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Modeling that Predicts Elementary Particles and Explains Data about Dark Matter, Early Galaxies, and the Cosmos — Source link

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

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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 modeling. The modeling uses extensions to harmonic oscillator mathematics. The modeling points to all known elementary particles. The modeling suggests new particles. Based on those results, we do the following. We explain observed 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 applications of harmonic oscillator mathematics. 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

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Contents

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1. Introduction and summary

We offer modeling 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 modeling outputs the elementary particle Standard Model particle set and suggests additional elementary particles. The modeling suggests a well-specified description of dark matter particles. The modeling adds aspects to concordance cosmology.

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

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

Table 1 lists some goals that we have for proposed modeling.

The core of this essay has bases in synergies between core ongoing modeling and core proposed modeling. For example, each one of core ongoing modeling and core proposed modeling embraces symmetries that correlate with, for example, conservation of momentum and conservation of angular momentum.

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 2 summarizes some of the results that our modeling produces. (Table 27b notes the new property - isomer or isomers - that pertains regarding elementary particles. Discussion regarding table 27 points to additional information about isomers.)

Table 3 points to tables that summarize some results from proposed modeling.

Table 4 discusses relationships between some aspects of ongoing modeling and some aspects of proposed modeling.

The following remarks provide perspective about this essay.

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

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

Table 1: Some goals for proposed modeling

Goal
• Explain data that ongoing modeling seems not to explain.
• Predict data that people can (at least eventually) verify or refute.
• Develop and use models that are compatible with essentially all relevant currently known data.
• Develop and use models that are compatible with core ongoing modeling. (The models might point to limits of applicability for some aspects of core ongoing modeling.)
• Develop and use models that people might find, based on notions such as preponderance of evidence, to be more compelling than aspects of current unverified ongoing modeling.
• Develop and use models - that people might find to be compelling - regarding relevant topics that ongoing modeling seems not to address.

Table 2: Some results

Field	Area	Results
Mathematics	Harmonic oscillators	Solutions that lie below traditional ground states
Applied mathematics	Mathematical physics	Models that catalog and interrelate properties of elementary particles and other objects
Applied mathematics	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 possible cause for baryon asymmetry
Astrophysics	Galaxy evolution	Predictions and explanations regarding galaxy formation
Physics	Properties of elementary particles	Relationships between masses of elementary particles
Physics	Properties of elementary particles	A relationship between the strengths of electromagnetism and gravity

Table 3: Tables that summarize some results from proposed modeling

Topic, table, and results
• Listing all elementary particles. Table 23 lists all the elementary particles that proposed modeling suggests. The list includes all known elementary particles. The list includes elementary particles that may suffice to correlate with, underlie, or explain all observed phenomena. This essay includes modeling that outputs the list.
• Explaining observed ratios of dark matter to ordinary matter. Table 95 catalogs observed approximate ratios of dark matter effects to ordinary matter effects. This essay shows modeling that explains various ratios.
• Explaining various astrophysics aspects and cosmology aspects. Table 87 lists aspects of cosmology and astrophysics for which proposed modeling seems to provide insight that augments insight that ongoing modeling suggests. This essay shows proposed modeling models that suggest the new insight.
• Interrelating properties of objects. Table 58 catalogs properties that pertain to elementary particles and that may pertain to objects that contain more than one component object. This essay shows modeling that organizes the catalog. This essay shows relationships between properties. This essay shows relationships between masses of elementary particles.

Table 4: Relationships between some aspects of ongoing modeling and some aspects of proposed modeling

(a) Core ongoing modeling and core proposed modeling

Aspect of core ongoing modeling - Discussion based on core proposed modeling
• The elementary particle Standard Model - Proposed modeling 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 modeling embraces observed aspects (of nature) that the Lambda-CDM model embraces. Proposed modeling suggests explanations for some observed aspects for which people have yet to agree on explanations. Proposed modeling suggests aspects that people might want to add to the Lambda-CDM model. • Dark matter - Proposed modeling suggests that much dark matter has some similarities to unverified ongoing modeling 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. • 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 modeling points to reasons why such modeling may not apply adequately accurately to some aspects of large-scale phenomena. • Modeling regarding motion - People can use core proposed modeling with modeling regarding motion that comports with conservation of energy, conservation of angular momentum, and conservation of momentum. Each one of core ongoing modeling and supplementary proposed modeling includes such modeling regarding motion.

(b) Unverified ongoing modeling and core proposed modeling

Aspect of unverified ongoing modeling - Discussion based on core proposed modeling
• Quantum gravity - Proposed modeling outputs (rather straightforwardly) a model of quantum gravity. That modeling 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 modeling 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 modeling and supplementary proposed modeling

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

Table 5: Goals for PEPM (or, proposed elementary particle modeling)

PEPM should include modeling 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 core ongoing modeling regarding motion.
• Helps explain data that ongoing modeling seems not to explain.

Table 6: Concepts and steps underlying development of PEPM (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 modeling and ongoing modeling.
• ALG modeling bridging includes aspects correlating with motion.

This essay cites references regarding data. For some aspects of mathematics and modeling, this essay does not cite references. Perhaps, reference [2] points to precedent for not necessarily citing references regarding mathematics and modeling as well as to precedent for discussing context.

2. Methods

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

2.1. Goals, concepts, and steps

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

Table 5 suggests goals for PEPM. Interactions can change, regarding objects in general, each of internal properties and motion.

