton to name that boson. Proposed theory suggests the possibility that the octupole components of 4γ provided the repulsive aspect of gravity. (See, for example, table 91.) Those components interact with individual simple particles and are repulsive. Equation (142) shows such an interaction. Here, x and y might be either of a and b. The end of the inflationary epoch would correlate with a change, regarding effects of 4γ, from octupole repulsion being dominant to quadrupole attraction being dominant. The end of the inflationary epoch might also correlate with a growth of spatial inhomogeneities regarding (at least) aye particles. The quadrupole component of 4γ might help catalyze some of the spatial inhomogeneities. The quadrupole component of 4γ might amplify some of the spatial inhomogeneities.

$$\mathrm{0I} + \mathrm{4(1)G2468x} \to \mathrm{0I} + \mathrm{4(1)G2468y} \tag{142}$$

References [25] and [24] suggest that inflaton particles dominated (what proposed theory would characterize as) the non-root-force composition of the universe for some time after the inflationary epoch. Inflatons produced a cascade of interactions that led to a preponderance of protons, neutrons, and electrons. Clumping of the resulting hydrogen atoms led to the formation of stars.

Proposed theory suggests the possibility that, for some time just after the inflationary epoch, the aye particle might have been a dominant non-root-force component of the universe. The dominant G-family force component would have been the quadrupole component of 4γ. That component interacts with individual simple particles and is attractive. Interactions between aye particles would produce components of 2G forces. (See equation (143).) Each of proposed theory and ongoing theory includes interactions by which 2G components produce matter-and-antimatter pairs of simple fermions. Interactions between elementary particles would produce non-aye simple bosons. From there, the above-mentioned cascade could occur. Proposed theory suggests the possibility that attraction based on the quadrupole component of 4γ contributed to clumping.

$$0\mathrm{I} + 0\mathrm{I} \to 2\mathrm{G} + 2\mathrm{G} \tag{143}$$

Discussion above de-emphasizes the question of the extent to which, for clumps or objects that involve multiple simple particles, 4γ octupole repulsion might dominate 4γ quadruple attraction for at least some time after the end of the inflationary epoch.

Discussion above de-emphasizes the notions of isomers and spans. Discussion above de-emphasizes the notion of phenomena that might have preceded the inflationary epoch.

We discuss isomers and spans.

Our work considers three PRι_IIC cases - ι_I is one, ι_I is six, and ι_I is 36. Table 65 suggests that the span for each of the quadrupole component of 4γ and the two octupole components of 4γ is one. For each one of the PR6IC case and the PR36IC case, the span of 0I might be one or might be more than one.

We discuss each of the 0I span is one and the 0I span exceeds one possibilities.

For each one of the PR6IC case and the PR36IC case, the proposed theory possibility that the span of 0I is one might point to the notion that each of the ι_I isomers originally develops similarly to and originally somewhat essentially independently from the other (ι_I minus one) isomers. More substantial coupling between isomers might start with the production of simple particles that have spans that exceed one. Coupling might also involve, for example, contributions correlating with the 4G48 component of 4γ, the 4G4 component of 4γ, and the 2G248 component of 2G.

For each one of the PR6IC case and the PR36IC case, the proposed theory possibility that the span of 0I is more than one would point to more robust coupling - early on - between isomers.

5.3.8. Baryon asymmetry

We explore the notion that the universe transited from an early state that did not exhibit baryon asymmetry to a later state that exhibits baryon asymmetry.

To the extent that the early universe featured essentially the same number of antimatter quarks as matter quarks, something happened to create baryon asymmetry. The two-word term baryon asymmetry correlates with the present lack, compared to matter quarks, of antimatter quarks.

Aspects of ongoing theory consider that early in the universe baryon symmetry pertained. Unverified ongoing theory posits mechanisms that might have led to asymmetry. Some conjectured mechanisms would suggest asymmetries between matter simple fermions and antimatter simple fermions. One set of such simple fermions might feature the neutrinos. (See reference [11].)

Proposed theory suggests scenarios that might have led to baryon asymmetry.

In one scenario, the interactions that equations (144) and (145) show pertain. This scenario converts three antimatter fermions into one matter fermion. Equation (146) shows an overall result. (Regarding equation (144) and to the extent that one wants to try to impose notions of conservation of lepton number and conservation of baryon number, the notion of $2\mathrm{T}^{-1}_{+2;0,-2}$ would pertain. Regarding equation (145) and to the extent that one wants to try to impose notions of conservation of lepton number and conservation of baryon number, the notion of $2\mathrm{T}^{-1}_{+2;+3,+1}$ would pertain.) Baryon asymmetry would arise because reactions such as equations (144) and (145) show dominated compared to similar reactions that involve antiparticles to the particles that equations (144) and (145) show. Domination might correlate with an occurrence of more $2\mathrm{T}^{-1}_{+2;}$ lasing than $2\mathrm{T}^{+1}_{-2;}$ lasing. Here, baryon asymmetry arises because of an imbalance - regarding lasing - that occurred, in effect, statistically.

$$1\mathrm{Q}^{+1}_{+1;0,-1} + 1\mathrm{Q}^{-2}_{+1;0,-1} \to 2\mathrm{T}^{-1}_{+2;} \tag{144}$$

$$1\mathrm{C}^{+3}_{-3;-3,0} + 2\mathrm{T}^{-1}_{+2;} \to 1\mathrm{Q}^{+2}_{-1;0,+1} \tag{145}$$

$$1\mathrm{C}^{+3}_{-3;-3,0} + 1\mathrm{Q}^{+1}_{+1;0,-1} + 1\mathrm{Q}^{-2}_{+1;0,-1} \to 1\mathrm{Q}^{+2}_{-1;0,+1} \tag{146}$$

A threshold energy might be in or above the range of 208 GeV to 221 GeV. (See equation (126).) A corresponding temperature is about 2×10^{15} degrees Kelvin. As far as we know, this result is not inconsistent with established ongoing theory.

We explore a concept that involves isomers.

Table 70 suggests possibilities for taking a multiple-isomer view of baryon asymmetry. We consider PR6IC modeling. In this view, the lepton range $9 \leq M'' \leq 12$ and quark range $9 \leq M'' \leq 11$ provide for an antimatter complement to the matter-centric lepton range $0 \leq M'' \leq 3$ and quark range $0 \leq M'' \leq 2$. Similar results pertain for each of the two pairs n = 1-and-n = 4 and n = 2-and-n = 5. With this view, there may be no need to posit interactions that led to baryon asymmetry. A similar conclusion can pertain regarding PR36IC modeling. This essay does not further explore details regarding or implications of this concept.

5.3.9. Filaments and baryon acoustic oscillations

Proposed theory is compatible with the ongoing theory notion that ordinary matter baryon acoustic oscillations contributed to the formation of filaments.

Regarding models for which ι_I (as in PRι_IIC) exceeds one, each of the five dark matter isomers has its own baryon-like particles and its own 2(1)G physics. Proposed theory suggests, for models for which ι_I exceeds one, that dark matter baryon-like acoustic oscillations occurred in the early universe. Proposed theory suggests that dark matter baryon-like acoustic oscillations contributed (along with ordinary matter baryon acoustic oscillations) to the formation of filaments.

5.3.10. Galaxy clusters - ratios of dark matter to ordinary matter

Regarding some galaxy clusters, people report inferred ratios of dark matter amounts to ordinary matter amounts.

References [26] and [27] report ratios of five-plus to one. The observations have bases in gravitational lensing. Reference [28] reports, for so-called massive galaxy clusters, a ratio of roughly 5.7 to one. (Perhaps note reference [29].) The observations have bases in X-ray emissions.

Proposed theory is not incompatible with these galaxy cluster centric ratios. Either one of PR6IC modeling and PR36IC modeling can pertain.

Reference [30] suggests a formula that correlates - across 64 galaxy clusters - dark matter mass, hot gas baryonic mass (or, essentially, ordinary matter mass), and two radii from the centers of each galaxy cluster. The reference suggests that the formula supports the notion of a correlation between dark matter and baryons. Proposed theory might suggest a correlation, based on proposed similarities between most dark matter and ordinary matter. We are uncertain as to the extent to which people might consider that the formula supports this aspect of proposed theory.

5.3.11. Galaxy clusters - an explanation for aspects of the Bullet Cluster

We consider either PR6IC modeling or PR36IC modeling. For each case, there are five dark matter isomers and one ordinary matter isomer.

Possibly, the evolution of each one of the six isomers paralleled the evolution of each of the other five isomers.

Such parallel evolution might lead to difficulties regarding explaining observations regarding the so-called Bullet Cluster.

People use the two-word term Bullet Cluster to refer, specifically, to one of two galaxy clusters that collided and, generally, to the pair of galaxy clusters. The clusters are now moving away from each other. Ongoing theory makes the following interpretations based on observations. For each of the two clusters, dark matter continues to move along trajectories generally consistent with just gravitational interactions. For each of the two clusters, stars move along trajectories generally consistent with just gravitational interactions. For each of the two clusters, (ordinary matter) gas somewhat generally moves along with the cluster, but generally lags behind the other two components (dark matter and stars). Regarding such gas, people use the acronym IGM and the two-word term intergalactic medium. Ongoing theory suggests that the IGM component of each original cluster interacted electromagnetically with the IGM component of the other original cluster. Electromagnetic interactions led to slowing the motion of the gas.

If each of the six dark matter or ordinary matter isomers evolved similarly, there might be problems regarding explaining aspects of the Bullet Cluster. One might expect that, in each galaxy cluster, more (than the observed amount of) dark matter would lag. The lag would occur because of one-isomer 2G-mediated interactions within each of the five dark matter isomers. Possibly, for each dark matter isomer, there would not be enough star-related stuff to explain the amount of dark matter that is not lagging. Possibly, there would not be enough 1R$\otimes$2U dark matter to significantly help regarding explaining the amount of dark matter that is not lagging.

The sameness row in table 71 correlates with the notion that the five dark matter isomers and the one ordinary matter isomer evolved similarly. The row with the theme differ-by-mass or the row with the theme differ-by-generation can correlate with the notion that the six isomers did not evolve similarly. We assume that four dark matter isomers correlate with proposed theory notions of cool dark matter and

Table 75: Aspects regarding a collision between two galaxy clusters (with the assumption that each of the two galaxy clusters has not undergone earlier collisions)

Aspects
• Up to essentially nearly all ordinary matter IGM (in each galaxy cluster) interacts with ordinary matter IGM (in the other galaxy cluster) and slows down. (The notion of up to essentially all correlates with equally sized colliding galaxy clusters and with a head-on collision.)
• Much of the stuff correlating with ordinary matter stars passes through with just gravitational interactions having significance.
• No more than 20 percent of isomeric dark matter interacts with isomeric dark matter and slows down. (For each galaxy cluster, this dark matter correlates with the IGM correlating with one dark matter isomer.)
• At least 80 percent of isomeric dark matter passes through with just gravitational interactions having significance.
• Essentially all of the incoming 1R⊗2U dark matter passes through the collision with just gravitational interactions having significance.

that one dark matter isomer exhibits behavior similar to behavior that ordinary matter exhibits. (See table 72.)

Proposed theory suggests that, for each of the two galaxy clusters, at least 80 percent of the incoming isomeric dark matter would pass through the collision with just gravitational interactions having significance. The 80 percent correlates with values of n of one, two, four, and five. Proposed theory suggests that essentially all of the incoming 1R⊗2U dark matter would also pass through the collision with just gravitational interactions having significance.

Table 75 lists aspects regarding a collision between two galaxy clusters. Here, we assume that each of the two galaxy clusters has not undergone earlier collisions.

We think that these proposed theory notions can comport with various possible findings about IGM after a collision such as the Bullet Cluster collision. The findings might point to variations regarding the fractions of IGM that, in effect, stay with outgoing clusters and the fractions of IGM that, in effect, detach from outgoing clusters.

We discuss possible aspects regarding an outgoing cluster.

Suppose that, before a collision, ordinary matter IGM comprised much of the ordinary matter in the cluster. Suppose that, because of the collision, the cluster has a significant net loss of ordinary matter IGM. After the collision, the cluster could have a (perhaps somewhat arbitrarily) large ratio of amount of dark matter to amount of ordinary matter.

We discuss possible aspects regarding detached IGM.

To the extent that IGM detaches from galaxy clusters after the clusters collide, the detached IGM might form one or more objects. Some such objects might have roughly equal amounts of dark matter and ordinary matter. The dark matter would correlate with a value of three for n.

5.3.12. Galaxies - formation

We discuss galaxy formation scenarios.

We assume that nature comports with at least one of PR6IC modeling and PR36IC modeling. (Neither ongoing theory nor PR1IC modeling includes the notion of dark matter isomers. We think that it would be, at best, difficult to explain - based on for example 1R⊗2U dark matter - ratios, that observations suggest, of dark matter amounts to ordinary matter amounts.) For now, we de-emphasize some phenomena such as 1R⊗2U hadron-like particles and collisions between galaxies.

We anticipate that such galaxy formation and evolution scenarios will explain galaxy centric data that table 68 shows.

Models for galaxy formation and evolution might take into account the following factors - one-isomer repulsion (which correlates with the 4G2468a and 4G2468b solutions), one-isomer attraction (which correlates with 4G246), two-isomer repulsion (which correlates with 4G48), six-isomer attraction (which correlates with 4G4), dissimilarities between isomers, the compositions of filaments and galaxy clusters, statistical variations in densities of stuff, and collisions between galaxies. Modeling might feature a notion of a multicomponent fluid with varying concentrations of gas-like or dust-like components and of objects (such as stars, black holes, galaxies, and galaxy clusters) for which formation correlates significantly with six-isomer (or 4G4) attraction.

Table 76: A scenario for the formation and evolution of a galaxy for which the original clump contains essentially just one isomer

Aspects
• Early on, stuff correlating with each one of the six isomers expands, essentially independently from the stuff correlating with other isomers, based on repulsion correlating with 4(1)G2468a and 4(1)G2468b.
• Then, each isomer starts to clump, essentially independently from the other isomers, based on attraction correlating with 4(1)G246.
• With respect to clumps correlating with any one isomer, 4(2)G48 repels one other isomer and repels some stuff correlating with the first-mentioned isomer.
• A galaxy forms based on a clump that contains mostly the featured isomer.
• The galaxy attracts and accrues, via 4(6)G4 attraction, stuff correlating with the four isomers that the featured isomer does not repel. The galaxy can contain small amounts of stuff correlating with the isomer that the featured isomer repels.

We focus on early-stage galaxy formation and evolution. For purposes of this discussion, we assume that we can de-emphasize collisions between galaxies. We suggest the two-word term untouched galaxy for a galaxy that does not collide, before and during the time relevant to observations, with other galaxies. We emphasize formation scenarios and evolution scenarios for untouched galaxies. (Communication 95a and communication 95b discuss data that pertains regarding a time range of about one billion years after the Big Bang to about 1.5 billion years after the Big Bang. Observations suggest that, out of a sample of more than 100 galaxies or galaxy-like rotating disks of material, about 15 percent of the objects might have been untouched.)

We assume that differences - in early evolution - regarding the various isomers do not lead, for the present discussion, to adequately significant differences - regarding 4G interactions and galaxy formation - between isomers. (We think that this assumption can be adequately useful, even given results that table 72 shows and our discussion regarding the Bullet Cluster. Regarding the Bullet Cluster, see discussion related to table 75.)

We organize this discussion based on the isomer or isomers that originally clump based on, respectively, 4G246 attraction or 4G246 and 4G4 attraction. Each one of some galaxies correlates with an original clump that correlates with just one isomer. Multi-isomer original clumps are possible. Because of 4G48 repulsion, an upper limit on the number of isomers that an original clump features might be three.

Table 76 discusses a scenario for the formation and evolution of a galaxy for which the original clump contains essentially just one isomer. Regarding this isomer, we use the word featured. We assume that PR6IC modeling pertains. We assume that stuff that will become the galaxy is always in somewhat proximity with itself. We assume that no collisions between would-be galaxies or between galaxies occur.

5.3.13. Galaxies - ratios of dark matter stuff to ordinary matter stuff

We continue to explore the realm of one-isomer clumps.

One of two cases pertains. For so-called case A, one isomer of 4G48 spans (or connects) isomers zero and three. (Regarding numbering for isomers, see n in table 72.) For so-called case B, one isomer of 4G48 spans isomer zero and one isomer out of isomers one, two, four, and five. The existence of many spiral galaxies might point to the notion that case A pertains. (Compare the rightmost column in table 77a and the rightmost column in table 77b.) We consider the possibility that people might not know of data or current theory that would adequately point to the one of case A and case B that pertains. We discuss both cases.

Table 77 pertains. (See table 68.) The following sentences illustrate the notion that some statements in table 77 are at least somewhat conceptual. We assume that local densities for the isomers are somewhat the same. We assume that the galaxy remains adequately untouched. For each row in the table, OM stars can form (and become visible) over time, whether or not significant OM star formation occurs early on. The notation DMA:OMA=1:0^+ denotes the notion that the ratio of OMA to DMA might be arbitrarily small. The notion of three or four DM isomers in a halo refers to the notion that one or zero (respectively) of the DM isomers in the halo is the featured isomer. We ignore 1R$\otimes$2U hadron-like particles, which presumably would measure as being parts of DM halos.

Table 77 reflects at least two assumptions. Each core clump features one isomer. Each galaxy does not collide with other galaxies. Yet, data of which we know and discussion below seem to indicate that ratios that table 77 features pertain somewhat broadly. We think that galaxies that have core clumps

Table 77: Aspects regarding untouched galaxies that correlate with original one-isomer clumps (with just one of cases A and B pertaining to all galaxies)

(a) Case A

Label	Featured isomer (n)	Early aspects regarding the galaxy	Possible later aspects regarding the galaxy
A0	0	Forms some ordinary matter stars early on. Starts at DMA:OMA=0^+:1.	Attracts cool dark matter over time. Can get to DMA:OMA≈4:1, with most DM in a halo. Might be a spiral galaxy.
A3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the four other DM isomers over time. Some OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
AX	1, 2, 4, or 5	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three or four DM isomers in a halo. Might become an elliptical galaxy.

(b) Case B

Label	Featured isomer (n)	Early aspects regarding the galaxy	Possible later aspects regarding the galaxy
B0	0	Forms some ordinary matter stars early on. Starts at DMA:OMA=0^+:1.	Attracts isomer three and three cool dark matter isomers over time. Can get to DMA:OMA≈4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BP	The DM isomer that 4G48 connects to the OM isomer	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the other DM isomers over time. OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
B3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BY	Any one of the other three DM isomers	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three or four DM isomers in a halo. Might appear to be an elliptical galaxy.

that feature more than one isomer are more likely to appear as elliptical galaxies (and not spiral galaxies) than are galaxies that have core clumps that feature only one isomer. Such likelihood can correlate with starting as being elliptical. Such likelihood can correlate with earlier transitions from spiral to elliptical.

We explore the extent to which the galaxy formation scenario comports with observations.

Observations regarding stars and galaxies tend to have bases in ordinary matter isomer 2G phenomena (or, readily observable electromagnetism). (The previous sentence de-emphasizes some observations - regarding collisions between black holes or neutron stars - that have bases in 4G phenomena.) People report ratios of amounts of dark matter to amounts of ordinary matter.

We discuss observations correlating with early in the era of galaxy formation. Table 68 comports with these results. We suggest that visible early galaxies correlate with generalization of label-A0 or with generalization of label-B0. (See table 77.) Label-A3 or label-B3 evolves similarly to label-A0 or label-B0, but is not adequately visible early on.

- Reference [31] provides data about early stage galaxies. (See, for example, figure 7 in reference [31]. The figure provides two graphs. Key concepts include redshift, stellar mass, peak halo mass, and a stellar - peak halo mass ratio.) Data correlating with redshifts of at least seven suggests that some galaxies accrue, over time, dark matter, with the original fractions of dark matter being small. Use of reference [32] suggests that redshifts of at least seven pertain to times ending about 770 million years after the Big Bang.
- Reference [33] reports zero-plus to one ratios. The observations have bases in the velocities of stars within galaxies and correlate with the three-word term galaxy rotation curves. Proposed theory suggests that the above galaxy evolution scenario comports with this data.

We discuss observations correlating with later times. Table 68 comports with these results.

- Reference [34] discusses some MED09 spiral - or, disk - galaxies. A redshift of approximately $z = 1.57$ pertains. (See reference [35].) The redshift correlates with a time of 4.12 billion years after the Big Bang. (We used reference [32] to calculate the time.) Reference [34] reports ratios of amount of dark matter to amount of ordinary matter of approximately four to one. The observations have bases in gravitational lensing. We suggest that each label - other than label-A3 or label-BP - that table 77 shows can pertain. (We note, without further comment, that this example might correlate with the notion that case A pertains to nature and that case B does not pertain to nature. This example features spiral galaxies. Label-A0 suggests a correlation with spiral galaxies. Each other label - pertaining to case A or to case B - either correlates with dark matter galaxies or might suggest a correlation with - at least statistically - evolution into elliptical galaxies. See table 77.)
  - To the extent that such an MED09 galaxy models as being nearly untouched, proposed theory offers the following possibility. The galaxy began based on a one isomer clump. The clump might have featured the ordinary matter isomer. The clump might have featured a dark matter isomer that does not repel ordinary matter. Over time, the galaxy accrued stuff correlating with the isomers that the original clump did not repel. Accrual led to a ratio of approximately four to one.
  - To the extent that such an MED09 galaxy models as not being untouched, proposed theory offers the following possibility. One type of collision merges colliding galaxies. One type of collision features galaxies that separate after exchanging material. For either type of collision, incoming galaxies having approximately four times as much dark matter as ordinary matter might produce outgoing galaxies having approximately four times as much dark matter as ordinary matter.
- Reference [36] discusses the Dragonfly 44 galaxy. A redshift of $z = 0.023$ pertains. The redshift correlates with a time of 13.45 billion years after the Big Bang. (We used reference [32] to calculate the time.) People discuss the notion that ordinary matter accounts for perhaps as little as one part in 10 thousand of the matter in the galaxy. (See reference [37].) The observations have bases in light emitted by visible stars. This case correlates with the three-word term dark matter galaxy. We suggest that label-A3 or label-BP can pertain. (See table 77.)

The following notions pertain regarding other data of which we know. Here, the ratios are ratios of dark matter amounts to ordinary matter amounts. Table 68 seems to comport with these results. (See table 77.)

- Reference [38] discusses six baryon-dominated ultra-diffuse galaxies that seem to lack dark matter, at least to the radius studied by gas kinematics via observations of light with a wavelength of 21 centimeters. These observations seem not to be incompatible with the early stages of label-A0 or label-B0.
- Reference [39] discusses 19 dwarf galaxies that lack having much dark matter, from their centers to beyond radii for which ongoing theory suggests that dark matter should dominate. These observations measure r-band light that the galaxies emitted. These observations seem not to be incompatible with the early stages of label-A0 or label-B0.
- People report two disparate results regarding the galaxy NGC1052-DF2. Proposed theory seems to be able to explain either ratio. Proposed theory might not necessarily explain ratios that would lie between the two reported ratios.
  - Reference [40] suggests a ratio of much less than one to one. The observation has bases in the velocities of stars - or, galaxy rotation curves. This observation seems not to be incompatible with the early stages of label-A0 or label-B0.
  - Reference [41] suggests that at least 75 percent of the stuff within the half mass radius is dark matter. This ratio seems similar to ratios that reference [34] discusses regarding some MED09 galaxies. (See discussion above regarding MED09 galaxies.) We suggest that each label - other than label-A3 or label-BP - that table 77 shows can pertain.
- The galaxy NGC1052-DF4 might correlate with a ratio of much less than one to one. (See reference [42].) The observation has bases in the velocities of stars - or, galaxy rotation curves. This observation seems not to be incompatible with the early stages of label-A0 or label-B0.
- The compact elliptical galaxy Markarian 1216 has an unexpectedly large amount of dark matter in its core and may have stopped accumulating each of ordinary matter and dark matter approximately 4 billion years after the Big Bang. (See reference [43].) Observations feature the X-ray brightness and temperature of hot gas. This galaxy might correlate with an original clump that features three isomers. One isomer would be the ordinary matter isomer. Around the time that the galaxy stopped accruing material, there was - near the galaxy - essentially nothing left for the galaxy to attract via 4(6)G4.
- The galaxy XMM-2599 stopped producing visible stars by approximately 1.8 billion years after the Big Bang. (See reference [44].) People speculate regarding a so-called quenching mechanism. Proposed theory suggests that phenomena similar to phenomena that might pertain regarding Markarian 1216 might pertain regarding XMM-2599.

People report other data. Table 68 and table 77 seem not to be incompatible with these results. We are uncertain as to the extents to which proposed theory provides insight that ongoing theory does not provide.

- One example features a rotating disk galaxy, for which observations pertain to the state of the galaxy about 1.5 billion years after the Big Bang. (See reference [45].) People deduce that the galaxy originally featured dark matter and that the galaxy attracted ordinary matter.
- One example features so-called massive early-type strong gravitation lens galaxies. (See reference [46].) Results suggest, for matter within one so-called effective radius, a minimum ratio of dark matter to dark matter plus ordinary matter of about 0.38. Assuming, for example, that measurements correlating with material within larger radii would yield larger ratios, these observational results might support the notion that the galaxies accumulated dark matter over time.
- One example pertains to early stages of galaxies that are not visible at visible light wavelengths. (See reference [47].) Observations feature sub-millimeter wavelength light. We might assume that proposed theory galaxy formation scenarios comport with such galaxies. We are not certain about the extent to which proposed theory might provide insight regarding subtleties, such as regarding star formation rates, correlating with this example.
- We are uncertain as to the extent to which proposed theory might provide insight regarding possible inconsistencies - regarding numbers of observed early stage galaxies and numbers of later stage galaxies - that correlate with various observations and theories. (For a discussion of some possible inconsistencies, see reference [48].)

- We are uncertain as to the extent to which proposed theory might provide insight regarding the existence of two types - born and tidal - of ultra-diffuse galaxies. (See reference [49].)

Observations that we discuss above indicate that some galaxies do not exhibit dark matter halos. Proposed theory that we discuss above comports with the notion that some galaxies do not exhibit dark matter halos.

5.3.14. Aspects regarding some components of galaxies

We discuss other effects, within galaxies, that might correlate with dark matter.

People study globular cluster systems within ultra-diffuse galaxies. Regarding 85 globular cluster systems in ultra-diffuse galaxies in the Coma cluster of galaxies, reference [50] suggests that 65 percent of the ultra-diffuse galaxies are more massive than people might expect based on ongoing theory relationships, for so-called normal galaxies, between stellar mass and halo mass. We are uncertain as to the extent to which proposed theory might explain this result. For example, proposed theory might suggest that phenomena related to isomers might play a role. (See, for example, table 77.) Higher-mass galaxies might tend to feature more dark matter isomers (or tend to feature more material that correlates with such isomers) than do lower-mass galaxies.

Discussion related to table 77 is not incompatible with the notion that visible stars do not include much dark matter.

Discussion related to table 77 is not incompatible with the notion that some black holes that form based on the collapse of stars might originally correlate with single isomers. Discussion above is not incompatible with the notion that supermassive black holes might contain material correlating with more than one isomer. (Perhaps, note references [51] and [52].)

We suggest that proposed theory might provide insight about other aspects regarding black holes. People suggest gaps in understanding about the formation of intermediate-mass and large-mass black holes. (Perhaps, note reference [53].) Proposed theory suggests the possibility that the 4G(1)246 attractive component of G-family forces plays key roles in the early formation of some intermediate-mass and large-mass black holes.

Regarding the coalescing of two black holes, proposed theory suggests that people might be able to estimate the extent to which 4G48 repulsion pertains. Effects of 4G48 repulsion would vary based on the amounts of various isomers that each black hole in a pair of colliding black holes features.

5.3.15. Dark matter effects within the Milky Way galaxy

People look for possible local effects, within the Milky Way galaxy, that might correlate with dark matter.

For one example, data regarding the stellar stream GD-1 suggests effects of an object of 10^6 to 10^8 solar masses. (See reference [54].) Researchers tried to identify and did not identify an ordinary matter object that might have caused the effects. The object might be a clump of dark matter. (See reference [55].) Proposed theory offers the possibility that the object is an originally dark matter centric clump of stuff.

For other examples, people report inhomogeneities regarding Milky Way dark matter. (See references [55] and [56].) Researchers note that simulations suggest that such dark matter may have velocities similar to velocities of nearby ordinary matter stars. We suggest that these notions are not incompatible with proposed theory notions of the existence of dark matter stars that would be similar to ordinary matter stars.

5.3.16. High-mass neutron stars

We discuss proposed theory that might explain some aspects regarding high-mass neutron stars.

The following results have bases in observations. An approximate minimal mass for a neutron star might be $1.1M_\odot$. (See reference [57].) The symbol $M_\odot$ denotes the mass of the sun. An approximate maximum mass for a neutron star might be $2.2M_\odot$. (See references [58] and [59].)

Some ongoing theory models suggest a maximum neutron star mass of about $1.5M_\odot$. (See reference [59].)

Observations correlate with most known neutron star pairs having masses in the range that equation (147) shows and one neutron star pair having a mass of about 3.4 solar masses. (See references [60] and [61].) Here, M denotes the mass of a pair. The 3.4 number results from the second detection via gravitational waves of a merger of two neutron stars. People assign the name GW190425 to that detection.

$$2.5M_{\odot} \lesssim M \lesssim 2.9M_{\odot} \tag{147}$$

People speculate - based on, at least, the GW190425 result - about needs for new theory regarding neutron stars. (See references [60] and [59].)

Detection GW190814 suggests that people have inferred the existence of an object for which equation (148) pertains. (See reference [62].) People speculate that the object might have been a high-mass neutron star or might have been a low-mass black hole.

$$M \approx 2.6M_{\odot} \tag{148}$$

We discuss possible bases for high-mass neutron stars.

The PR6IC span of each one of 4G4, the pie boson, and the cake boson is six.

Some high-mass seemingly ordinary matter neutron stars might include dark matter hadron-like particles. To the extent that some of the dark matter hadron-like particles have masses greater than the masses of relevant ordinary matter hadron-like particles, that extra mass might account for observations. Some 1R⊗2U dark matter hadron-like particles might have such masses. (See table 79.)

Some high-mass neutron stars might, in effect, result from mergers of neutron stars, with each merging neutron star correlating with an isomer that differs from the isomer pertaining to each other neutron star that forms part of the merger.

5.3.17. Dark energy density

We explore possible explanations for non-zero dark energy density.

Equation (149) shows an inferred ratio of present density of the universe of dark energy to present density of the universe of dark matter plus ordinary matter plus (ordinary matter) photons. (Reference [6] provides the four items of data.) From a standpoint of each of ongoing theory and proposed theory, equation (149) does not include neutrino density of the universe. From a standpoint of proposed theory, Ω_{c} includes effects correlating with 1R⊗2U hadron-like particles. (See equation (134).) From a standpoint of proposed theory, for models for which ι_I exceeds one, Ω_{c} includes effects correlating with dark matter isomers. We know of no inferences that would not comport with a somewhat steady increase, regarding the inferred ratio correlating with equation (149), from approximately zero, with time since somewhat after the Big Bang. (Communication 95c implies a ratio of approximately zero correlating with 380 thousand years after the Big Bang. Also, inferences that reference [63] discusses might suggest that dark energy density increases with time.)

$$\Omega_{\Lambda}/(\Omega_{\text{c}} + \Omega_{\text{b}} + \Omega_{\gamma}) \approx 2.3 \tag{149}$$

Some aspects of ongoing theory correlate inferred dark energy densities of the universe with phenomena correlating with terms such as vacuum energy, vacuum fluctuations, or quintessence. Proposed theory is not necessarily incompatible with notions such as vacuum energy. However, double-entry aspects of proposed theory point to possibilities for modeling that does not embrace notions such as vacuum energy.

Aspects related to aye (or, 0I) bosons might lead to phenomena similar to effects that ongoing theory correlates with quintessence. (See discussion related to equation (100).) Ongoing theory correlates some of those effects with data about dark energy densities. To the extent that phenomena correlating with aye bosons suffice to explain dark energy densities, there might not be a need to consider PR36IC modeling. Assuming that such phenomena might not adequately explain non-zero dark energy density, we discuss possibilities for other proposed theory aspects that might explain non-zero dark energy density.

For PR6IC modeling, proposed theory includes the notion of 2(6)G248, whereas ongoing theory correlates with the notion of 2(1)G248. We suggest that the difference, in proposed theory, between 2(6)G248 and 2(1)G248 might correlate with nature's indirectly producing effects, regarding CMB, that people correlate, via ongoing theory, with some non-zero dark energy density. The difference correlates with interactions between ordinary matter and dark matter.

For PR36IC modeling, differences between 2(>1)GΓ and 2(1)GΓ correlate with interactions between ordinary matter plus dark matter and doubly dark matter. For example, half or somewhat less than half of the effect that reference [17] reports correlates with 2G68 interactions correlating with one doubly dark matter isomer of hydrogen atoms. Also, any span-36 phenomena would correlate with interactions between ordinary matter plus dark matter and doubly dark matter. Neutrinos, 1R⊗2U hadron-like particles, and aye simple bosons might provide for such interactions. (See table 65.) Dark energy density might correlate with a notion of dark energy stuff. Much of the dark energy stuff would correlate with doubly dark matter. Modeling suggests an upper bound of approximately five regarding, in effect, a possible future value for the ratio that correlates with equation (149).