Our work contributes to each of the goals that table 5 lists.

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

Goals that table 5 lists correlate with potential synergy between proposed modeling and ongoing modeling. Together, proposed modeling and ongoing modeling seem to explain data that ongoing modeling seems not to explain.

Table 6 notes concepts and steps that underlie this essay's development of PEPM. (Regarding the correlation between spin and number of particles, see table 29c.) 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

Table 7: Possible values for and assumptions about $\Psi(r)$, Ω_{SA}, D, and ν_{SA}

(a) Possible values, plus some assumptions that ongoing modeling tends to embrace

Symbol	Possible values	Assumption that ongoing modeling tends to embrace
$\Psi(r)$	Complex numbers	Complex numbers
Ω_{SA}	Complex number	Non-negative integer
D	Complex number	Positive integer
ν_{SA}	Complex number	Non-negative integer

(b) Other aspects that ongoing modeling tends to embrace

Aspect that ongoing modeling tends to embrace
• The symbol $\Psi(r)$ denotes a function of angular coordinates, as well as of r.
• The symbol Ω_{SA} correlates with aspects correlating with angular coordinates.
• The symbol D correlates with a number of dimensions.
• The symbol ν_{SA} might correlate with an energy level.

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.

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

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

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. Each of ξ_{SA} and ξ'_{SA} is a constant. The symbol $\Psi(r)$ denotes a function of r. The symbol $\nabla_r{}^2$ denotes a Laplacian operator. The symbol Ω_{SA} is a constant. 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 - and correlate with temporal aspects of - some physics modeling.

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

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

We explore solutions that pertain for the range that equation (5) shows.

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

We consider solutions of the form that equation (6) shows.

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

Table 7 discusses possible values for and assumptions about $\Psi(r)$, Ω_{SA}, D, and ν_{SA}. Our work does not necessarily automatically embrace assumptions that ongoing modeling tends to embrace.

Table 8 provides details that lead to solutions that equations (7) and (8) characterize. 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).

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

Table 8: 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}

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

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

We explore the topic of normalization regarding $\Psi(r)$.

In ongoing modeling, people consider that $\Psi(r)$ normalizes if and only if equation (9) pertains. The symbol $(\Psi(r))^*$ denotes the complex conjugate of $(\Psi(r))$.

$$\int_0^\infty (\Psi(r))^* \Psi(r) r^{D-1} dr < \infty \tag{9}$$

Our work embraces somewhat the same concept - as ongoing modeling embraces - regarding normalization. The difference in the domain for r (that is, $0 < r < \infty$ for our work versus $0 \leq r < \infty$ for ongoing modeling) is not material for this essay. For essentially the entire remainder of this essay, we assume that equation (10) pertains. (For a complex number z, the expression $z = \Re(z + i\Im(z))$ pertains. The expression $\Re(z)$ denotes the real part of z. The expression $\Im(z)$ denotes the imaginary part of z. The symbol i denotes the positive square root of the number -1.) We take the liberty to assume that the normalization criterion that equation (9) defines pertains for any real number D.

$$\Im(D) = 0 \tag{10}$$

For essentially the entire remainder of this essay, we assume that equation (11) pertains.

$$\Im(\nu_{SA}) = 0 \tag{11}$$

Equation (12) 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 (13) shows pertains. Here, x^2 correlates with r^2 and 4ϵ correlates with $(\eta_{SA})^2$. (Reference [3] provides equation (13).) 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, regarding singularities as r approaches zero, regarding some $\Psi(r)$.)

$$D + 2\nu_{SA} \geq 0 \tag{12}$$

$$\delta(x) = \lim_{\epsilon \to 0^+}(1/(2\sqrt{\pi\epsilon}))e^{-x^2/(4\epsilon)} \tag{13}$$

We use the one-element term volume-like to describe solutions for which $D + 2\nu_{SA} > 0$. The term volume-like pertains regarding behavior with respect to the coordinate or coordinates that underlie modeling. (For ongoing modeling, generally, the word coordinates - as in r plus angular coordinates - can be appropriate.) 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 the coordinate or coordinates that underlie modeling.

We explore some relationships regarding and between solutions.

We explore modeling regarding cases for which ν_{SA} is not necessarily an integer, j is an integer, and $j\nu_{SA}$ is an integer. We develop a process for transforming fractional-integer-ν_{SA} modeling into integer-ν_{SA} modeling. We anticipate using such modeling for cases for which $D + 2\nu_{SA} \geq 0$, $j = 2$, and $j\nu_{SA}$

Table 9: Some results of recursive applications of equation (15), assuming that $j = 2$

D_1	D_2	D_3	D_4	D_5	$D...$
$\cdots$					
-1	-4	-10	-22	-46	$\cdots$
0	-2	-6	-14	-30	$\cdots$
1	0	$\cdots$			Note the case for which $D_1 = 0$.
2	2	$\cdots$			2
3	4	6	10	18	$\cdots$
4	$\cdots$				Note the case for which $D_2 = 4$.
5	8	14	26	50	$\cdots$
$\cdots$					

satisfies one of $j\nu_{SA} = -1$ and $j\nu_{SA} = -3$. (See, for example, table 17.) People might also find interest in, for example, cases for which $j = 2$, $\nu_{SA} > 0$, $j\nu_{SA}$ is an integer, and ν_{SA} is not an integer. (Ongoing modeling does not necessarily consider cases for which $2\nu_{SA}$ is a positive integer and ν_{SA} is not an integer.)