Table 78: Some phenomena that people might want to add to the cosmology timeline or for which people might want to add details to the cosmology timeline

Phenomena
• Possible transition to dominance by left-handed simple fermions. (See discussion related to equation (154).)
• Production of 1R⊗2U hadron-like particles. (Possibly, the vanishing of seas composed of gluons and quarks or arcs.)
• Transition in dominance, regarding various sizes of objects, from repulsion based on 4(1)G2468a and 4(1)G2468b to attraction based on 4(1)G246. (See discussion related to table 74.)
• Earliest visible galaxies of various types that table 77 suggests.
• Achievement, by some galaxies, of approximately four to one ratios of dark matter density to ordinary matter density. (See table 77.)
• Transition in dominance, regarding various sizes of objects, from attraction based on 4(1)G246 to repulsion based on 4(2)G48. (See discussion related to table 74.)
• Transition in dominance, regarding various sizes of objects, from repulsion based on 4(2)G48 to attraction based on 4(6)G4. (See discussion related to table 74.)

6. Discussion: established ongoing theory and core proposed theory

This unit discusses possibilities for adding aspects of core proposed theory to established ongoing theory.

6.1. The elementary particle Standard Model

We explore synergies between proposed theory and the elementary particle Standard Model.

People might try to add to the Standard Model some of the symmetries that proposed theory suggests. Examples include conservation of charge and somewhat conservation of fermion generation.

People might try to add to the Standard Model some of the simple particles and root forces that proposed theory suggests.

People might try to add to the Standard Model the 1R⊗2U hadron-like particles that proposed theory suggests.

Proposed theory might provide a basis for extending the Standard Model to include concepts related to mass and to forces that correlate with bosons that have spins of at least two.

This essay does not speculate regarding the extent to which people might find synergies between Lagrangian aspects of the Standard Model and modeling that proposed theory suggests regarding refraction. (See discussion related to equation (63).)

This essay does not speculate regarding the extent to which people might be able to add concepts related to isomers to Lagrangian aspects of the Standard Model.

6.2. Concordance cosmology

We discuss aspects that people might want to add to concordance cosmology.

We note aspects that discussion elsewhere in this essay de-emphasizes.

- Early in the evolution of the universe, quarks, arcs, and gluons formed hadron-like seas. The seas might have undergone phase changes, with the last changes featuring at least one transition from seas to hadron-like particles.
- Scenarios regarding clumping suggest that a significant fraction of early black holes contained stuff correlating with essentially just one isomer. Regarding PR6IC modeling, approximately one-sixth of such one-isomer black holes feature ordinary matter and approximately five-sixths of such one-isomer black holes feature dark matter.
- Proposed theory is not necessarily incompatible with an ongoing theory notion of possible large-scale flatness for the universe.

Table 78 suggests some phenomena that people might want to add to the cosmology timeline or for which people might want to add details to the cosmology timeline.

6.3. Large-scale physics

Ongoing theory concepts that people use to try to model observed changes in the rate of expansion of the universe include the Hubble parameter (or, Hubble constant), equations of state (or, relationships between density and pressure), and general relativity.

While general relativity comports with various phenomena, people discuss possible problems regarding the applicability of general relativity to large-scale physics. (See, for example, reference [64].)

People suggest possible incompatibilities between observations and ongoing theory modeling. (See, for example, reference [65], reference [66], reference [67], and communication 95d. However, some people note possible objections to some notions of incompatibility. See, for example, references [68] and [69].) People suggest phenomenological remedies regarding the modeling. (See, for example, reference [70].)

Proposed theory offers possible insight and resolution regarding such concerns.

We consider modeling that might pertain to large-scale phenomena for other than the very early universe. We assume that general relativity pertains regarding PR1IC modeling, including 4γ aspects of PR1IC modeling.

We consider the case of PR6IC modeling.

We assume that galaxy clusters tend to have equal amounts of stuff correlating with each of the six isomers.

We consider modeling that includes both the multi-billion-year era of decreasing rate of expansion of the universe and the current multi-billion-year era of increasing rate of expansion of the universe. The 4G246 attractive component of 4γ has a span of one isomer. The 4G48 repulsive component of 4γ has a span of two isomers. Tuning a model to the era of decreasing rate might produce a model that underestimates repulsive effects that lead to the increasing rate that correlates with the current era.

We generalize. Regarding the large-scale universe and motions of objects, one might need to limit applications of equations of state and general relativity to motions of objects that modeling can treat as having a span of six and as having roughly equal amounts of stuff correlating with each isomer.

We explore a possible concern regarding smaller objects.

We consider modeling regarding black holes and neutron stars. To the extent that a black hole or neutron star includes significant amounts of material correlating with each of at least two isomers, modeling - based on general relativity - for gravitational effects regarding high-outflow phenomena might be less than adequately accurate. Inaccuracy might occur, for example, to the extent that the outflow material does not interact via 4G48 with an isomer for which the black hole or neutron star has a significant amount. People observe high-outflow phenomena related to - for example - quasars, blazars, and pulsars.

We consider the case of PR36IC modeling.

Six isomers of 4(6)G4 pertain. General relativity might pertain somewhat for each of the six PR6IC-like isomers. The concept of geodesic motion would not pertain across PR6IC-like isomers.

6.4. The masses of 1R⊗2U hadron-like dark matter particles

We discuss rest energies for 1R⊗2U hadron-like particles.

The rest energy of a proton does not differ much from the rest energy of a neutron. For hadrons composed of generation-one quarks, the masses of hadrons do not vary much based on the masses of the quarks or on the charges of the quarks. The rest energies of 1R⊗2U hadron-like particles that contain exactly three arcs might approximate the rest energy of the proton, which is about 938 MeV. (Reference [6] provides data regarding hadron masses.) The rest energies of 1R⊗2U hadron-like particles that contain exactly two arcs might approximate the rest energy of the zero-charge pion, which is about 135 MeV.

We explore another concept for estimating masses for 1R⊗2U hadron-like particles. The concept has bases in the relative densities of the universe of 1Q⊗2U hadrons and 1R⊗2U hadron-like particles.

Nature might have created concurrently, essentially, the current populations of 1Q⊗2U hadrons and 1R⊗2U hadron-like particles. We assume that each of 1Q⊗2U hadrons and 1R⊗2U hadron-like particles consists mainly of three-fermion particles. We explore three cases, in which, respectively, the span, s, of 1R⊗2U is one, six, and 36. (See table 65a.) A span of one correlates with PR1IC modeling. A span of six correlates with PR6IC modeling and might correlate with PR36IC modeling. A span of 36 might correlate with PR36IC modeling. Equation (150) might estimate the current relevant ratio of density of 1R⊗2U hadron-like particles to density of ordinary matter. The symbol $m\_$ denotes the rest mass of a typical hadron-like particle. The leftmost use of the ratio $m_{1\mathrm{R}\otimes 2\mathrm{U}}/m_{1\mathrm{Q}\otimes 2\mathrm{U}}$ correlates with rest energy (or rest mass) per particle. The rightmost use of the ratio $m_{1\mathrm{R}\otimes 2\mathrm{U}}/m_{1\mathrm{Q}\otimes 2\mathrm{U}}$ occurs as the input to a calculation of an exponential and correlates with a hypothesis regarding the relative number of particles that nature created.

Table 79: Possible rest energies for 1R⊗2U hadron-like particles

Possible rest energies (in GeV) for 1R⊗2U
1. ~ 0.009.
2. ~ 0.06.
3. ~ 0.6.
4. ~ 0.9.
5. ~ 1.5.
6. ~ 4.4.
7. ~ 6.6.
8. Other.

Table 80: PST, PSC, and PSP transformations (regarding PS ALG modeling)

Swap (for each odd j' and with $j'' = j' + 1$)	Swap	Swap pertains for the transformation		
		PST	PSC	PSP
$n_{TAj'}$ and $n_{TAj''}$	-	Yes	Yes	No
-	n_{TA0} and n_{SA0}	No	No	No
$n_{SAj'}$ and $n_{SAj''}$	-	No	Yes	Yes

$$\Omega_{\mathrm{ib}}/(\mathrm{s} \cdot \Omega_{\mathrm{b}}) \sim (m_{1\mathrm{R}\otimes 2\mathrm{U}}/m_{1\mathrm{Q}\otimes 2\mathrm{U}}) \exp(-m_{1\mathrm{R}\otimes 2\mathrm{U}}/m_{1\mathrm{Q}\otimes 2\mathrm{U}}) \tag{150}$$

The respective values of $\Omega_{\mathrm{ib}}/(\mathrm{s} \cdot \Omega_{\mathrm{b}})$ are ~ 0.33, ~ 0.054, and ~ 0.0090. For each value of s, two mathematical solutions exist. The respective solutions, expressed in terms of m_c^2 and in units of GeV are ~ 0.6 and ~ 1.5, ~ 0.06 and ~ 4.4, and ~ 0.009 and ~ 6.6.

Table 79 summarizes some possible rest energies for 1R⊗2U hadron-like particles.

6.5. *CPT-related symmetries*

We discuss some proposed theory symmetries and some aspects of ongoing theory CPT-related symmetries.

Ongoing theory includes notions of C (or, charge-reversal) transformation and approximate symmetry, P (or, parity-reversal) transformation and approximate symmetry, and T (or, time-reversal) transformation and approximate symmetry. KS modeling pertains. In ongoing theory, invariance under CPT transformation pertains.

Table 80 defines proposed theory PST, PSC, and PSP transformations. The table pertains for PS ALG modeling. PST abbreviates the four-element phrase PS modeling T transformation. PSC abbreviates the four-element phrase PS modeling C transformation. PSP abbreviates the four-element phrase PS modeling P transformation. (Table 80 does not necessarily correlate directly with table 36, which correlates with KS modeling.)

Table 81 suggests correlations between aspects of table 80 and ongoing theory KS notions of T, C, and P approximate symmetries.

A significant difference between PSC symmetry and C symmetry might pertain and might correlate with gluons and with color charge. A significant difference between PSP symmetry and P symmetry might pertain and might correlate with gluons and with color charge.

Table 81: Ongoing theory KS modeling T, C, and P transformations, in a context of proposed theory PS ALG modeling

Swap (for each odd j' and with $j'' = j' + 1$)	Swap	Swap pertains for the transformation			Transformation and swap pertain for gluons and color charge		
		T	C	P	T	C	P
$n_{TAj'}$ and $n_{TAj''}$	-	Yes	Yes	No	No	No	No
-	n_{TA0} and n_{SA0}	No	No	No	No	No	No
$n_{SAj'}$ and $n_{SAj''}$	-	No	Yes	Yes	No	No	No

People might want to consider implications of the possibility that conservation of each of PST, PSC, and PSP pertains more exactly than does conservation of (respectively) T, C, and P. This possibility might explain aspects of the strong CP problem. (Regarding CP violations, see, for example, reference [71]. Regarding the strong CP problem, see discussion related to table 85.)

7. Discussion: unverified ongoing theory and core proposed theory

This unit discusses possibilities that core proposed theory provides insight regarding unverified aspects of ongoing theory.

7.1. Supersymmetry

Table 9 might suggest possibilities for some notion of symmetry based on equation (151). Here, the symbol $\leftrightarrow$ correlates with notions of exchanging roles. Table 9 might suggest possibilities for some notion of symmetry based on equation (152). For some relevant nonnegative values of Σ, table 9 might not suggest possibilities for a relevant notion of symmetry based on equation (153).

$$\text{free} \leftrightarrow \text{unfree} \tag{151}$$

$$m \dot{>} 0 \leftrightarrow m \doteq 0 \tag{152}$$

$$\Sigma \leftrightarrow \Sigma + 1 \tag{153}$$

Tables 9 and 64 seem, in themselves, to be incompatible with supersymmetry. People might explore the notion of layering supersymmetry over results that tables 9 and 64 show. However, given aspects of proposed theory, supersymmetry might not be necessary to explain known phenomena.

7.2. String theory

We discuss the notion that aspects of proposed theory might help people explore the relevance of string theory to elementary particle physics.

We suggest that would-be applications of string theory to elementary particle physics, correlate with KS modeling. Regarding physics modeling, proposed theory adds, compared to ongoing theory, the notion of PS modeling. To the extent that string theory continues not to output a well-defined, potentially-complete list of elementary particles, people might want to explore reusing or extending string theory mathematics to incorporate PS aspects along with KS aspects.

People might want to explore possible correlations between string theory notions of so-called frothiness of space-time and aspects of PS modeling. PS PDE modeling includes notions of both odd integer D^*_{XA} and even integer D''. Perhaps people can correlate notions of frothiness with this duality. PS ALG modeling includes notions of channels and (at least, mathematical) transitions that might correlate with conceptually transient $SU(2)$ symmetries. Perhaps people can correlate notions of frothiness with modeling correlating with such transient symmetries.

We suggest perspective about string theory and about proposed theory. (Reference [72] provides perspective about string theory.) Regarding simple particles and root forces, proposed theory correlates with the three-word term theory of what. Proposed theory outputs a list of what elementary particles nature embraces or might embrace. We contrast notions of a theory of what with notions correlating with the three-word term theory of how. Proposed theory might not yet suggest a theory of how nature selects or forms elementary particles. Attempts to apply string theory to elementary particle physics might correlate with trying to develop a theory of how and trying to use the theory of how to produce a theory of what.

7.3. Speculation regarding phenomena before inflation

We speculate about phenomena that might have preceded the inflationary epoch.

Proposed theory correlates an $SU(5)$ symmetry with conservation of energy. The number of generators of $SU(5)$ is 24. Equation (154) might pertain. Here, $g_{U(1)}$ denotes the number of generators for $U(1)$ and equals two. The number 24 equals six times two times two.

$$(g_7/g_3) \times g_{U(1)} \times g_{U(1)} \tag{154}$$

One factor of two might correlate with the possibility for two values of handedness for leptons.

Table 82: Aspects of a possible superset of a so-called theory of everything

Aspects
• Theory that lists properties of elementary particles and of other objects.
• Theory that lists elementary particles.
• Theory that embraces or integrates theories of motion.
• Theory that unifies the aspects above.

One factor of two might correlate with the possibility for two values for handedness for baryons.

We discuss two possibilities regarding the factor of six.

The factor of six might correlate with the relevance of six isomers regarding color charge. Specifically, the factor of six might correlate with a $\pi_{r,b,g}$ symmetry correlating with red, blue, and green color charges and with oscillators SA0, SAo, and SAe. (See table 51.) Here, six equals three times two. There are three possibilities regarding the color charge associated with SA0. For each of the three possibilities, there are two possibilities for the color charge associated with SAo.

The factor of six might correlate with the relevance of six isomers regarding mass (or energy). Here, from the perspective of PR1IC modeling, PR36IC modeling pertains. Conservation of energy might pertain across all isomers but not within each isomer.

To the extent that such aspects correlating with the $SU(5)$ symmetry comport with nature, one might consider models that suggest 24 somewhat similar entities. For the case of relevance of six isomers regarding color charge, people might correlate the two-word term our universe with one of the 24 somewhat similar entities. For the case of relevance of six isomers regarding mass, people might correlate the two-word term our universe with one of the four somewhat similar entities that correlate with PR36IC modeling.

We note, but do not pursue further, the possibility that theory might correlate, with the Big Bang, a transition that involves, in effect, a decoupling of the possible 24 somewhat similar entities (for the case of isomers of color charge) or of the possible four somewhat similar entities (for the case of isomers of mass).

7.4. Theory of everything

We speculate that proposed theory points toward possibilities for a superset of a so-called theory of everything.

People discuss the notion of a single theory that would describe much of fundamental physics. Within this context, people use the three-word term theory of everything to allude to theory that would unify quantum mechanics and general relativity.

We suggest that such a use of the term theory of everything might correlate with overlooking key aspects of nature. In the context of proposed theory and ongoing theory, that use of the term theory of everything might correlate with a notion of a unified theory of motion and might overlook the topic of objects that move.

Table 82 notes aspects of a possible superset of a so-called theory of everything.

The superset correlates, at the least, with the notion of a theory of what. The superset does not necessarily correlate with a theory of how nature, in effect, selects or creates properties of objects, elementary particles, or relevant aspects regarding motion.

People characterize some ongoing theory candidates for a ToE (or, theory of everything) by groups with which the candidates correlate.

We discuss the possibility that people can find a group theoretic statement that correlates with the superset. We structure this discussion based on the rows in table 82.

We suggest that the properties portion of our work correlates with the group $SU(17)$.

Table 83 illustrates the notion that table 36 correlates with the group $SU(17)$ and with six applications of equation (36).

Table 84 lists aspects that might support the notion that people might find a group theoretic expression that correlates with the list of elementary particles that nature includes.

Notions above may suffice to embrace any theory of motion - including classical physics theories and quantum physics theories - that comports with six isomers of charge, conservation of energy, conservation of momentum, and conservation of angular momentum. (Regarding six isomers of charge, see table 83a. The notion of six isomers of charge correlates with the notion that one might need to limit the range of applicability of modeling based on general relativity.) Notions above include quantum gravity - as

Table 83: Possible correlation between properties and an $SU(17)$ symmetry

(a) Possible correlations between properties and subgroups of $SU(17)$

$j_1 + j_2$	j_1	j_2	Use of $SU(j_2)$	Use of $U(1)$
17	15	2	Charge	Conservation of charge
15	11	4	Rest energy minus freeable energy	Conservation of rest minus freeable energy
11	9	2	3LB number	Conservation of 3LB number
9	7	2	Momentum	Conservation of momentum
7	5	2	Angular momentum	Conservation of angular momentum
5	3	2	Isomers of charge	Isomers of charge
3	-	3	$SU(3)$ strong interaction symmetry	-

(b) Notes regarding table 83a

Notes
• For the first row (in table 83a), the value of 17 for $j_1 + j_2$ equals the 17 in the expression $SU(17)$.
• For each row (in table 83a) after the first row, $j_1 + j_2$ equals j_1 for the immediately preceding row. (Note equation (36).)
• For the first five rows (in table 83a), the $U(1)$ item correlates both with an exact (not somewhat) conservation law and with an ability to sum the property (that the $SU(j_2)$ item shows) across values for components of a multicomponent object.
• For the first four rows (in table 83a) for which $j_2 = 2$, the SA-side count column in table 36a interprets the three generators of $SU(2)$.
• For the sixth row (in table 83a) and for PR6IC modeling or PR36IC modeling, the multiplicative product of three generators for $SU(2)$ and two generators for $U(1)$ correlates with a number, six, of isomers of charge. (Regarding the notions of six isomers of mass and PR36IC modeling, see discussion related to equation (154).)

Table 84: Aspects that might support the notion that people might find a group theoretic expression that correlates with the list of elementary particles that nature includes

Aspects
• The notion that table 83 correlates with a group, $SU(17)$.
• A link from table 83 to table 36.
• A link from XA in table 36 to representations for almost all elementary bosons. (G-family mathematics seems to point to all elementary bosons other than the gluons, pie, and cake bosons. See discussion related to tables 40 and 48 and discussion related to equation (126).)
• A possible link - via PDE modeling, between G-family mathematics and U-family mathematics, plus the notion that U-family mathematics points to gluons and to the pie and cake elementary bosons. (See table 33.)
• A link from PDE modeling to modeling for all elementary fermions.

an aspect of core proposed theory PS modeling and with independence from classical theories (including general relativity) of motion. Classical theories of motion correlate with ongoing theory KS modeling.

Beyond notions above, we are uncertain as to the extent people might want to add group theoretic concepts related to specific theories of motion. (For example, people might treat Newtonian physics as comporting with special relativity in the limit of small velocities. If so, people might not want to add group theoretic concepts related to Newtonian physics.)

Notions above might suffice for people to state a group theoretic expression that correlates with the superset.

7.5. The strong CP problem

We discuss insight, that proposed theory might provide, regarding the strong CP problem.

Ongoing theory explores the possibility that the strong interaction contributes to violation of CP symmetry (or, charge conjugation parity symmetry). People might have yet to detect strong interaction contributions to the violation of CP symmetry. People use the three-element term strong CP problem. Theoretically, such violation might correlate with the existence of axions.

Table 85 lists aspects correlating with insight that proposed theory might provide regarding the extent to which nature includes strong CP violation. Table 85a lists aspects that people might interpret as ruling out strong interaction contributions to CP violation. Table 85b lists aspects that, if relevant, people might interpret as suggesting that the strong interaction contributes to CP violation.

7.6. Possible lacks of some unverified ongoing theory elementary particles

We discuss notions that proposed theory correlates with nature possibly not including some elementary particles that some unverified ongoing theory models suggest might exist.

7.6.1. A possible lack of magnetic monopoles

Table 64 points to no G-family solutions that would correlate with interactions with a magnetic monopole elementary particle. The lack of such G-family solutions might correlate with nature not including a magnetic monopole elementary particle. People might want to consider the notion that equation (155) expresses.

$$\text{The 2G2 solution correlates with electromagnetic (not magnetic) monopole moments.} \tag{155}$$

7.6.2. A possible lack of axion elementary particles

Each of the following statements might point to insight regarding attempting to detect axions. Proposed theory suggests the possibility that people might mistake observations of phenomena related to the difference between 2(6)G248 and 2(1)G248 for observations related to axions. (See discussion related to equation (179).) Proposed theory suggests the possibility that people might mistake observations of phenomena related to the aye (or, 0I) boson for observations related to axions. (For example, equation (143) shows an interaction that people might interpret as correlating with producing a magnetic field.)

Aspects of table 85 seem to suggest that the existence of axions would not correlate with non-zero CP violation.

To the extent that nature includes axions, proposed theory offers the possibility that axions correlate with existence of 4U forces. (Consider discussion related to table 33 and consider the possibility that the relevant ΣU forces might correlate with an identity operator. Discussion related to equations (165) and (166) might suggest a use for modeling based on 4U forces. However, proposed theory seems not to suggest the existence of 4U forces.) The masses of axions might correlate with an interaction range. (See discussion related to table 33 and discussion related to equation (71).) For an assumed interaction range of the size of a galaxy, a mass for axions would be roughly $10^{-31}eV/c^2$. (Here, we used the following assumptions. The range of the residual strong interaction is about 10^{-15} meters. A size for galaxies correlates with 10^5 light years. The number of meters per light year is 10^{16}. The mass of a pion is about $10^5 eV/c^2$. Equation (156) pertains.) For an assumed range of the size of a neutron star, a mass for axions would be roughly $10^{-14}eV/c^2$. (Here, we used a size of 10^4 meters.)

$$-31 = -15 - 5 - 16 + 5 \tag{156}$$

Table 85: Aspects correlating with insight that proposed theory might provide regarding the extent to which nature includes strong CP violation

(a) Aspects that people might interpret as ruling out strong interaction contributions to CP violation

Aspects
• Unverified ongoing theory regarding strong CP violation seems to suggest that the observed smallness of the electric dipole moment of the neutron might conflict with the notion that strong CP violation exists. Insight that proposed theory suggests might include the notion that the electric dipole moment of the neutron is, for purposes relevant to this discussion, zero. (See discussion related to equation (169).)
• Unverified ongoing theory seems to suggest that if at least one quark had zero mass, strong CP violation would not exist. Proposed theory suggests that nature includes six arc elementary fermions, each of which is a zerolike-mass zero-charge analog to one of the six quarks. People might want to consider the notion that the existence of arcs might suffice, from a standpoint of unverified ongoing theory, to rule out strong CP violation.
• Each of core ongoing theory and core proposed theory correlates weak interaction CP violation with two (or possibly more) excitations of 2W in the presence of two (or possibly more) quarks. (See discussion related to tables 25 and 26.) With respect to conservation of fermion generation (or aspects correlating with the oscillator pair TA5-and-TA6), a proposed theory representation for gluons has similarities to a proposed theory representation for the 2W subfamily. (Compare table 32 and table 25.) The mass - zero - of gluons is less than the masses of the weak interaction bosons. Seemingly, in known hadrons, multiple virtual excitations of 2U would occur more copiously than do multiple virtual excitations of 2W. To the extent that phenomena correlating with 2W reasonably adequately explain measurable CP violation in hadrons, it might be likely that nature does not exhibit CP violation catalyzed by gluons.
• Unverified ongoing theory seems to suggest that, if nature includes magnetic monopoles, strong CP violation can occur. Proposed theory suggests possible insight regarding the possible existence of magnetic monopoles. (See discussion related to equation (155).) The insight seems to suggest that nature does not include magnetic monopoles.

(b) Aspects that, if relevant, people might interpret as suggesting that the strong interaction contributes to CP violation

Aspects
• Table 81 points to aspects that might correlate with non-conservation of CP symmetry. That non-conservation might correlate with breaking a possible $\pi_{r,b,g}$ symmetry correlating with red, blue, and green color charges. (Perhaps, see discussion related to equation (68) and discussion related to table 81.) That non-conservation might correlate with breaking a proposed theory $SU(5)$ symmetry that correlates with conservation of energy. (See discussion related to equation (154).) Conservation of energy might pertain only to the extent that one includes consideration for at least two isomers of the universe that correlates with the relevant PRι_IIC modeling. (See table 63.)
• Detection of currently hypothetical so-called axion elementary particles might point to non-conservation - that might correlate with the strong interaction - of CP symmetry.
• Each of the pie and cake elementary bosons might engage in interactions that produce axions.

Table 86: Comparative features of supplementary proposed theory dynamics modeling and ongoing theory dynamics modeling

Compared to ongoing theory modeling regarding motion, use of proposed theory modeling might be ...
• As or more successful regarding describing allowed states.
• As or less successful regarding estimating - based on limited use of observed data - energies for allowed states.
• Easier or simpler - when applicable - to use.
• Based on more rigorous use of mathematics.

8. Discussion: supplementary proposed theory and established ongoing theory

This unit explores the possibility that supplementary proposed theory points to useful models for motion.

Discussion above in this essay features proposed theory suggestions regarding elementary particles and dark matter particles, plus ongoing theory modeling regarding motion. We generally assume that the proposed theory PEPT particle set and ongoing theory models for motion are adequately compatible with each other. We generally assume that the proposed theory PEPT particle set and ongoing theory models for motion are adequate for modeling relevant aspects of nature.

Discussion herein speculates about proposed theory that would have bases in core proposed theory modeling and would pertain directly to motion.

8.1. Modeling that proposed theory suggests regarding dynamics

Table 16 alludes to possible proposed theory applications, based on mathematics that underlies PDE modeling, to aspects of nature beyond the application correlating with matching known and suggesting new elementary particles.

We use the term CQFT to denote results from developing, from PS modeling, a possibly useful somewhat analog to ongoing theory QFT (or, quantum field theory). The acronym CQFT correlates with the four-word term complementary quantum field theory. Ongoing theory QFT modeling correlates with the notion of KS modeling. CQFT would feature KS modeling. (See table 5.)

We do not necessarily expect that proposed theory models for motion duplicate ongoing theory models for motion. Ongoing theory models tend to be linear in energy. Ongoing theory quantum models for motion tend to be linear in $\hbar$. Proposed theory models for motion tend to be quadratic in energy. Proposed theory quantum models tend to be quadratic in $\hbar$. (Note, for example, that Ω_{SA} in equation (4) can correlate with the expression $S(S+1)\hbar^2$.) Indeed, we anticipate that CQFT might include models that feature potentials or that CQFT might point to models that feature potentials.

We do not necessarily expect that proposed theory aspects that seem to have parallels to ongoing theory QFT (or, quantum field theory) need to comply with special relativity. (Regarding ongoing theory, reference [73] discusses a definition of QFT that does not necessarily imply a correlation with special relativity.)

Table 86 compares aspects of supplementary proposed theory dynamics modeling and aspects of ongoing theory dynamics modeling.

8.1.1. CQFT interaction vertices that involve simple particles and root forces

We explore notions that underlie possible CQFT modeling regarding interaction vertices. (See the second row in table 16. Perhaps, see aspects, that mention $\nu_{SA} < 0$, of table 17.)

This work generalizes from work above that, nominally, pertains for free simple particles. Equations (39) and (40) pertain regarding all simple particles and all root forces. We posit that results - regarding some roles for ν_{SA}, ν_{TA}, and ν'' - from that work extend to all simple particles and all root forces. (See, for example, table 18b.)

Table 87 lists types of interaction vertices that proposed theory includes. Here, in the symbol nf, n denotes a number of simple fermions. In the symbol nb, n denotes a number of simple bosons and root forces. A symbol of the form a↔b denotes two cases, namely a→b and b→a. A symbol of the form a→b denotes the notion that the interaction de-excites each component of a by one unit and excites each component of b by one unit. (Note, for example, that de-excitation of a photon mode does not necessarily produce a ground state.) For each type of interaction vertex, the effective ν is the sum, over incoming field solutions, of the relevant $\nu\_$ and is also the sum, over outgoing field solutions, of the relevant $\nu\_$.

Table 87: Interaction vertices for interactions involving only simple particles and root forces (with ν denoting the effective ν)

Interaction	ν	Example
0f+1b↔2f+0b	-1	A Z boson creates a matter-and-antimatter pair of fermions.
1f+1b↔1f+1b	$-3/2$	An electron and a W^{+3} boson produce a neutrino.
1f+1b↔3f+0b	$-3/2$	Three antimatter fermions produce a matter fermion and a boson.
(3f+0b↔3f+0b)	$-3/2$	-
0f+nb↔0f+nb, for n≥2	$-n$	A Higgs boson creates two photons.

In effect, the value of effective ν can correlate with aspects of a product of solutions of the form that equation (6) shows. The case 3f+0b↔3f+0b pertains mathematically, but does not explicitly involve bosons. We are uncertain, in the current context, as to the possible relevance of 3f+0b↔3f+0b. In a broader context, 3f+0b↔3f+0b might point toward possibilities for extending work herein.

CQFT posits that the notion of 3f does not necessarily violate ongoing theory notions of fermion statistics. CQFT features aspects that appear to aggregate QFT interactions. (For one example, CQFT does not necessarily require notions of virtual particles. For this example, CQFT appears to aggregate numerous QFT Feynman diagrams. For another example, CQFT points toward modeling that replaces bosons with potentials.) Leaving aside the notion of aggregation, 3f can involve dissimilar elementary fermions. Dissimilarity can correlate with differences regarding generations; matter and antimatter; and (if nothing else) types of simple particle - neutrino, charged lepton, quark, or arc.

We discuss an example that contrasts established ongoing theory QFT and supplementary proposed theory CQFT.

Proposed theory can accommodate, for the weak interaction, modeling that does not require the notion of virtual particles. Equation (157) shows an ongoing theory 1f+1b↔1f+1b vertex. A muon transforms into a matter neutrino and a W boson. Equation (158) shows an ongoing theory 1f+1b↔1f+1b vertex. The W boson transforms into an electron and an antimatter neutrino. Core proposed theory can accommodate that modeling. Supplementary proposed theory can accommodate that modeling and can accommodate the 1f+1b↔3f+0b vertex that equation (159) shows. Equation (159) does not show a virtual particle such as a W boson. Modeling based on equation (159) can be useful. However, modeling based just on equation (159) would not support research that estimates properties of the W boson and would not necessarily estimate the strength of the interaction that equation (159) shows.

$$\mu^{-3} \rightarrow \nu^{0} + \mathrm{W}^{-3} \tag{157}$$

$$\mathrm{W}^{-3} \rightarrow \mathrm{e}^{-3} + \bar{\nu}^{0} \tag{158}$$

$$\mu^{-3} + 0\mathrm{I}^{0} \rightarrow \nu^{0} + \mathrm{e}^{-3} + \bar{\nu}^{0} \tag{159}$$

8.1.2. Supplementary proposed theory dynamics modeling for multicomponent objects

We discuss the possibility that CQFT extends to include interactions involving objects that are not elementary particles.

For proposed theory modeling of interactions that involve simple particles and root forces in free environments, the KS PDE notion of the mathematical limit expression $(\eta_{SA})^2 \rightarrow 0$ pertains. (See discussion related to equation (10).) Here, $(\eta_{TA})^2 \rightarrow 0$ pertains. We say that the vertex models as being point-like with respect to KS coordinates. Here, point-like refers to the temporal coordinate and refers to either a radial spatial coordinate or three spatial coordinates.

An example of modeling of interactions that involve simple particles in so-called confined environments might feature modeling regarding interactions with a quark that exists within a proton.

For proposed theory modeling of interactions that involve simple particles and root forces in confined environments, the PDE notion of $(\eta_{SA})^2 > 0$ can pertain. The expression that equation (160) shows might correlate with the size of the multicomponent object that correlates with the term confined environment. We say that the vertex models as being volume-like with respect to coordinates. Here, volume-like refers to, at least, either a radial spatial coordinate or three spatial coordinates. Volume-like correlates also with a non-point-like domain for the temporal coordinate.

$$|\eta_{SA}| \tag{160}$$

Table 88: PDE symbols and, for modeling related to physics dynamics, dimensions correlating with terms

Symbol	Discussion	Dimensions - square of ...	Related constant
ξ'_{SA}	$\xi'_{SA}\Omega_{SA} \propto S(S+1)\hbar^2$	Angular momentum	$\hbar^2$
$\xi'_{SA}(\eta_{SA})^{-2}$		Momentum	
$\xi'_{TA}(\eta_{TA})^{-2}$		Energy	
$(\eta_{SA})^2/(\eta_{TA})^2$		Velocity	c^2
$\xi'_{SA}(\eta_{SA})^{+2}$		Angular momentum times length	
$\xi'_{TA}(\eta_{TA})^{+2}$		Energy times square of time	

We discuss some aspects of proposed theory modeling. (These remarks tend to correlate with the last row in table 16. However, some of these remarks pertain regarding the existence of elementary particles and regarding the first row in table 88. See discussion regarding table 33 and the pie and cake simple bosons.)

Table 88 notes aspects of PDE mathematics that can pertain for dynamics modeling and $\nu_{SA} \geq 0$. In table 88, the associations that the first row shows provide a basis for the remaining rows. The row that notes $\xi'_{SA}(\eta_{SA})^{+2}$ might point to a series - momentum, angular momentum, and angular momentum times length.