We start with equation (14), which re-expresses equation (8). Equation (15) defines, for integer k, D_{k+1} in terms of D_k. Equation (16) pertains. Equation (16) correlates with an equivalent of equation (8). (Some uses of equation (16) may correlate with, in effect, absorbing the factor - in the rightmost term in the equation - of j^{-2} into the term $\xi'_{SA}/2$.)

$$\Omega_{SA} = (1/j^2)(j\nu_{SA})((j\nu_{SA} + jD_1 - 2j) \tag{14}$$

$$D_{k+1} = j(D_k - 2) + 2 \tag{15}$$

$$\Omega_{SA} = (1/j^2)(j\nu_{SA})(j\nu_{SA} + (j(D_1 - 2) + 2) - 2) = (1/j^2)(j\nu_{SA})(j\nu_{SA} + D_2 - 2) \tag{16}$$

Adding the assumption that $D_2 > 0$ yields equation (17).

$$D_1 > 2(1 - (1/j)) \tag{17}$$

Adding the assumptions that D_1 is an integer and that $j > 0$ yields equation (18).

$$D_1 \geq 2 \tag{18}$$

For the case $j = 2$, equation (19) pertains for $D_1 \geq 2$.

$$D_2 = 2D_1 - 2 \tag{19}$$

For the case $j = 2$ and $D_1 = 3$, equation (20) pertains.

$$D_2 = 2D_1 - 2 = 4 \tag{20}$$

Table 9 shows, for $j = 2$, results D_2 from applying equation (15) once to some values of D_1 and results D_k (for $k > 2$)) of reapplying equation (15).

We explore modeling that considers angular coordinates for the sub-case for which $D_1 = 3$, $j = 2$, and $\nu_{SA} = 1/2$. Here, ν_{SA} is positive and the possibly (that is, for example, for ongoing modeling) so-called total angular momentum $l\hbar$ correlates with $l = \nu_{SA} = 1/2$. Equation (21) shows the angular factor in $\Psi(r) = \phi(r)Y_{l,m}(\theta,\phi)$. Equations (22) and (23) pertain. In ongoing modeling, people use notions of two-component spinors and four-component spinors to avoid problems to which the non-equality in equation (22) seems to point.

$$Y_{1/2,\pm 1/2}(\theta,\phi) = \exp(\pm i(1/2)\phi), \text{ for } 0 \leq \phi \leq 2\pi \tag{21}$$

$$Y_{l,m}(\theta,2\pi) = \exp(\pm i\pi) = -1 \neq 1 = Y_{l,m}(\theta,0) \tag{22}$$

$$Y_{l,m}(\theta,j(2\pi)) = Y_{l,m}(\theta,0) \tag{23}$$

Table 10: Steps to avoid problems to which equation (22) seems to point

Possible steps
• Use a transformation from $D_1 = 3$ to $D_2 = 4$. (See equation (20).)   • Split a set of four (as in, $D_2 = 4$) oscillators into two sets, each consisting of a pair of oscillators.   • Develop appropriate modeling that correlates with at least one of the two sets of a pair of oscillators.

Table 11: A process for transforming a solution that is appropriate for $D_1 = D$ dimensions into a solution that is appropriate for $D_2 = D'_{SA}$ dimensions

Steps
• Choose values of ν_{SA}, σ_{SA}, S_{SA}, and D'_{SA}.   • Determine (a first value of) D via equation (26). Let D_1 denote this value of D.   • Embrace the radial dependence of $\Psi(r)$ that equation (6) implies and set any dependence on angular coordinates to a non-zero constant.   • Combine the radial dependence with an angular dependence appropriate to a solution (to equations (3) and (4)) for which (a second value of) D (in equation (4)) satisfies $D = D'_{SA}$. Let D_2 denote this (second) value of D. (The value of D_2 is not necessarily the same as the value of D_1.)   • Thereby, produce a $\Psi(r)$ that (may have angular dependence and) pertains regarding D'_{SA} dimensions.

Table 10 list steps - other than deploying mathematics correlating with spinors - that proposed modeling suggests to avoid problems to which equation (22) seems to point.

We explore some modeling that considers angular coordinates. Regarding equation (8), we explore mathematics for which equation (24) pertains for some choice of σ_{SA}, S_{SA}, and D'_{SA}. Equation (25) restates equation (8). Combining equations (24) and (25) yields equation (26).

$$\Omega_{SA} = \sigma_{SA} S_{SA}(S_{SA} + D'_{SA} - 2), \text{ for } \sigma_{SA} = \pm 1 \tag{24}$$

$$D = 2 - \nu_{SA} + (\nu_{SA})^{-1}\Omega_{SA} \tag{25}$$

$$D = 2 - \nu_{SA} + (\nu_{SA})^{-1}\sigma_{SA} S_{SA}(S_{SA} + D'_{SA} - 2) \tag{26}$$

Table 11 shows a process for transforming a solution that is appropriate for $D_1 = D$ dimensions into a solution that is appropriate for $D_2 = D'_{SA}$ dimensions. (See equation (26).) Here, we deploy some concepts that ongoing modeling embraces. (See table 7.)

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

$$A^{PDE}_{TA}\Psi(t,r) = \xi_{TA}\Psi(t,r) = (\xi'_{TA}/2)(-(\eta_{TA})^2\nabla_t{}^2 + (\eta_{TA})^{-2}t^2)\Psi(t,r) \tag{27}$$

$$\nabla_t{}^2 = t^{-(D_{TA}-1)}(\partial/\partial t)(t^{D_{TA}-1})(\partial/\partial t) - \Omega_{TA}t^{-2} \tag{28}$$

$$A^{PDE}_{SA}\Psi(t,r) = \xi_{SA}\Psi(t,r) = (\xi'_{SA}/2)(-(\eta_{SA})^2\nabla_r{}^2 + (\eta_{SA})^{-2}r^2)\Psi(t,r) \tag{29}$$

$$\nabla_r{}^2 = r^{-(D_{SA}-1)}(\partial/\partial r)(r^{D_{SA}-1})(\partial/\partial r) - \Omega_{SA}r^{-2} \tag{30}$$

For core proposed modeling, we assume that equation (31) pertains.

$$0 = A^{PDE} = A^{PDE}_{TA} - A^{PDE}_{SA} \tag{31}$$

Table 12: 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}	...								

2.3. ALG mathematics

We explore mathematics underlying ALG modeling.

Equation (32) shows an ongoing modeling representation for states for a one-dimensional harmonic oscillator. The symbol $|\_>$ correlates with the notion of quantum state. (See equation (2).) Equation (33) shows the ongoing modeling representation for a raising operator. Equation (34) shows the ongoing modeling representation for a lowering operator. In ongoing modeling, n is a nonnegative integer.

$$|n > \tag{32}$$

$$a^+|n >= (1+n)^{1/2}|n+1 > \tag{33}$$

$$a^-|n >= n^{1/2}|n-1 > \tag{34}$$

Proposed modeling extends the domain correlating with equation (32) from the ongoing modeling domain of $n \geq 0$ to the domain of $n \geq -1$. Proposed modeling includes equations (35) and (36). The extended domain plays roles regarding multidimensional harmonic oscillators.

$$a^+|-1 >= 0|0 > \tag{35}$$

$$a^-|0 >= 0|-1 > \tag{36}$$

Equation (37) correlates with equations (27), (28), (29), and (30). 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.

$$A_{XA}^{ALG} = (\xi'_{XA}/2) \sum_{\iota=0}^{D_{XA}-1} -(\eta_{XA})^2 (\frac{d}{dr_{XA\iota}})^2 + (\eta_{XA})^{-2}(r_{XA\iota})^2 \tag{37}$$

For ALG modeling, equation (38) 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.

$$0 = A^{ALG} = A_{TA}^{ALG} - A_{SA}^{ALG} \tag{38}$$

For core proposed modeling, we assume that equation (38) pertains. Equation (38) provides an ALG analog to PDE equation (31).

Table 12 provides ways to visualize solutions to equation (38). 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 (32). Also, for some applications, we assume the following. We assume that equation (38) implies that $(\xi'_{TA}/2) = (\xi'_{SA}/2) \neq 0$. 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 (38) and (39) characterize all solutions that we include in ALG modeling that is based on isotropic harmonic oscillators.

$$A_{XA}^{ALG} = \sum_{\iota=0}^{D_{XA}-1} (n_{XA\iota} + 1/2) \tag{39}$$

We posit that equations (40) and (41) extend equation (38). Here, the number, n, correlating with excitations satisfies $n \geq 0$.

$$a^+ A_{TA}^{ALG} = a^+ A_{SA}^{ALG} \tag{40}$$

$$a^- A_{TA}^{ALG} = a^- A_{SA}^{ALG} \tag{41}$$

We posit that equations (42) and (43) have relevance for the domain $-1 \leq n \leq 0$. (See discussion regarding table 44 - which pertains for charged leptons - and discussion regarding table 46 - which pertains for neutrinos.) This essay de-emphasizes fully discussing implications of applications of equations (42) and (43).

$$b^+ |n> = n^{1/2}|n+1> \tag{42}$$

$$b^- |n> = (1+n)^{1/2}|n-1> \tag{43}$$

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

Table 13 shows symbols that this essay suggests and groups to which proposed modeling refers. Regarding information pertaining to groups, aside from rows (in the table) that show a negative contribution to A_{XA}^{ALG} or that show the symbol $\pi_{@_0, @_{-1}}$, 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 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 $S1G$ 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 $n\_ \geq 0$. One generator correlates with integer decreases regarding the number of excitations that pertain for the oscillator for which the table shows $n\_ \geq 0$. 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. Regarding the symbol $\pi_{n,@_{-1}}$, the $U(1)$ symmetry correlates with the n. Use of the symbol $\pi_{@_0, @_{-1}}$ is sensitive to context. In some contexts, a $U(1)$ symmetry pertains and correlates with the appearance of $@_0$. In some contexts, no $U(1)$ symmetry pertains. The symbol A0+ denotes $\pi_{@_0, @_0}$. The symbol κ correlates with the concept of a continuous set of choices. For example, regarding two oscillators XA1 and XA2, equations (44) and (45) describe the continuum of possibilities correlating with $\kappa_{0,-1}$. Here, each of d and e is a complex number. The symbol [blank] denotes the concept that, in tables such as table 35, one can interpret a blank cell as correlating with $\kappa_{0,-1}$. Regarding $SU(j)$, each one 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. The number of generators for $SU(j)$ is $j^2 - 1$.

$$d|n_{XA1} = 0, n_{XA2} = -1> \ + \ e|n_{XA1} = -1, n_{XA2} = 0> \tag{44}$$

$$|d|^2 + |e|^2 = 1 \tag{45}$$

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

In equation (46), 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 ∤ denotes the four-word phrase does not divide evenly. For some aspects of proposed modeling, equation (46) correlates with ending the series $SU(3)$, $SU(5)$, $\cdots$ at the item $SU(7)$. For some aspects of proposed modeling, the series $SU(3)$, $SU(5)$, $SU(7)$, and $SU(17)$ might pertain.