PDE-based modeling might correlate with some aspects of unification of the strong, electromagnetic, and weak interactions. We consider modeling for which $2\nu_{SA}$ is a non-negative integer. Based on the r^{-2} spatial factor, the V_{-2} term might correlate with the square of an electrostatic potential. (See table 6.) Based on the r^2 spatial factor, the V_{+2} term might correlate (at least, within hadrons) with the square of a potential correlating with the strong interaction. The sum $K_{0a} + K_{0b}$ might correlate with the strength of the weak interaction. (The effective range of the weak interaction is much smaller than the size of a hadron. Perhaps, the spatial characterization r^0 correlates with an approximately even distribution, throughout a hadron, for the possibility of a weak interaction occurring.) Based on the V_{-2} term, we expect that ξ'_{SA} includes a factor $\hbar^2$.

Electrostatics includes each of interactions that attract objects to each other and interactions that repel objects from each other. One might consider the possibility that, in some modeling, the term proportional to Ω_{SA}/r^2 might seem to allow for repulsion, but not for attraction. (See equations (3) and (4).) However, when equations (15), (161), and (162) pertain, one can swap the Ω_{SA}/r^2 term and the Ω_{TA}/t^2 term in equation (15). The swap leads, in effect, to a new Ω_{SA}/r^2 that has the opposite sign as the old Ω_{SA}/r^2. The new Ω_{SA}/r^2 would correlate with attraction. For some aspects of modeling, equations (163) and (164) pertain.

$$(t/\eta_{TA})^2 = (r/\eta_{SA})^2 \tag{161}$$

$$\xi'_{TA} = \xi'_{SA} \tag{162}$$

$$t^2/(2(\eta_{TA})^2) + r^2/(2(\eta_{SA})^2) = tr/(|\eta_{TA}| \cdot |\eta_{SA}|) \tag{163}$$

$$v_c = |\eta_{SA}|/|\eta_{TA}| \tag{164}$$

A swap, regarding the TA-side $(\eta_{TA})^{-2}t^2$ term and the SA-side $(\eta_{SA})^{-2}r^2$ term, could lead to modeling that pertains to some aspects of repulsion. (See, for example, table 33.) Absent this swap, modeling regarding hadrons in a multi-hadron atomic nucleus, might correlate with the attractive component of the residual strong force. With this swap, modeling regarding hadrons in a multi-hadron atomic nucleus, might also correlate with the repulsive component of the residual strong force.

We anticipate exploring notions correlating with the third and fourth rows in table 16.

8.1.3. Dynamics models for hadron-like particles

We discuss the notion that each hadron-like particle that includes no more than three quarks (or, 1Q particles) and arcs (or, 1R particles) does not include both quarks and arcs.

Discussion related to table 45 suggests that a hadron-like particle has a charge for which the magnitude is either zero or a non-zero integer multiple of $|q_\epsilon|$ and has a baryon number that is either zero or a non-zero integer multiple of one. For a hadron-like particle that includes no more than three quarks and arcs, the restrictions to integer charge and integer baryon number preclude the simultaneous presence of more than zero quarks and more than zero arcs.

A tetraquark might contain a matter-and-antimatter pair of quarks and a matter-and-antimatter pair of arcs.

We discuss modeling for dynamics in hadrons that contain no more than three quarks.

Ongoing theory QCD (or, quantum chromodynamics) modeling correlates with symmetries, for each of quarks and gluons, that correlate with special relativity.

We explore the notion that proposed theory suggests possibilities for modeling that correlates, with each of quarks and gluons, a less than full set of symmetries correlating with special relativity.

Modeling for a free hadron requires two TA-side $SU(5)$ symmetries and four SA-side $SU(2)$ symmetries. (See discussion - regarding combining two objects to form one free object - related to table 38. There, we assume that the original two objects are objects that can model as being free objects. Here, we do not assume that the original objects necessarily can model as being free. Here, we retain the notions of a set of kinematics symmetries for the motion of a combined object and a set of kinematics symmetries for internal aspects of the same combined object.) Proposed theory suggests that each one of bosons (within the hadron) and simple fermions (within the hadron) can contribute one TA-side $SU(5)$ symmetry and two SA-side $SU(2)$ symmetries. One TA-side $SU(5)$ symmetry and two SA-side $SU(2)$ symmetries correlate with modeling for the free hadron. The other TA-side $SU(5)$ symmetry correlates with modeling for dynamics regarding internal aspects of the hadron. For each one of bosons and simple fermions, modeling might correlate with just one SA-side $SU(2)$ symmetry.

This proposed theory dynamics modeling correlates with the notion that neither one of quarks and gluons behaves like free simple particles. Proposed theory suggests that a hadron-like particle must include at least two (non-virtual) unfree fermions. (The notion of virtual correlates with ongoing theory. Core proposed theory can work in conjunction with modeling that includes the notion of virtual fermions and in conjunction with modeling that does not include the notion of virtual fermions.)

We discuss notions that might correlate with modeling that might output masses for hadrons.

References [74] and [75] suggest opportunities to improve understanding regarding modeling that might explain the masses of hadrons such as protons. Proposed theory suggests concepts that might help regarding such opportunities. One concept correlates with avoiding relying on modeling that correlates with special relativity. (See discussion nearby above.) One concept correlates with equations (3) and (4) and with $D = 3$. Here, the term that is proportional to r^2 might correlate with the square of a potential. For a two-quark hadron, the potential associated with one quark affects the other quark. For a three-quark hadron, the potential associated with two quarks affects the third quark.

We discuss modeling for dynamics in hadrons that contain more than three quarks.

Reference [76] suggests that some of the dynamics within at least some pentaquarks correlates with the dynamics for a system composed of a meson-like particle and a baryon-like particle. The meson-like particle features a matter quark and an antimatter quark. The baryon-like particle features three matter quarks. Aspects that proposed theory correlates with the pie simple particle and with the cake simple particle might play roles in such dynamics.

Modeling might consider that, if hexaquarks exist, some hexaquarks have parallels to atomic nuclei.

8.1.4. Dynamics models for nuclear physics

We discuss possibilities for developing proposed theory models for atomic nuclei.

Ongoing theory bases some aspects of modeling on notions of a Pauli exclusion force and on notions of a Yukawa potential. Ongoing theory correlates these effects with notions of a residual strong force. The Pauli exclusion force keeps hadrons apart from each other. The Yukawa potential attracts hadrons to each other. Modeling suggests virtual pions as a source for the Yukawa potential.

Reference [77] expresses concerns regarding modeling some aspects of nuclear physics based on the notion of virtual pions.

Core proposed theory PS modeling and established ongoing theory KS modeling can pertain. Here, KS modeling includes a Pauli exclusion force and a notion of virtual pions.

Supplementary proposed theory KS modeling does not correlate with a Pauli exclusion force or with notions of virtual pions.

From a standpoint of modeling, pie (or, 0P) bosons might correlate with attraction between hadrons. (See discussion related to table 33.) The attraction might correlate with a PDE-centric expression proportional to the term that equation (165) shows. (See discussions related to equations (163) and (160).)

$$\exp(-tr/(|\eta_{TA}|\cdot|\eta_{SA}|)) \to \exp(-r/|\eta_{SA}|) \tag{165}$$

Cake (or, 0K) bosons might correlate with repulsion between hadrons. (See discussion related to table 33.) A potential correlating with equation (166) might pertain. For this case, the scale length $|\eta_{SA}|$ would be less than the scale length pertaining to the 0P centric Yukawa potential.

$$\exp(-tr/(|\eta_{TA}|\cdot|\eta_{SA}|)) \to \exp(-r/|\eta_{SA}|) \tag{166}$$

People might try to develop models, for atomic nuclei, based on potentials that correlate with spatial aspects of equations (165) and (166).

Some ongoing theory modeling for atomic nuclei correlates with potentials similar to harmonic oscillator potentials. Speculatively, people might try to develop models based on notions of a possible 4U subfamily.

We are uncertain as to the extent to which such models for atomic nuclei would improve on ongoing theory techniques.

8.1.5. Dynamics models for atomic physics

Regarding some atomic physics, people might want to explore using modeling that correlates with equations (167) and (168). Equation (167) can correlate with de-emphasizing non-residual aspects of the strong force. The strong force is not relevant to the relevant aspects of atomic physics. KS PDE modeling might feature electrons in a potential that correlates with an atomic nucleus and perhaps correlates with other electrons. Numbers of electrons per shell and per subshell can - based on two notions - correlate with numbers that nature exhibits. One notion features relevance of the Laplacian operator that equation (4) shows. One notion features a limit of no more than two electron spin states per solution correlating with the Laplacian operator. The numbers of electrons do not correlate with the existence of the r^2 term in equation (3).

$$(\xi'_{SA}/2)(\eta_{SA})^{-2} \to 0^+ \tag{167}$$

$$(\xi'_{SA}/2)(\eta_{SA})^{2} \text{ is a positive constant} \tag{168}$$

8.1.6. Dynamics models for quantum transitions

We discuss the possibility that aspects of proposed theory pertain to temporal aspects of quantum transitions.

People may have observed quantum transitions that take non-zero time. (See reference [78].)

Proposed theory suggests the possibility that people can model such aspects of transitions via volume-like vertices. Modeling that features volume-like vertices might parallel temporal aspects of equation (165). (See discussions regarding equations (163) and (165).)

8.2. Possible applications of proposed theory KS modeling

We explore possible applications of supplementary proposed theory KS modeling.

8.2.1. A possible lack of a neutron electric dipole moment

We discuss modeling that would comport with the notion that nature does not include a non-zero neutron electric dipole moment.

Equation (169) shows an upper bound on the electric dipole moment for the neutron. (See reference [6]. Here, the one-letter symbol m denotes meters.)

$$0.30 \times 10^{-27}\,|q_\epsilon|\,\mathrm{m} \tag{169}$$

For each hadron for which dynamics modeling based on supplementary proposed theory PDE techniques pertains and for which all the quarks occupy one state with respect to spatial characteristics, the electric dipole moment might be zero. (See discussion, related to table 6, regarding PDE-based modeling that correlates with some aspects of the strong, electromagnetic, and weak interactions.)

Proposed theory suggests that the neutron and proton might be such hadrons.

Some research suggests that some pentaquarks might not be such hadrons. (See interpretation, in reference [76], of reference [79].)

We think that this discussion comports with comparisons that table 86 suggests.

8.2.2. Anomalous magnetic dipole moments

We explore two possibilities regarding supplementary proposed theory approaches to estimating charged lepton anomalous magnetic dipole moments.

Equations (170), (171), and (172) show ongoing theory KS interpretations of results of experiments regarding anomalous magnetic dipole moments. (See reference [6].) The subscripts ϵ, μ, and τ denote, respectively, electron, muon, and tauon. The symbol a correlates with anomalous magnetic dipole moment. The symbol α denotes the fine-structure constant. (See equation (85).)

$$a_\epsilon - (\alpha/(2\pi)) \approx -1.76 \times 10^{-6} \tag{170}$$

$$a_\mu - (\alpha/(2\pi)) \approx +4.51 \times 10^{-6} \tag{171}$$

$$-0.052 < a_\tau < +0.013 \tag{172}$$

Ongoing theory provides means, correlating with Feynman diagrams, to calculate an anomalous magnetic dipole moment for each of, at least, the electron and the muon. The ongoing theory Standard Model suggests computations whereby the anomalous magnetic dipole moment for a charged lepton is a sum of terms. The first term is $\alpha/(2\pi)$. The second term is proportional to α^2. The third term is proportional to α^3. The exponent associated with α correlates with a number of virtual photons.

Regarding the tauon, equation (173) shows a result correlating with a first-order Standard Model (or, ongoing theory) calculation. (See reference [80].)

$$a_{\tau,\mathrm{SM}} \approx +1.177 \times 10^{-3} \tag{173}$$

We explore a possible proposed theory approach that tries to parallel the ongoing theory approach.

Proposed theory suggests that notions of anomalous electromagnetic moments correlate with $\gamma 2$ solutions. Electromagnetic dipole solutions correlate with $\gamma 2$ solutions for which RSDF is r^{-3}. The following remarks pertain for other than the 2G24 solution, which correlates with the ongoing theory nominal magnetic moment result of $g \approx 2$. (2G24 correlates with 2γ and not with $\gamma 2$.) The relevant solutions might be 4G26, 6G24, 6G28, 8G26, and 10G28. However, 6G28 and 10G28 do not interact with individual simple fermions. (Each of 6G28 and 10G28 correlates with a TA-side $SU(5)$ symmetry. See table 40. Perhaps, note table 65.) Solutions 6G28 and 10G28 might correlate with, for example, the Lamb shift. Regarding anomalous electromagnetic dipole moments, we assume that 4G26, 6G24, and 8G26 pertain.

We explore the possibility that proposed theory suggests that contributions to a scale as $\alpha^{(\Sigma-2)/2}$. (Compare with discussion regarding equation (120).)

Solution 4G26 might correlate with the $\alpha/(2\pi)$ term that ongoing theory provides for charged leptons. For solution 6G24, $4 \in \Gamma$. Solution 6G24 might correlate with a result that varies with charged lepton rest mass. Solution 6G24 might correlate with a term that is proportional to $\alpha^2/(2\pi)$. (See equation (170), equation (171), and discussion regarding table 90. Note the result $\alpha^2/(2\pi) \approx 8.48 \times 10^{-6}$.) Solution 8G26 might correlate with a term proportional to $\alpha^3/(2\pi)$.

We try to estimate a_τ.

We assume that the 4G26 solution correlates with the ongoing theory result of $\alpha/(2\pi)$. We assume that the 6G24 solution correlates with contributions of the order α^2.

We assume that, for a charged lepton cl, equation (174) pertains. Here, t_{cl} is the construct that the first column of table 89 identifies.

$$a_{\mathrm{cl}} - (\alpha/(2\pi)) \approx a_{6\mathrm{G}24,1} + a_{6\mathrm{G}24,\mathrm{t}} t_{\mathrm{cl}} \tag{174}$$

Table 89 shows approximate possible values for $a_{6\mathrm{G}24,1}$ and $a_{6\mathrm{G}24,\mathrm{t}}$, based on fitting data that equations (170) and (171) show and based on using various candidates for t_{cl}. We de-emphasize the notion that 8G26 might also contribute to an actual value.

Table 90 provides, based on table 89 and equation (174), some possible suggestions for $a_\tau - (\alpha/(2\pi))$. The comparison is with respect to a Standard Model first order calculation. (See equation (173).) Per the notion that the interaction strength does not necessarily correlate linearly or quadratically with an ongoing theory property and per the quadratic behavior with respect to $|q_\epsilon|$ in the expression $\alpha^{(\Sigma-2)/2}$, appropriate results might correlate with the square of generation or with the square of a function of $\log(m)$. (See work that includes equation (84).)

Each one of the results that table 90 shows comports with experimental results. Except for the row regarding m and the row regarding m^2, each row in table 90 might comport with the calculation based

Table 89: Possible approximations regarding the 6G24,1 and 6G24,t contributions to $a_{\mathrm{cl}} - (\alpha/(2\pi))$ for charged leptons

Assumption regarding t_{cl}	$a_{6\mathrm{G24,1}}$	$a_{6\mathrm{G24,t}}$
m	-1.79×10^{-6}	5.96×10^{-8}
m^2	-1.76×10^{-6}	5.62×10^{-10}
M''	-1.76×10^{-6}	3.13×10^{-6}
$(M'')^2$	-1.76×10^{-6}	1.57×10^{-6}
generation	-8.03×10^{-6}	6.27×10^{-6}
(generation)^2	-3.85×10^{-6}	2.09×10^{-6}
$\log(m/m_\epsilon)$	-1.76×10^{-6}	1.18×10^{-6}
$(\log(m/m_\epsilon))^2$	-1.76×10^{-6}	2.21×10^{-7}

Table 90: Possible approximations for $a_\tau - (\alpha/(2\pi))$

Assumption regarding first order behavior for $a_{\mathrm{cl}} - (\alpha/(2\pi))$. The term is linear in a lepton's:	First order suggestion for $a_\tau - (\alpha/(2\pi))$	Prediction for a_τ	Approximate comparison $(a_\tau - a_{\tau,\mathrm{SM}})/a_{\tau,\mathrm{SM}}$	Fit
m	$+1.04 \times 10^2 \times 10^{-6}$	$+1.266 \times 10^{-3}$	$+75 \times 10^{-3}$	-
m^2	$+1.77 \times 10^3 \times 10^{-6}$	$+2.933 \times 10^{-3}$	$+1500 \times 10^{-3}$	-
M''	$+7.65 \times 10^{-6}$	$+1.169 \times 10^{-3}$	-6.9×10^{-3}	!
$(M'')^2$	$+12.35 \times 10^{-6}$	$+1.174 \times 10^{-3}$	-2.9×10^{-3}	!
generation	$+10.8 \times 10^{-6}$	$+1.172 \times 10^{-3}$	-4.3×10^{-3}	!
(generation)^2	$+15.0 \times 10^{-6}$	$+1.176 \times 10^{-3}$	-0.7×10^{-3}	!!
$\log(m/m_\epsilon)$	$+7.83 \times 10^{-6}$	$+1.169 \times 10^{-3}$	-6.8×10^{-3}	!
$(\log(m/m_\epsilon))^2$	$+12.9 \times 10^{-6}$	$+1.174 \times 10^{-3}$	-2.5×10^{-3}	!

on the Standard Model. The (generation)^2-centric result that table 90 shows might comport best, of the results that the table suggests, with the calculation based on the Standard Model. The (generation)^2-centric result differs from the result that equation (173) shows by about 0.7 parts in 1000.