Table 13: Number of oscillators, symbols, groups, and contributions to A_{XA}^{ALG}

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

Table 14: Some aspects and objectives of physics modeling regarding an object

Aspect and objective
• Description - Describe the object.
• Motion - Regarding the object, describe a trajectory (classical physics) or wave function (quantum physics).
• Measurements - Regarding an observer's measurements of the object, predict or explain measured values.

$$g_3|g_5,\ g_3|g_7,\ g_5|g_7 \quad g_5\!\!\!/g_9,\ g_7\!\!\!/g_9,\ g_7\!\!\!/g_{11} \quad g_3|g_{17},\ g_5|g_{17},\ g_7|g_{17} \tag{46}$$

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 (47) echoes mathematics and some ongoing 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.

$$SU(j_1 + j_2) \supset SU(j_1) \times SU(j_2) \times U(1) \tag{47}$$

2.4. Relationships between applications of various types of models

Table 14 shows some aspects and objectives of physics modeling regarding an object. (This essay de-emphasizes discussing many notions regarding the completeness with which modeling does or could meet objectives that table 14 notes. For example, we do not necessarily adequately discuss the extent to which modeling regarding objects leads to modeling that sub-optimally describes nature. For example, we do not necessarily adequately discuss the extent to which models completely separate one object from the rest of the universe. Ongoing modeling devotes much attention to the notion of entanglement. For example, we do not necessarily adequately discuss the notion of how well modeling defines objects. In ongoing modeling, modeling based on the Dirac equation does not necessarily completely separate an electron from a correlated positron. And so forth.)

This essay seeks to develop core proposed modeling - that models descriptions of objects - that complements core ongoing modeling models regarding motion and measurements.

Table 15 discusses the terms KMS (or, kinematics modeling space), PFS (or, particle field space), and UMS (or, united modeling space).

Table 16 discusses uses for core proposed modeling ALG models.

Table 17 characterizes applications - that this essay discusses - of various types of modeling based on harmonic oscillator mathematics. For each of the cases PFS PDE and KMS PDE, this essay uses symbols such as t and r to denote relevant coordinates. PFS PDE use of such a symbol does not necessarily completely correlate with KMS PDE use of the same symbol.

UMS modeling provides a basis to explore relationships between KMS modeling and core proposed modeling PFS models. This essay does not fully explore relationships between KMS modeling and core

Table 15: KMS (or, kinematics modeling space), PFS (or, particle field space), and UMS (or, united modeling space)

Aspect
• The term KMS abbreviates the three-word term kinematics modeling space. The term KMS refers to modeling that can - and, in ongoing modeling, often does - use coordinates that people use to model aspects that people correlate with notions of space-time. Ongoing modeling tends to use KMS modeling to address the topics of motion and measurements. (See table 14.) Core proposed modeling tends to embrace results from such ongoing modeling. Supplementary proposed modeling suggests new KMS modeling that might supplement such ongoing modeling.   • The term PFS abbreviates the three-word term particle field space. The term PFS refers to modeling that generally does not correlate directly with space-time coordinates. Core proposed modeling tends to use PFS modeling to address the topic of objects (especially, elementary particles). (See table 14.) Core ongoing modeling seems not to include, for at least elementary particles, an analog to PFS modeling.   • The term UMS abbreviates the three-word term united modeling space. The term UMS refers to modeling that embraces aspects that correlate with, at least, KMS modeling and PFS modeling. Core proposed modeling tends to use UMS ALG modeling to address topics regarding properties of objects and regarding conservation laws. Here, the two-word term conservation laws pertains regarding internal properties of objects and regarding motions of objects. (Perhaps, note table 14.) Unverified ongoing modeling seems to suggest - for example via the notion of a so-called theory of everything - possible desirability for people to explore notions such as UMS modeling.

Table 16: Uses for core proposed modeling ALG models

Use
• Core proposed modeling ALG models provide means to extend and catalog results - regarding elementary particles - that core proposed modeling PDE models output.   • Core proposed modeling ALG models suggest means to integrate modeling regarding the aspects that table 14 discusses.

Table 17: Applications of various types of modeling based on harmonic oscillator mathematics

Type	Applications	Integer 2ν (pertains re PDE)	Integer n (pertains re ALG)
Core proposed modeling	PFS	$2\nu < 0$	$n \geq -1$
Core ongoing modeling	KMS	$2\nu \geq 0$, even	$n \geq 0$
Unverified ongoing modeling	KMS	$2\nu \geq 0$, even	$n \geq 0$
Supplementary proposed modeling	KMS	$2\nu \geq 0$, even	$n \geq 0$
Core proposed modeling ALG models	UMS	-	$0 \geq n \geq -1$

proposed modeling PFS models. We suggest that some such exploration might feature linking PFS modeling and KMS modeling via modeling that involves concepts such as phase spaces, tangent spaces, or symplectic geometry. (See, for example, reference [4].) One concept might include the notion of considering that PFS PDE modeling might pertain mathematically to a tangent space to a space that correlates with space-time coordinates. One concept might include the notion of considering that PFS PDE modeling might pertain mathematically to a tangent space to a space that correlates with a phase space that correlates with an energy-momentum space and with space-time coordinates. Per table 17, we suggest that people might use core proposed modeling ALG models as bases for exploring such concepts.