Based on the notion that contributions to a scale as $\alpha^{(\Sigma-2)/2}$ and on results that table 89 shows, it might seem unlikely that $a_{6\mathrm{G24,1}}$ correlates with 8G26. However, it is possible that the strength of interactions correlating with 4G26 differs from the ongoing theory result that correlates with $\alpha/(2\pi)$ and that $a_{6\mathrm{G24,1}}$ correlates with such a difference.

Given remarks just above, we explore another approach to estimating a_τ.

We assume that the strength of each of 4G26 and 8G26 does not change with generation. We assume that, in effect, equation (175) pertains. We assume that, in effect, equation (176) pertains. Here, we have assumed a clean split between contributions that do not correlate with generation and contributions that do correlate with generation. For the left side of equation (175), $4 \notin \Gamma$. For the left side of equation (176), $4 \in \Gamma$. Regarding table 90, the leftmost column and the rightmost three columns pertain regarding this approach. (Technically, one needs to change the column heading for the leftmost column. The new heading should be the following: "Assumption regarding the behavior for $a_{6\mathrm{G24}}$. The term is linear in a lepton's:".)

$$a_{4\mathrm{G26}} + a_{8\mathrm{G26}} = (\alpha/(2\pi)) + a_{6\mathrm{G24,1}} \tag{175}$$

$$a_{6\mathrm{G24}} = a_{6\mathrm{G24,t}} \tag{176}$$

Discussion related to equations (175) and (176) suggests the possibility that proposed theory modeling via just two terms can pertain. One term would not vary with generation. One term would vary with generation.

Here, the following notions may correlate with each other. Modeling for freeable energy features oscillator pair SA5-and-SA6. The solution 6G24 correlates with $\Sigma = 6$ and with oscillator pair SA5-and-SA6. The notion that t_{cl} equals (generation)^2 might pertain. (See, in table 90, the column labeled fit.

Table 91: Possible correlations, regarding PR1IC modeling, with general relativity

Aspect regarding proposed theory	Aspect regarding general relativity
4G48	rotational frame-dragging
4G48 repulsion	Einstein field equations
4G246 attraction	Einstein field equations
4G2468a and 4G2468b repulsion	Einstein field equations
4G components other than 4γ components	Einstein field equations
RSDF (or, radial spatial dependence of force) of r^{-6}	Cosmological constant

For this example, the notion of freeable energy correlates with generation.) The exponent of two in the expression (generation)^2 parallels the exponent of two that pertains regarding the factor $(q_\epsilon)^2$ in α in the sense that contributions seem to scale as the squares of particle properties.

We think that the second approach illustrates comparisons that table 86 suggests.

8.3. Possibilities to complement ongoing theory classical physics

We explore possibilities that supplementary proposed theory might offer useful complements to established ongoing theory classical physics modeling.

8.3.1. Possibilities for using Newtonian modeling in place of general relativity

Table 91 lists aspects related to 4GΓ solutions. In the context of PR1IC modeling, each row (possibly except for the last row) in the table points to a possible correlation with general relativity. For each row, the extent to which the possible correlation pertains might be an open question. People associate the two-element term Lense-Thirring effect with the two-element term rotational frame-dragging. The Einstein field equations allow solutions that correlate with repulsion. This essay does not explore the extent to which modeling based on the notion of an RSDF (or, radial spatial dependence of force) of r^{-6} and on the notion of $\rho \neq 0$ might correlate with general relativity modeling for which a non-zero cosmological constant pertains. (See discussion related to table 40.)

People might explore the feasibility of developing supplementary proposed theory KS modeling based on correlations that table 91 suggests. People might explore the extent to which such supplementary proposed theory KS modeling can be useful regarding PR1IC modeling and regarding PR6IC modeling.

8.3.2. Possibilities for extending aspects related to Maxwell's equations

A standard representation of Maxwell's equations features two properties and two fields. The properties are charge and current. The fields are an electric field and a magnetic field.

People try to embed aspects of Maxwell's equations into broader contexts. People try to develop or understand theories and models based on such broader contexts. People look for evidence that such theories or models comport with nature.

Special relativity provides an example. Here, charge and current become components of a 4-vector.

The notion of a magnetic monopole provides another example. Here, people try adding a property to Maxwell's equations. People have yet to find evidence that nature includes magnetic monopoles. (See discussion related to equation (155).)

Our work suggests possibilities for another example. (See table 43.) Here, up to six properties might pertain. Three properties would be charge, nominal magnetic dipole moment, and rotating nominal magnetic dipole moment. Here, rotation is likely with respect to an axis that does not equal the axis that correlates with the nominal magnetic dipole moment. The three properties do not necessarily correlate with aspects of translational motion. The three properties correlate respectively with the words monopole, dipole, and quadrupole. The three properties correlate respectively with the terms scalar (or, rank-zero tensor), vector (or, rank-one tensor), and rank-two tensor. The other up to three properties would correlate with motion of the first three properties. For example, one property would be charge current, which correlates with the notion of moving charge.

Our work might suggest possibilities for yet another example. The previous example features three properties that do not necessarily correlate with translational motion. People might extend the previous example by considering the three-element series - which is related to translational motion - static, moving with an unchanging velocity, and moving with changing velocity. Here, the notion of moving with changing velocity might correlate with linear motion and acceleration and might correlate with angular velocity.

Table 92: Possible themes for experiments or observations

Theme
• Find or rule out elementary particles that we (or other people) suggest.
• Measure properties of new particles.
• Hone some measurements regarding some known particles.
• Verify or rule out the notion that gravity does not produce the main contributions to neutrino oscillations.
• Verify or rule out the relationship that we suggest regarding the tauon mass and the gravitational constant.
• Verify, hone, or refute relationships, that we suggest, between particle properties and other constants.
• Verify or rule out the description of dark matter that we propose.
• Determine properties of dark matter.
• Hone, extend, or rule out aspects that we suggest regarding galaxies.
• Add details - or rule out aspects that we suggest - regarding the cosmological timeline.
• Explore, for times after recombination, evolution of density of the universe ratios for inferred (or inferable) dark matter to inferred (or inferable) ordinary matter.
• Explore evolution of density of the universe ratios for inferred (or inferable) dark energy to inferred (or inferable) dark matter plus ordinary matter.
• Explore each of the following topics and relationships between the following topics - the domain of applicability of general relativity; equations relating pressures to densities; the notion and applicability of the concept of a Hubble parameter; notions regarding geodesic motion; and the spans and the strengths of forces correlating with the 4G48, 4G246, 4G2468a, and 4G2468b solutions.
• Determine ranges of usefulness regarding - and test synergies between - various theories and models.
• Predict and try to verify other phenomena that might correlate with proposed theory.

9. Discussion: possible opportunities

This unit notes possible opportunities for research.

9.1. Possible opportunities for experimental or observational research

We note possible opportunities for experimental or observational research.

9.1.1. Possible themes for experiments or observations

Table 92 suggest themes for experiments and observations that people might want to conduct. This essay de-emphasizes the topic of when techniques and technology will suffice to enable specific experiments or observations. We de-emphasize the topic of when - for each of various predictions we or other people make based on proposed theory - falsifiability becomes feasible.

9.1.2. Possibilities for detecting or inferring aye bosons

Table 93 lists possible roles for the aye particle and for the 0I solution.

We discuss items that table 93a shows.

Discussion related to equation (142) pertains regarding inflation.

Discussion related to equation (143) pertains regarding just after inflation.

Some aspects of ongoing theory propose interactions that would produce unspecified particles that people might not have detected. For example, people propose an interaction $K_L^0 \rightarrow \pi^0 + X$ for which there is an intermediate state of two simple fermions that interact via a W boson and produce the so-designated X particle. (See reference [81].) Here, the symbol K_L^0 correlates with the K-long meson. The symbol π^0 denotes a zero-charge pion. To the extent that this interaction actually occurs, proposed theory suggests the possibility that the X particle is an aye simple boson.

Ongoing theory proposes concepts such as interactions with a so-called quantum vacuum. Proposed theory can be compatible with modeling that features a quantum vacuum and can be compatible with modeling that does not embrace a notion of quantum vacuum. Interactions with 0I bosons might produce effects similar to effects that ongoing theory correlates with the notion of interactions with a quantum vacuum.

Table 93: Possible roles for the aye particle and for the 0I solution

(a) Possible roles in nature for the aye particle

Possible roles - the particle ...
• Plays a role during the inflationary epoch
• Functions as the inflaton and plays a role after inflation
• Helps explain some interactions
• Explains phenomena that ongoing theory correlates with a so-called quantum vacuum
• Explains phenomena that ongoing theory correlates with density of dark energy
• Might correlate with situation-specific interaction rates

(b) Possible roles in modeling for the 0I solution

Possible roles - the solution ...
• Helps explain scaling by factors of α correlating with adding vertices or with increasing spin
• Simplifies some aspects of modeling (and does not necessarily correlate with nature)

Discussion related to equation (149) pertains regarding non-zero density of dark energy.

Equation (177) shows a possibility for decay of a Higgs boson. The equation might correlate with a rate that is not very situation specific. (Here, we assume a lack of lasing.) Equation (178) shows another possibility for the decay of the Higgs boson. The equation might correlate with a rate that correlates with a density of 0I particles and might be situation specific.

$$0\mathrm{H}^0 \to ... \tag{177}$$

$$0\mathrm{I}^0 + 0\mathrm{H}^0 \to ... \tag{178}$$

We discuss items that table 93b shows.

Discussion related to the relative strengths of some components of G-family forces points to terms proportional to $\alpha^{(\Sigma-2)/2}$. (See discussion related to equation (100) and discussion related to equation (120).) Possibly, modeling based on the 0I solution correlates with aspects regarding spins and interactions. (See discussion related to equation (114).)

Table 30a shows a representation for the ground state of the 0I solution. The next two sentences provide possible interpretations. People might interpret the SA-side of the representation as implying that, in nature, the aye particle would not excite. (See table 30a.) People might interpret the SA-side representation as correlating with five channels and, therefore, with the notion that excitement can pertain. (Regarding channels, see discussion regarding equation (111).) Proposed theory suggests that the second possibility pertains.

9.1.3. Possibilities for directly detecting dark matter

We discuss possibilities for observing dark matter effects without creating dark matter.

We discuss possibilities for inferring the presence of dark matter in seemingly ordinary matter atomic nuclei or seemingly ordinary matter neutron stars.

The span for each one of the pie boson and the cake boson might be six. Proposed theory does not rule out the possibility that seemingly ordinary matter atomic nuclei can contain dark matter hadron-like particles. Some dark matter hadron-like particles have masses that differ from the mass of an ordinary matter neutron. Examples include dark matter isomer analogs to ordinary matter protons and might include 1R⊗2U particles. People might want to look for individual atomic nuclei or individual atoms for which, respectively, the rest masses or the atomic weights do not correlate completely with the properties of atomic nuclei that contain only protons and neutrons.

People might want to consider possibilities for inferring the presence of dark matter content in neutron stars. (See discussion related to equations (147) and (148).)

We discuss other possibilities for observing dark matter effects without creating dark matter.

Possibly, people can develop techniques for detecting gravitationally the presence of nearby dark matter.

People attempt to directly detect dark matter. (See, for example, reference [82].) Some efforts look for WIMPs. We are uncertain as to the extent to which these efforts might be able to detect 1R⊗2U hadron-like particles. Some efforts look for axions. We are uncertain as to the extent to which these efforts might attribute axion sightings to effects that correlate with the difference that equation (179) shows.

$$2(6)\mathrm{G}248 \neq 2(1)\mathrm{G}248 \tag{179}$$

Proposed theory suggests new possibilities for directly detecting dark matter or doubly dark matter. To the extent that PR6IC pertains to nature and PR36IC does not pertain to nature, the following discussion pertains to detecting dark matter. To the extent that PR36IC pertains to nature, the following discussion pertains to detecting doubly dark matter. The basis for one possibility is the difference between 2(6)G248 and 2(1)G248. Here, a detector might feature a rotating magnetic dipole moment, with the axis of rotation not matching (and perhaps being orthogonal to) the axis correlating with the magnetic dipole. Independent of that possible means for detection, people might try to infer 2(6)G248 phenomena correlating with dark matter magnetic fields (or - for the PR36IC case - 2(6)G248 phenomena correlating with doubly dark matter magnetic fields). A basis for another possibility is the difference between 2(2)G68 and 2(1)G68. Proposed theory suggests that 2G68 correlates with, at least, some atomic transitions.

We discuss three possibilities for making and detecting dark matter.

Equations (180), (181), and (182) show interactions that convert a neutron into a dark matter 1R⊗2U hadron-like particle that features three arc (or, 1R) simple fermions. (A neutron includes two Q^{-1} quarks and one Q^{+2} quark.) The minimum energy to trigger this set of interactions correlates with the sum of the rest energies of one neutron and two charged tweaks. A minimum range for that minimum energy is 417 GeV to 443 GeV. (Here, we assume results that equation (126) shows.) For an experiment, the number of conversions might be small. The following notions might correlate with such smallness. The range of the $2\mathrm{T}^{\pm}$ boson might be small compared to the size of a neutron. (See discussion related to equation (71).) Effects that ongoing theory correlates with the two-word term Pauli exclusion might imply that the probability for the original three quarks to be adequately close to each other is low.

$$2(\mathrm{Q}^{-1} \rightarrow \mathrm{R}^{0} + \mathrm{T}^{-1}) \tag{180}$$

$$\mathrm{Q}^{+2} + \mathrm{T}^{-1} \rightarrow \mathrm{Q}^{+1} \tag{181}$$

$$\mathrm{Q}^{+1} + \mathrm{T}^{-1} \rightarrow \mathrm{R}^{0} \tag{182}$$

We speculate about means for detecting such a conversion of a neutron into a three-arc hadron-like particle. We assume that the neutron resides in an atomic nucleus in a target material. Given the relevant energies, we assume that the three-arc particle exits the target. We speculate that people would not detect the three-arc particle. With one target and enough conversions that do not produce escapes of atomic nuclei, people might detect a change in the isotopic composition of the target. Possibly, an easiest detection would correlate with effects other than those we just mentioned. Such effects might correlate with byproducts of the interaction.

Equations (183), (184), and (185) show interactions that convert a proton into a dark matter 1R⊗2U hadron-like particle that features three arc (or, 1R) simple fermions. (A proton includes two Q^{+2} quarks and one Q^{-1} quark.) The minimum energy to trigger this set of interactions correlates with the sum of the rest energies of one proton and three charged tweaks. A minimum range for that minimum energy is 625 GeV to 664 GeV. (Here, we assume results that equation (126) shows.)

$$2(\mathrm{Q}^{+2} \rightarrow \mathrm{R}^{0} + \mathrm{T}^{+2}) \tag{183}$$

$$\mathrm{Q}^{-1} \rightarrow \mathrm{R}^{0} + \mathrm{T}^{-1} \tag{184}$$

$$2(\mathrm{T}^{+2}) + \mathrm{T}^{-1} \rightarrow \mathrm{W}^{+3} + \mathrm{I}^{0} \tag{185}$$

Compared with trying to detect the conversion of a neutron into dark matter, the possibility for converting a proton offers advantages and disadvantages. One advantage might be the possibility for detecting the weak interaction that the W^{+3} boson would catalyze. Another advantage might correlate with an ability to use colliding beams instead of an approach that might feature one beam and a fixed target. One disadvantage might be the need to use higher energy for the incoming particles.

Equations (186) and (187) show interactions that convert a positron and an electron into the fermion components for a 1R⊗2U hadron-like particle that would have some similarity to a neutral pion. A threshold energy could be about 81 GeV. Detecting the 1R⊗2U particle might prove difficult. To the extent that the preferred decay of the particle features a matter neutrino and an antimatter neutrino, detecting decay products might prove difficult.

$$\mathrm{C}^{+3} \rightarrow \mathrm{R}^0 + \mathrm{W}^{+3} \tag{186}$$

$$\mathrm{C}^{-3} + \mathrm{W}^{+3} \rightarrow \mathrm{R}^0 \tag{187}$$

9.2. Possible opportunities regarding PDE harmonic oscillator mathematics

We note possible opportunities to explore or extend some aspects of harmonic oscillator mathematics and some aspects of modeling based on harmonic oscillator mathematics.