We provide additional perspective about modeling that this essay discusses.

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

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

Proposed modeling 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 modeling KMS modeling that uses space-time coordinates. We use the term temporal aspects in the context of PFS modeling and in the context of KMS modeling. Proposed modeling 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 modeling KMS modeling that uses space-time coordinates. We use the term spatial aspects in the context of PFS modeling and in the context of KMS modeling.

2.5. A method that organizes properties of elementary particles and other objects

We discuss a method to organize and conceptualize aspects of modeling that we develop below. The method itself might point to insight about modeling and about nature. (See discussion related to table 111.) However, for the moment, we treat the method as, in essence, an organizational convenience.

The method has bases in the notion that $SU(17)$ symmetry might be relevant. The method has bases in the notion that modeling based on 17 harmonic oscillators can correlate with $SU(17)$ symmetry. (See table 13.)

The method has bases in table 12b. We label the 17 oscillators as HO1, HO2, ..., and HO17.

The method uses equation (47).

The method correlates with the two one-element terms UMS and ALG.

Table 18 notes aspects pertaining to some types of symmetries and related conservation laws. Proposed modeling correlates these aspects with aspects regarding interactions between objects. The terms exact symmetry, approximate symmetry, and no symmetry correlate with mathematical modeling and with aspects of ongoing modeling. The following discussion reprises examples that table 18 shows. An electron, correlates with an exact symmetry regarding conservation of charge. An electron correlates with a rebuttable always conservation law that correlates with charge. For an interaction between the electron and other objects that all correlate with rebuttable always conservation of charge, the outgoing fermion that correlates with the incoming electron has the same charge as the electron. For that example, a notion of always conservation of charge - across the electron and the related outgoing fermion - pertains. Suppose, however, that one of the incoming particles is a W boson. The W boson correlates with no symmetry and with not necessarily conservation of charge. If the W boson is a positively charged W boson, the interaction can transform the electron into a neutrino, which has zero charge. Here, in effect, the not necessarily conservation of charge correlating with the W boson rebuts the rebuttable always conservation of charge for the electron.

Table 19 discusses aspects relevant to the method to organize properties of objects.

Table 20 discusses the method and previews aspects of applications of the method.

Table 21 posits aspects - of proposed modeling and of nature - that might correlate with SM6a and SM6b symmetries.

3. Results: elementary particles

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

Table 18: Aspects pertaining to some types of symmetries and related conservation laws

Aspect
• The following correlations pertain.

Symmetry	Conservation
Exact	Rebuttable always
Approximate	Rebuttable somewhat
No	Not necessarily

• Symmetries rank as follows regarding exactness. An exact symmetry is more exact than an approximate symmetry. An exact symmetry is more exact than no symmetry. An approximate symmetry is more exact than no symmetry.
• Conservation laws interrelate as follows. Not necessarily takes precedence over rebuttable somewhat. Not necessarily takes precedence over rebuttable always. Rebuttable somewhat takes precedence over rebuttable always.
• For an interaction, the least exact symmetry that pertains regarding any incoming elementary particle or object pertains.
• For example, for an interaction between an electron and a photon, the following sentences pertain. The electron correlates with a $\pi_{@_0,@_{-1}}$ exact symmetry, which correlates with rebuttable always conservation of fermion charge. The photon correlates with a $\pi_{@_0,@_{-1}}$ exact symmetry, which correlates with rebuttable always conservation of fermion charge. The interaction correlates with rebuttable always conservation of fermion charge. The outgoing particle is a negatively charged lepton.
• For example, for an interaction between an electron and a positively charged W boson, the following sentences pertain. The electron correlates with a $\pi_{@_0,@_{-1}}$ exact symmetry, which correlates with rebuttable always conservation of fermion charge. The W boson correlates with a $\kappa_{@_0,@_{-1}}$ no symmetry, which correlates with not necessarily conservation of fermion charge. The interaction correlates with not necessarily conservation of fermion charge. The outgoing particle is a neutrino, which has zero charge.

Table 19: Aspects relevant to a method to organize properties of objects

Aspect
• A $U(1)$ symmetry might correlate with a quantity (such as charge) for which a rebuttable always conservation law pertains across objects. The quantity sums across individual objects (including elementary particles) that a so-called larger object includes. An individual object can shed or gain amounts of the quantity.

• An $SU(2)$ symmetry might correlate with a trio of degrees of freedom for aspects that sum. For example, regarding charge, the three degrees of freedom correlate with negative charge, zero charge, and positive charge. One can sum - across components of an object - each of the three quantities. One can obtain a net charge for the object by combining the three sums. Regarding momentum and either proposed modeling or ongoing modeling, the three degrees of freedom correlate with the three components of a vector that can correlate with momentum or with three spatial dimensions. Regarding any one of the three components of momenta vectors, one can sum - across components of an object - that component of momentum.
• A $U(1)$ symmetry might not correlate with a rebuttable always conservation law. An $SU(2)$ symmetry might not correlate with a trio of degrees of freedom. A pairing of one such $U(1)$ symmetry and one such $SU(2)$ symmetry provides a symmetry that correlates with six generators and that can correlate with six isomers of a physics property. Such properties seem to include charge and may include mass.
• The symbol 3LB denotes the notion of three times the quantity lepton number minus baryon number. In each of proposed modeling and ongoing modeling, lepton number minus baryon number is a conserved quantity.
• The series of symbols 2G, 4G, 6G, and 8G denotes four elementary particles that proposed modeling suggests. The symbols correlate respectively with the (spin-one) photon (which correlates with each of core proposed modeling and core ongoing modeling), a (spin-two) graviton (which correlates with each of core proposed modeling and unverified ongoing modeling), a spin-three elementary particle (which correlates with core proposed modeling and not with ongoing modeling), and a spin-four elementary particle (which correlates with core proposed modeling and not with ongoing modeling).

Table 20: A method to organize properties of objects (with the one-element term HO abbreviating the two-word phrase harmonic oscillator)

(a) Steps that develop the method (with the word generations pertaining to elementary fermions)

HO range	$j_1 + j_2$	j_1	j_2	HO range rej_1	HO range rej_2	Use of $U(1)$
1-17	17	8	9	1-8 (deferred)	9-17 (deferred)	(deferred to 1-2)
1-8	8	4	4	1-2; 7-8 (deferred)	3-6 (deferred)	Cons of energy
1-2; 7-8	4	2	2	1-2 Cons of charge	7-8 Cons of 3LB	Cons of 3LB
3-6	4	2	2	3-4 Mass, SM6a $SU(2)$	5-6 Generations	3-4 SM6a $U(1)$
9-17	9	5	4	9-10; 15-17 (deferred)	11-14 (deferred)	(deferred to 11-12)
9-10; 15-17	5	3	2	9-10; 17 SI $SU(3)$	15-16 SM6b $SU(2)$	15-16 SM6b $U(1)$
11-14	4	2	2	11-12 Cons of ang mom	13-14 Cons of mom	Cons of mom

(b) Some notes

Note
• Each one-word item (deferred) implies that a later row in table 20a pertains for the HO range.   • Each multi-element item (deferred to k_1-k_2) implies that a later row discusses the HO range k_1-k_2 and that the $U(1)$ symmetry pertains to the k_1-k_2 HO range.   • The multi-element item 1-2; 7-8 denotes the four oscillators 1, 2, 7, and 8.   • Cons denotes the word conservation.   • Regarding the item 3-4 Mass, a property pertaining to all objects is rest mass (or - equivalently - rest energy).   • The items 3-4 SM6a $SU(2)$ and 3-4 SM6a $U(1)$ correlate with the six generators of an $SU(2) \times U(1)$ symmetry.   • Regarding the item 5-6 Generations, the property pertaining to all objects is freeable energy (or, energy above ground state).   • Conservation of energy - for an individual object - correlates with conservation of rest energy (or, rest mass times c^2 - in which c denotes the speed of light) minus freeable energy.   • The multi-element item 9-10; 15-17 denotes the five oscillators 9, 10, 15, 16, and 17.   • The SI $SU(3)$ item correlates with strong interaction $SU(3)$ symmetry.   • The items 15-16 SM6b $SU(2)$ and 15-16 SM6b $U(1)$ correlate with the six generators of an $SU(2) \times U(1)$ symmetry.   • The two-element abbreviation ang mom abbreviates the two-word phrase angular momentum.   • The one-element abbreviation mom abbreviates the word momentum.

(c) Additional notes

Note
• In table 20a, HO range 1-2 correlates with charge and with the notion that 2G interacts with charge.   • In table 20a, HO range 3-4 correlates with rest energy and with the notion that 4G interacts with rest energy.   • In table 20a, HO range 5-6 correlates with freeable energy and with the notion that 6G interacts with freeable energy.   • Regarding elementary particles, the $SU(2)$ that correlates with SM6a correlates with three generations for elementary fermions. (See table 58a.) This notion correlates with a seemingly approximate - but not exact - symmetry that pertains regarding elementary leptons. (See discussion regarding table 96.)   • In table 20a, HO range 7-8 correlates with 3LB and with the notion that 8G interacts with 3LB.   • The two-element term G-family physics includes 2G, 4G, 6G, and 8G. The term G-family physics does not include, for example, the bosons associated with the weak interaction.   • In table 20a, assignments of oscillators in the HO range 9-17 do not necessarily reflect G-family physics. People might explore possibilities for developing principles governing such assignments. Without such principles, people might consider that proposed modeling is invariant under permutation of the assignments.

Table 21: Aspects - of proposed modeling and of nature - that might correlate with SM6a and SM6b symmetries

(a) Aspects

Aspect
• Six isomers of charge (and of elementary particles having non-zero charge).
• Six isomers of all elementary particles, except ΣG (or, G-family) elementary particles. (See discussion - regarding 2G, 4G, and so forth - in table 19 and in table 20c.)
• Six isomers of mass and gravity.
• Six permutations of color charge.