9.2.1. Possible opportunities re PDE harmonic oscillator mathematics

Discussion above includes - regarding Ψ - the topic of normalization. (See discussion related to equation (9).) Discussion above does not include the topic of orthogonality. To the extent that people want to address orthogonality, people might want to add emphasis (compared to emphasis in work above) to the aspect of angular coordinates. Generally, this essay de-emphasizes the topic of orthogonality.

People might want to explore possible opportunities - regarding mathematics or modeling - related to the transformation - regarding number of dimensions - that correlates with equation (18).

9.2.2. Possible opportunities re ALG harmonic oscillator mathematics and modeling

Discussion above suggests using ALG modeling that is based on non-isotropic harmonic oscillators to model aspects regarding refraction. (See discussion related to table 49.) People might further explore using ALG modeling based on non-isotropic harmonic oscillator mathematics to do PS modeling or to do KS modeling.

People might try to express, via harmonic oscillator mathematics or combinations of symmetries, kinematics models or dynamics models that pertain for each of a few or many interacting particles or objects. People might try to develop parallels to ongoing theory equations that, for example, sum momenta. (Discussion above points to symmetries that correlate with summable quantities related, for example, to charge and to lepton number minus baryon number. See, for example, table 47.)

People might try to correlate modeling involving many objects with modeling regarding entropy. (See discussion related to equation (192).)

9.3. Possible opportunities to develop deeper insight

We discuss modeling that people might use as bases for developing new aspects of physics theory.

9.3.1. Numbers of dimensions

Proposed theory suggests that, at least in some sense, a number - three - of spatial dimensions correlates with $D^*_{SA} = 3$ and a number - one - of temporal dimensions correlates with $D^*_{TA} = 1$. (See equations (39) and (40).)

Proposed theory includes modeling that features other than three spatial dimensions. (See, for example, the SA-side aspects of representations that table 31 shows or the column labeled with the one-element symbol D in table 18b.) Ongoing theory includes modeling that features other than three spatial dimensions.

Some proposed theory uses of notions of $D^*_{SA} = 3$ and $D^*_{TA} = 1$ include modeling that correlates with $\nu_{SA} < 0$ and that outputs a list of known and possible elementary particles. (See table 16.) As far as we know, ongoing theory does not include parallels to such proposed theory modeling. Ongoing theory aspects that correlate with three spatial dimensions and one temporal dimension tend to correlate with proposed theory aspects for which $\nu_{SA} \geq 0$ pertains. (See table 16.)

Equations (39) and (40) might provide a characterization that can be useful, for much physics modeling, of the notions of three spatial dimensions and one temporal dimension.

9.3.2. Numbers of fermion generations and numbers of color charges

Unverified ongoing theory includes notions of a fourth generation of neutrino. People use the two-word term sterile neutrino. We know of no data that supports the existence of a fourth neutrino.

Possibly, applications of equation (18) correlate with the notion that the number of fermion generations is three and with the notion that the number of color charges is three.

Regarding the number of fermion generations, $D = 3$ pertains regarding PDE representations for fermion elementary particles. (See table 18b and note that the table pertains for SA-side aspects.) Regarding equation (18), $j = 2$ pertains. The resulting substitution correlates with $D = 4$. Per table 29, out of those four dimensions, two dimensions correlate with modeling - independently from generations and independently from modeling regarding generations - for fermions. (Those two dimensions correlate - in that table - with the two ALG oscillators SA0 and SA1.) The other two dimensions might correlate with modeling for generations. In the sense of ALG modeling, an $SU(2)$ symmetry might pertain. (ALG modeling correlates the two relevant ALG oscillators with the SA5-and-SA6 oscillator pair.) The number of generators of $SU(2)$ is three. This discussion might correlate with a notion that three (and no more than three) generations pertain for each elementary fermion.

Regarding the number of color charges, a similar discussion might pertain. The discussion starts with the notion that $D = 3$ pertains regarding TA-side aspects of modeling for fermion elementary particles. (See table 18c.) This discussion might correlate with a notion that three (and no more than three) color charges pertain for each quark and each arc.

9.3.3. Arrow of time

Equation (163) and discussion related to equation (27) suggest a notion of a $\Psi(t, r)$ that correlates with the TA0-and-SA0 oscillator pair. (See equation (6).) We suggest that equation (188) might pertain. (Perhaps, see also discussion related to equation (163) and discussion related to equation (165).) The domains $t > 0$ and $r > 0$ pertain for $\Psi(t, r)$. Without loss of generality, we posit that $\eta_{TA} > 0$ pertains regarding after an interaction, $\eta_{TA} > 0$ does not pertain regarding before an interaction, $\eta_{TA} < 0$ pertains regarding before an interaction, and $\eta_{TA} < 0$ does not pertain regarding after an interaction. We posit that $\eta_{SA} > 0$ pertains regarding elementary particles that exit an interaction, $\eta_{SA} > 0$ does not pertain regarding elementary particles that enter an interaction, $\eta_{SA} < 0$ pertains regarding elementary particles that enter an interaction, and $\eta_{SA} < 0$ does not pertain regarding elementary particles that exit an interaction. Of the four possibilities $\eta_{TA} > 0$ and $\eta_{SA} > 0$, $\eta_{TA} < 0$ and $\eta_{SA} < 0$, $\eta_{TA} > 0$ and $\eta_{SA} < 0$, and $\eta_{TA} < 0$ and $\eta_{SA} > 0$, mathematically, Ψ normalizes for only the first two possibilities.

$$\Psi(t, r) \propto \exp(-tr/(\eta_{TA}\eta_{SA})) \tag{188}$$

To the extent that this modeling correlates with the topic of arrow of time, the lack of dual normalization regarding each of the case of incoming and the case of outgoing might provide insight.

The proposed theory notion that aspects of modeling of conservation of energy correlate with an $SU(5)$ symmetry (and not necessarily with an ongoing theory notion of $S1G$ symmetry) might provide insight regarding the topic of arrow of time. Proposed theory tends to correlate $SU(\_)$ symmetries with origins (with respect to coordinates) and with radial coordinates.

9.3.4. Notions that might link physics constants and modeling

Table 94 shows speculation about possible conflations regarding two notions. One notion is the Σ in G-family mathematical solutions $\Sigma G\Gamma$. One notion is quantities (or, properties) with which some $\Sigma\gamma$ components of G-family forces interact. Each quantity (or, property) might pertain for each of some aspects of classical physics modeling and some aspects of quantum physics modeling. (Compare with table 43 and table 59.) In table 94, an item in parentheses shows a non-zero magnitude that pertains for modeling that correlates with the notion of free. Except for regarding speed, the number is a minimal non-zero magnitude. (For charge, for unfree, $|q_\epsilon|/3$ pertains. For lepton number minus baryon number, for unfree, 1/3 pertains. Except for regarding speed, the numbers are minimal non-zero magnitudes.) Some modeling regarding refraction and effective mass might correlate (via, aspects correlating with longitudinal polarization) with a lack of a minimal non-zero quantity. (See discussion related to equations (62) and (63).) Regarding the case of $\Sigma = 16$, there might be a correlation with the notion that modeling might correlate boost symmetry with the oscillator pair SA15-and-SA16. (See discussion that includes discussion of table 38.) Such a correlation might be useful with solutions that allow $\lambda = [\![16]\!] \in \Gamma$.

Some items in table 94 might correlate, in essence, with other physics constants. Charge might correlate with $1/(4\pi\varepsilon_0)$ and the vacuum electric permittivity ε_0. Magnetic flux correlates with $|q_\epsilon|$ and

Table 94: Possible conflations regarding G-family solutions and properties with which G-family forces interact (with (_) denoting a suggested smallest non-zero property magnitude, _, regarding modeling free objects; and with ((_)) denoting a different type of non-zero physics constant)

Σ	Scalar	Vector	2-tensor	3-tensor
0				
2	Charge ($\lvert q_\epsilon \rvert$)	Magnetic flux (K_J)	Precessing flux	
4	Mass	Rotating mass	Moments of inertia	Rotating moments
6	Freeable energy			
8	N_{L-B} (1)	Spin ($\hbar/2$)		?
...				
16	Speed ((c))			

$\hbar$ and might correlate with μ_0, the vacuum magnetic permeability. Mass might correlate with G_N, the gravitational constant.

Proposed theory might suggest opportunities to further explore relationships between charge and mass and relationships between strengths of components of G-family forces. For example, table 58 points to possible relationships between charge and mass.

Proposed theory might offer an opportunity for new looks, regarding models, at relationships between handedness, chirality, helicity, lepton number or baryon number, rotation, and spin. (Note the row, in table 94, for which $\Sigma = 8$ pertains.)

Proposed theory might suggest another opportunity to explore modeling related to masses. We discuss a possibly useful notion regarding masses of non-zero-mass simple particles. Equations (189) and (190) pertain. The symbol m denotes mass. Boson simple particle masses tend to feature relationships regarding squares of masses. Equation (189) points to results that feature squares of masses. For each free simple boson, the equation evaluates approximately to an integer. The equation might correlate with the 2U-related potential that scales like r^1 and that pertains regarding unfree simple fermions in hadron-like particles. Equation (190) points to results that feature logarithms of masses. For each simple fermion other than the neutrinos and the arcs, the equation evaluates somewhat approximately to an integer. The equation might correlate with ΣG-related potentials that scale like r^{-1} and that pertain regarding simple fermions that have quantum interactions with 2G2 and 4G4 root forces. Equation (191) follows from equation (190) and produces results pertaining to squares of simple fermion masses other than neutrino masses and arc masses.

$$\int_0^{m/(m_Z/3)} 2r^1 dr \tag{189}$$

$$\int_1^{m/m_\epsilon} r^{-1} dr \tag{190}$$

$$\int_1^{m/m_\epsilon} 2r^{-1} dr \tag{191}$$

We are uncertain regarding the usefulness of further pursuing notions that we discuss immediately above.

9.3.5. Entropy

We consider cases of multicomponent objects that involve $k+1$ peer component objects. Here, k is a nonnegative integer.

We consider the case of $k = 1$. The multicomponent object includes two peer component objects. Compared with dynamics symmetries for the multicomponent object, the two peer components collectively contribute one too many instance of each of conservation of energy symmetry, conservation of angular momentum symmetry, and conservation of momentum symmetry. Modeling might re-assign the extra three symmetries to a combination of the two peer components and a field - such as a gravitational field - that correlates with interactions between the peer components.

We consider the case of $k > 1$. Here, we de-emphasize the possibility of stepwise subdivision. An example of stepwise subdivision involves the sun, earth, and moon. For this example of stepwise subdivision, one might use two steps, each correlating with $k = 1$. The first step considers each of the sun and the earth plus moon to be objects. The second step considers the earth plus moon to be a multicomponent object consisting of the earth and the moon. Without adequately significant additions to modeling, this example might correlate with modeling for which - regarding ocean tides - effects of lunar gravity pertain and effects of solar gravity do not pertain.

For $k > 1$ and no stepwise subdivision, ongoing theory modeling becomes more complex than ongoing theory modeling for two-body (or, $k = 1$) systems. Many applications might pertain - for example, to astrophysical systems, to ideal gasses, and so forth. For some applications, keeping the number of fields at one might correlate with a notion of entropy and, at least within that notion, with the ongoing theory expression for entropy that equation (192) shows. Here, people might want to consider at least one of the two cases $j = k + 1$ and $j = k$. Here, people might want to consider each of a notion of entropy for physical systems and a notion that might correlate, regarding mathematics-based modeling, with a term correlating with the word entropy.

$$j \log(j) \tag{192}$$

10. Concluding remarks

This unit discusses possible opportunities based on proposed theory.

Proposed theory might provide impetus for people to tackle broad agendas that our work suggests. Proposed theory might provide means to fulfill aspects of such agendas. Proposed theory might fulfill aspects of such agendas.

Opportunities might exist to develop more sophisticated theory and modeling than the theory and modeling that we present. Such a new level of work might provide more insight than we provide.

Proposed theory might suggest - directly or indirectly - opportunities for observational research, experimental research, development of precision measuring techniques and data analysis techniques, numerical simulations, and theoretical research regarding elementary particle physics, nuclear physics, atomic physics, astrophysics, and cosmology.

Proposed theory might suggest applied mathematics techniques that have uses other than uses that we make.

Acknowledgments

William Lama provided useful comments regarding the effectiveness of drafts of parts of this essay.

The following people pointed, via presentations or writings, to topics or aspects that we considered for inclusion in the scope of the work: Alex Filippenko, Brian Greene, Robert McGehee, Risa Wechsler, and various science journalists.

The following people pointed, via personal contact, to topics or aspects that we considered for inclusion in the scope of the work: Andrea Albert, Raphael Bousso, Lance Dixon, Persis Drell, Kamal Melek Hanna, Wick Haxton, Nick Hutzler, William Lama, Surhud More, Holger Muller, J. Xavier Prochaska, and Martin Rees.

The following people helped formally publish aspects of the work: Charles K. Chui, Kamal Melek Hanna, Keith Jones, and Zeger Karssen. The following people provided or pointed to aspects regarding expressing or propagating the work: Elliott Bloom, Man Ho Chan, Maxwell Chertok, Charles K. Chui, Andrei Lucian Dragoi, Xanthe Du, Steven Frautschi, Carl Frederick, Richard B. Holmes, Christian Liang, Juan Jose Lietor-Santos, Frank Hiroshi Ling, Michael Mulhearn, Richard A. Muller, Stephen Perrenod, Paul Preuss, Amir Sharif, and Wendy Shi. The following people suggested perspective, means, or suggestions regarding people with whom to try to have discussions: Yanbei Chen, Vint Cerf, James S. Clegg, Bill Daul, George Djorgovski, Erica Ellingson, Ron Fredericks, Vesselin Gueorguiev, William Lama, Lianne La Reine, Robert Morgan, Doug Osheroff, Kennan Salinero, Jim Spohrer, Peter Walstrom, and Jon F. Wilkins. The following people provided means or encouragement relevant to this work: various family members, Hugh E. DeWitt, George Michael, and various teachers.

Table 95 lists communications for which the following two sentences pertain. This essay cites the communications. We did not necessarily find information sufficient to qualify the communications for inclusion in the bibliography.

Table 95: Communications that this essay cites but that do not necessarily qualify for inclusion in the bibliography

(a)

Communication	Note
Clavin, W. Rotating Galaxies Galore 2020. Posted by the California Institute of Technology. Link(2020): https://www.caltech.edu/about/news/rotating-galaxies-galore	We did not find a name for a series of articles that pertains to this article.

(b)

Communication	Note
LeFevre, O.; Bethermin, M.; Faisst, A. & others. The ALPINE-ALMA [CII] survey: Survey strategy, observations and sample properties of 118 star-forming galaxies at 4<z<6. 2019. Link(2020): https://arxiv.org/abs/1910.09517	We found a claim of a status of "working paper."

(c)

Communication	Note
Anonymous. Content of the universe - pie chart. National Aeronautics and Aerospace Administration, April 2013. Link(2020): https://map.gsfc.nasa.gov/media/080998/index.html	We did not find a source for the data that the chart presents.

(d)

Communication	Note
Wong, K. C.; Suyu, S. H.; Chen, G. C.-F. & others. H0LiCOW XIII. A 2.4% measurement of H_0 from lensed quasars: 5.3σ tension between early and late-Universe probes. Mon. Not. R. Astron. Soc., in press 2020. Link(2020): https://arxiv.org/abs/1907.04869.	We were unable to verify a claim of a status of "in press."

References

[1] Richard P. Feynman. Cargo Cult Science. Commencement address, California Institute of Technology, June 1974. Link(2020): http://calteches.library.caltech.edu/51/2/CargoCult.htm. 1

[2] Eric Weisstein. Delta Function. Wolfram MathWorld web page. Link(2020): http://mathworld.wolfram.com/DeltaFunction.html. 2.2

[3] D. Mendeleev. Ueber die beziehungen der eigneschaften zu den atomgewichten der elemente. *Zeitschrift fur Chemie*, 12:405–406, March 1869. 3.2, 3.2.2

[4] Sarah Charley. W bosons remain left-handed. *Symmetry*, July 2015. Link(2020): https://www.symmetrymagazine.org/article/july-2015/w-bosons-remain-left-handed. 3.2.8

[5] K. Abe, R. Akutsu, A. Ali, et al. Constraint on the matter–antimatter symmetry-violating phase in neutrino oscillations. *Nature*, 580(7803):339–344, April 2020. 3.2.8

[6] M. Tanabashi and others (Particle Data Group). Review of Particle Physics. *Phys. Rev. D*, 98(3):030001, August 2018. 4.3.1, 4.3.3, 4.3.3, 4.3.3, 4.3.4, 4.3.10, 4.3.11, 4.3.13, 5.3.2, 5.3.2, 5.3.17, 6.4, 8.2.1, 8.2.2

[7] M. Tanabashi and others (Particle Data Group). Review of Particle Physics. *Phys. Rev. D*, 98(3):030001, August 2018 and update 2019. Link(2020): http://pdg.lbl.gov/index.html. 4.3.2, 4.3.3, 4.3.3, 4.3.4

[8] Nathalie Palanque-Delabrouille, Christophe Yeche, Julien Baur, et al. Neutrino masses and cosmology with Lyman-alpha forest power spectrum. *J. Cosmol. Astropart. Phys.*, 2015(11):011–011, November 2015. 4.3.10

[9] M. Aker, K. Altenmuller, M. Arenz, et al. Improved Upper Limit on the Neutrino Mass from a Direct Kinematic Method by KATRIN. *Phys. Rev. Lett.*, 123(22), November 2019. 4.3.12

[10] G. Drexlin. Direct neutrino mass measurement. TAUP 2019, September 2019. Link(2020): http://www-kam2.icrr.u-tokyo.ac.jp/indico/event/3/contribution/27. 4.3.12

[11] Johanna L. Miller. Closing in on neutrino CP violation. *Phys. Today*, 2020(1):0423a, April 2020. 4.3.15, 5.3.8

[12] V. C. Rubin. Galaxy dynamics and the mass density of the universe. *Proceedings of the National Academy of Sciences*, 90(11):4814–4821, June 1993. 5.2.1

[13] Edward Witten. Cosmic separation of phases. *Phys. Rev. D*, 30(2):272–285, July 1984. 5.2.1

[14] M. H. Chan. Observational evidence for dark matter interacting through a Yukawa potential. *Astrophys. J. Letters*, 769(1):L2, May 2013. 5.2.1

[15] Motoi Endo, Koichi Hamaguchi, and Go Mishima. Constraints on hidden photon models from electron $g-2$ and hydrogen spectroscopy. *Phys. Rev. D*, 86(9):095029, Nov 2012. 5.2.1

[16] Ned Wright. Brief History of the Universe. UCLA web page, July 2004. Link(2020): http://www.astro.ucla.edu/˜wright/BBhistory.html. 5.3.4

[17] Judd D. Bowman, Alan E. E. Rogers, Raul A. Monsalve, et al. An absorption profile centred at 78 megahertz in the sky-averaged spectrum. *Nature*, 555(7694):67–70, March 2018. 5.3.5, 5.3.17

[18] Rennan Barkana. Possible interaction between baryons and dark-matter particles revealed by the first stars. *Nature*, 555(7694):71–74, March 2018. 5.3.5

[19] Paolo Panci. 21-cm line Anomaly: A brief Status. In *33rd Rencontres de Physique de La Vallee d'Aoste*, July 2019. 5.3.5

[20] N. G. Busca, T. Delubac, J. Rich, et al. Baryon acoustic oscillations in the Lya forest of BOSS quasars. *A&A*, 552(A96), April 2013. 5.3.6

[21] S. Perlmutter, G. Aldering, G. Goldhaber, et al. Measurements of Ω and Λ from 42 high-redshift supernovae Ω. *Astrophys. J.*, 517(2):565–586, June 1999. 5.3.6

[22] Adam G. Riess, Alexei V. Filippenko, Peter Challis, et al. Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant. *Astron. J.*, 116(3):1009–1038, September 1998. 5.3.6

[23] Adam G. Riess, Louis-Gregory Strolger, John Tonry, et al. Type Ia Supernova Discoveries at z $>$ 1 from the Hubble Space Telescope: Evidence for Past Deceleration and Constraints on Dark Energy Evolution. *Astrophys. J.*, 607(2):665–687, June 2004. 5.3.6

[24] Mark P. Hertzberg. Structure Formation in the Very Early Universe. *Physics Magazine*, 13(26), February 2020. Link(2020): https://physics.aps.org/articles/v13/16. 5.3.7, 5.3.7

[25] Brian Green. *Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe*. Alfred A. Knopf, February 2020. 5.3.7, 5.3.7

[26] Ewa L. Lokas and Gary A. Mamon. Dark matter distribution in the Coma cluster from galaxy kinematics: breaking the mass-anisotropy degeneracy. *Mon. Not. R. Astron. Soc.*, 343(2):401–412, August 2003. 5.3.10

[27] Elena Rasia, Giuseppe Tormen, and Lauro Moscardini. A dynamical model for the distribution of dark matter and gas in galaxy clusters. *Mon. Not. R. Astron. Soc.*, 351(1):237–252, June 2004. 5.3.10

[28] Lawrence Rudnick. The Stormy Life of Galaxy Clusters: astro version. January 2019. Link(2020): https://ned.ipac.caltech.edu/level5/March19/Rudnick/frames.html. 5.3.10

[29] Lawrence Rudnick. The stormy life of galaxy clusters. *Phys. Today*, 72(1):46–52, January 2019. 5.3.10

[30] Man Ho Chan. A tight correlation between the enclosed gravitational mass and hot gas mass in galaxy clusters at intermediate radii. *Phys. Dark Universe*, 28:100478, May 2020. 5.3.10

[31] Peter Behroozi, Risa Wechsler, Andrew Hearin, and Charlie Conroy. UniverseMachine: The correlation between galaxy growth and dark matter halo assembly from z = 0-10. *Mon. Not. R. Astron. Soc.*, 488(3):3143–3194, May 2019. 5.3.13

[32] Nick Gnedin. Cosmological Calculator for the Flat Universe, 2015. Link(2020): http://home.fnal.gov/~gnedin/cc/. 5.3.13

[33] R. Genzel, N. M. Forster Schreiber, H. Ubler, et al. Strongly baryon-dominated disk galaxies at the peak of galaxy formation ten billion years ago. *Nature*, 543(7645):397–401, March 2017. 5.3.13

[34] J. Jimenez-Vicente, E. Mediavilla, C. S. Kochanek, and J. A. Munoz. Dark Matter Mass Fraction in Lens Galaxies: New Estimates from Microlensing. *Astrophys. J.*, 799(2):149, January 2015. 5.3.13

[35] J. Jimenez-Vicente, E. Mediavilla, J. A. Munoz, and C. S. Kochanek. A ROBUST DETERMINATION OF THE SIZE OF QUASAR ACCRETION DISKS USING GRAVITATIONAL MICROLENSING. *Astrophys. J.*, 751(2):106, May 2012. 5.3.13

[36] Pieter van Dokkum, Roberto Abraham, Jean Brodie, et al. A High Stellar Velocity Dispersion and ~100 Globular Clusters for the Ultra-diffuse Galaxy Dragonfly 44. *Astrophys. J.*, 828(1):L6, August 2016. 5.3.13

[37] Shannon Hall. Ghost galaxy is 99.99 per cent dark matter with almost no stars. *New Sci.*, August 2016. Link(2020): https://www.newscientist.com/article/2102584-ghost-galaxy-is-99-99-percent-dark-matter-with-almost-no-stars/. 5.3.13

[38] Pavel E. Mancera Pina, Filippo Fraternali, Elizabeth A. K. Adams, et al. Off the Baryonic Tully-Fisher Relation: A Population of Baryon-dominated Ultra-diffuse Galaxies. *Astrophys. J.*, 883(2):L33, September 2019. 5.3.13

[39] Qi Guo, Huijie Hu, Zheng Zheng, et al. Further evidence for a population of dark-matter-deficient dwarf galaxies. *Nature Astronomy*, 4(3):246–251, November 2019. 5.3.13

[40] Pieter van Dokkum, Shany Danieli, Yotam Cohen, et al. A galaxy lacking dark matter. *Nature*, 555(7698):629–632, March 2018. 5.3.13

[41] Ignacio Trujillo, Michael A. Beasley, Alejandro Borlaff, et al. A distance of 13 Mpc resolves the claimed anomalies of the galaxy lacking dark matter. *Mon. Not. R. Astron. Soc.*, 486(1):1192–1219, March 2019. 5.3.13

[42] Pieter van Dokkum, Shany Danieli, Roberto Abraham, et al. A Second Galaxy Missing Dark Matter in the NGC 1052 Group. *Astrophys. J.*, 874(1):L5, March 2019. 5.3.13

[43] David A. Buote and Aaron J. Barth. The Extremely High Dark Matter Halo Concentration of the Relic Compact Elliptical Galaxy Mrk 1216. *Astrophys. J.*, 877(2):91, May 2019. 5.3.13

[44] Ben Forrest, Marianna Annunziatella, Gillian Wilson, et al. An Extremely Massive Quiescent Galaxy at z = 3.493: Evidence of Insufficiently Rapid Quenching Mechanisms in Theoretical Models. *Astrophys. J.*, 890(1):L1, February 2020. 5.3.13

[45] Marcel Neeleman, J. Xavier Prochaska, Nissim Kanekar, and Marc Rafelski. A cold, massive, rotating disk galaxy 1.5 billion years after the Big Bang. *Nature*, 581(7808):269–272, May 2020. 5.3.13

[46] Adam S. Bolton, Tommaso Treu, Léon V. E. Koopmans, et al. The Sloan Lens ACS Survey. VII. Elliptical Galaxy Scaling Laws from Direct Observational Mass Measurements. *Astrophys. J.*, 684(1):248–259, September 2008. 5.3.13

[47] T. Wang, C. Schreiber, D. Elbaz, et al. A dominant population of optically invisible massive galaxies in the early Universe. *Nature*, 572(7768):211–214, August 2019. 5.3.13

[48] Heather Hill. Massive galaxies from the early universe found hiding in plain sight. *Phys. Today*, September 2019. 5.3.13

[49] Laura V. Sales, Julio F. Navarro, Louis Penafiel, et al. The Formation of Ultra-Diffuse Galaxies in Clusters. *Mon. Not. R. Astron. Soc.*, 494(2):1848–1858, March 2020. 5.3.13

[50] Duncan A Forbes, Adebusola Alabi, Aaron J Romanowsky, et al. Globular clusters in Coma cluster ultra-diffuse galaxies (UDGs): evidence for two types of UDG? *Mon. Not. R. Astron. Soc.*, 492(4):4874–4883, January 2020. 5.3.14

[51] M. Volonteri. Evolution of Supermassive Black Holes. In *ESO Astrophysics Symposia*, pages 174–182. Springer Berlin Heidelberg, 2007. 5.3.14

[52] Francesca Civano, Nico Cappelluti, Ryan Hickox, et al. Cosmic evolution of supermassive black holes: A view into the next two decades, May 2019. Link(2020): https://ui.adsabs.harvard.edu/abs/2019BAAS...51c.429C/abstract. 5.3.14

[53] Elizabeth Landau. Black hole seeds missing in cosmic garden. *Jet Propulsion Laboratory News*, September 2019. Link(2020): https://www.jpl.nasa.gov/news/news.php?feature=7504. 5.3.14

[54] Ana Bonaca, David W. Hogg, Adrian M. Price-Whelan, and Charlie Conroy. The Spur and the Gap in GD-1: Dynamical Evidence for a Dark Substructure in the Milky Way Halo. *Astrophys. J.*, 880(1):38, July 2019. 5.3.15

[55] David Ehrenstein. Mapping Dark Matter in the Milky Way. *Phys. Magazine*, 12(51), May 2019. Link(2020): https://physics.aps.org/articles/v12/51. 5.3.15

[56] Lina Necib, Mariangela Lisanti, and Vasily Belokurov. Inferred Evidence for Dark Matter Kinematic Substructure with SDSS–Gaia. *ApJ*, 874(1):3, March 2019. 5.3.15

[57] Feryal Ozel, Dimitrios Psaltis, Ramesh Narayan, and Antonio Santos Villarreal. ON THE MASS DISTRIBUTION AND BIRTH MASSES OF NEUTRON STARS. *Astrophys. J.*, 757(1):55, September 2012. 5.3.16

[58] Luciano Rezzolla, Elias R. Most, and Lukas R. Weih. Using Gravitational-wave Observations and Quasi-universal Relations to Constrain the Maximum Mass of Neutron Stars. *Astrophys. J.*, 852(2):L25, January 2018. 5.3.16

[59] Heather Hill. Strange matter interacts strongly with nucleons. *Phys. Today*, 2020(1):0327a, March 2020. 5.3.16, 5.3.16

[60] Dana Najjar. 'Radical Change' Needed After Latest Neutron Star Collision. *Quanta Magazine*, February 2020. Link(2020): https://www.quantamagazine.org/radical-change-needed-after-latest-neutron-star-collision-20200220/. 5.3.16, 5.3.16

[61] Mohammadtaher Safarzadeh, Enrico Ramirez-Ruiz, and Edo Berger. GW190425 is inconsistent with being a binary neutron star born from a fast merging channel. January 2020. Link(2020): https://inspirehep.net/literature/1775566. 5.3.16

[62] R. Abbott, T. D. Abbott, S. Abraham, et al. GW190814: Gravitational Waves from the Coalescence of a 23 Solar Mass Black Hole with a 2.6 Solar Mass Compact Object. *Astrophys. J.*, 896(2):L44, June 2020. 5.3.16

[63] G. Risaliti and E. Lusso. Cosmological constraints from the Hubble diagram of quasars at high redshifts. *Nature Astronomy*, 3(3):272–277, January 2019. 5.3.17

[64] Daniel E. Holz, Scott A. Hughes, and Bernard F. Schutz. Measuring cosmic distances with standard sirens. *Phys. Today*, 71(12):34–40, December 2018. 6.3

[65] L. Verde, T. Treu, and A. G. Riess. Tensions between the early and late Universe. *Nature Astronomy*, 3(10):891–895, September 2019. 6.3

[66] Johanna L. Miller. Gravitational-lensing measurements push Hubble-constant discrepancy past 5σ. *Phys. Today*, 2020(1):0210a, February 2020. 6.3

[67] Thomas Lewton. What Might Be Speeding Up the Universe's Expansion? *Quanta Magazizne*, May 2020. Link(2020): https://www.quantamagazine.org/why-is-the-universe-expanding-so-fast-20200427/. 6.3

[68] Natalie Wolchover. New Wrinkle Added to Cosmology's Hubble Crisis. *Quanta Magazine*, February 2020. Link(2020): https://www.quantamagazine.org/new-wrinkle-added-to-cosmologys-hubble-crisis-20200226/. 6.3

[69] Wendy L. Freedman, Barry F. Madore, Taylor Hoyt, et al. Calibration of the Tip of the Red Giant Branch (TRGB). *Astrophysical Journal*, 891(1):57, March 2020. 6.3

[70] Vivian Poulin, Tristan L. Smith, Tanvi Karwal, and Marc Kamionkowski. Early Dark Energy can Resolve the Hubble Tension. *Phys. Rev. Lett.*, 122(22):221301, June 2019. 6.3

[71] J. Michael Roney. Viewpoint: CP Violations Newly Observed in Beauty Meson Decays. *Physics Magazine*, 13(6), January 2020. Link(2020): https://physics.aps.org/articles/v13/6. 6.5

[72] Sophie Ritson. *The Many Dimensions of the String Theory Wars.* phdthesis, The University of Sydney, May 2016. Link(2020): https://ses.library.usyd.edu.au/handle/2123/14968. 7.2

[73] Meinard Kuhlmann. Quantum Field Theory. In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, winter 2018 edition, 2018. Link(2020): https://plato.stanford.edu/archives/win2018/entries/quantum-field-theory/. 8.1

[74] Abhay Deshpande and Rikutaro Yoshida. The Experiment That Will Probe the Deepest Recesses of the Atom. *Sci. Amer.*, 320(6), June 2019. 8.1.3

[75] Charlie Wood. What Goes On in a Proton? Quark Math Still Conflicts With Experiments. *Quanta*, May 2020. Link(2020): https://www.quantamagazine.org/what-goes-on-in-a-proton-quark-math-still-conflicts-with-experiments-20200506/. 8.1.3

[76] Marric Stephens. Synopsis: How a Pentaquark is Put Together. *Physics Magazine*, June 2019. Link(2020): https://physics.aps.org/synopsis-for/10.1103/PhysRevLett.122.222001. 8.1.3, 8.2.1

[77] Philip W. Anderson. Brainwashed by Feynman? *Phys. Today*, 53(2):11–12, February 2000. 8.1.4

[78] Z. K. Minev, S. O. Mundhada, S. Shankar, P. Reinhold, et al. To catch and reverse a quantum jump mid-flight. *Nature*, 570(7760):200–204, June 2019. 8.1.6

[79] R. Aaij, C. Abellan Beteta, B. Adeva, et al. Observation of a Narrow Pentaquark State, $P_c(4312)^+$, and of the Two-Peak Structure of the $P_c(4450)^+$. *Phys. Rev. Lett.*, 122:222001, June 2019. 8.2.1

[80] G. A. Gonzalez-Sprinberg and J. Vidal. Tau magnetic moment. *J. Phys. Conf. Ser.*, 912(1):012001, 2017. 8.2.2

[81] Teppei Kitahara, Takemichi Okui, Gilad Perez, et al. New Physics Implications of Recent Search for KL→π0νν$^-$ at KOTO. *Phys. Rev. Lett.*, 124(7), February 2020. 9.1.2

[82] A. M. Sirunyan, A. Tumasyan, W. Adam, et al. Search for dark matter in events with a leptoquark and missing transverse momentum in proton-proton collisions at 13 TeV. *Phys. Lett. B*, 795:76–99, August 2019. 9.1.3