(b) Notes

Note
• Proposed modeling explores three possibilities regarding isomers. We denote the possibilities by symbols of the form PRι_IISP, with - respectively for the three possibilities - $\iota_I = 1$, $\iota_I = 6$, and $\iota_I = 36$. The two letters PR abbreviate the one-element term physics-relevant. The symbol ι correlates with the two-word phrase number of. The subscript $_I$ correlates with the word isomers. The three letters ISP abbreviate the four-word phrase isomers of simple particles. (The two-word term simple particles denotes all - except gluons and G-family elementary particles - elementary particles that proposed modeling suggests. See discussion related to table 23. Each isomer of simple particles correlates with its own isomer of gluons.)
• We say that the case PR1ISP correlates with - for each elementary particle - one isomer. Core ongoing modeling features a subset of the elementary particles that proposed modeling suggests. Core ongoing modeling correlates with a subset of PR1ISP.
• We invoke SM6a symmetry.
• We say that - regarding all elementary particles except G-family elementary particles - PR6ISP correlates with six isomers of PR1ISP. PR6ISP correlates with the notions of six isomers of charge and one isomer of mass. The one isomer of mass correlates with a notion of one isomer of gravity. The six isomers of PR1ISP interact with each other via at least (one aspect of) gravity. (Technically, some aspects of gravity do not connect all six isomers to each other. See, for example, table 93. Technically, some aspects of electromagnetism connect all six isomers to each other. See, for example, table 93.) Proposed modeling PR6ISP models seem to explain observed ratios - of dark matter effects to ordinary matter effects - that proposed modeling PR1ISP models and ongoing modeling seem not to explain.
• We explore one possible way to invoke SM6b symmetry.
• We say that - regarding all elementary particles except G-family elementary particles - PR36ISP correlates with six isomers of PR6ISP. PR36ISP correlates with the notions of 36 isomers of charge and six isomers of mass. Each one of the isomers of mass correlates with its own isomer of gravity. The six isomers of PR6ISP interact with each other via (some aspects of) electromagnetism. The six isomers of PR6ISP do not interact with each other via gravity. Proposed modeling PR36ISP models might provide an (alternative to ongoing modeling) explanation for ratios of density of dark energy to density of dark matter plus ordinary matter.
• We explore another possible way to invoke SM6b symmetry.
• Six permutations of color charge: Table 20a correlates the three-oscillator HO range 9, 10, and 17 with an $SU(3)$ symmetry that correlates with the strong interaction. Proposed modeling correlates, in effect, each one of the color charge red, the color charge blue, and the color charge green with a different one of three oscillators. (See discussion related to table 69.) Possibly, a permutation symmetry - $\pi_{r,b,g}$ - has physics relevance.

Table 22: Use of the two-word term elementary particle

(a) Vocabulary regarding aspects that people might consider as settled

Note
• This essay de-emphasizes the notion that each quark correlates, based on the existence of three color charges, with three elementary particles.

(b) Aspects that are not necessarily universal throughout proposed modeling and ongoing modeling

Aspect
• Proposed modeling suggests some modeling that correlates aspects of the residual strong force with elementary particles and not necessarily with ongoing modeling notions that do not directly involve elementary particles. Examples include the following. Proposed modeling based on so-called 2J bosons (or, jay elementary particles) might correlate with ongoing modeling that correlates with the so-called Pauli exclusion force and a repulsive component of the residual strong force. Proposed modeling based on a so-called 0P boson (or, pie elementary particle) might correlate with ongoing modeling that correlates with virtual pions, a Yukawa potential, and an attractive component of the residual strong force.
• Proposed modeling suggests some new modeling that people might correlate with ongoing modeling notions that correlate with terms such as the five-word term interactions with the quantum vacuum. Examples include some interactions involving the so-called 0I boson (or, aye elementary particle) and some interactions involving the 2J bosons.

(c) Policy regarding using the two-word term elementary particle

Aspect
• This essay uses the two-word term elementary particle so as to include proposed modeling aspects - such as the 0I, 0P, and 2J bosons - to which table 22b alludes.

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

We suggest that the notion of elementary particle might depend, to some extent, on modeling and vocabulary that people choose to use.

Table 22 discusses use - in this essay - of the two-word term elementary particle. Table 22a discusses vocabulary regarding aspects that people might consider as settled. Table 22b discusses aspects that are not necessarily universal throughout proposed modeling and ongoing modeling. Aspects that table 22b mentions correlate directly with possible elementary bosons and do not necessarily correlate directly with possible elementary fermions. Table 22c states policy that this essay follows regarding using the two-word term elementary particle.

Table 23 catalogs elementary particles that core ongoing modeling recognizes or that core proposed modeling suggests. (Core proposed modeling includes all of the elementary particles that core ongoing modeling recognizes.) Each row in the table 23a features one value of spin S. The symbol S denotes spin, in units of $\hbar$. (Technically, S correlates with the S in the ongoing modeling 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. The expression $m \doteq 0$ denotes a notion of zerolike mass. Some ongoing modeling models correlate neutrinos with small positive masses. Some ongoing modeling models correlate neutrinos with zero masses. The expression $m \gtrdot 0$ correlates with mass being positive in all ongoing modeling models and in all proposed modeling models. A number (n) denotes a number of elementary particles. A number ((n)) denotes a number of modes. Table 23b provides additional information regarding items that table 23a lists. Table 26c alludes to possible candidate elementary particles that table 23 does not include and that this essay de-emphasizes. For some elementary particles that people have yet to find, table 23b shows names that this essay suggests. Regarding Σ_{max}, see discussion regarding equation (48) and equation (49).

We use the two-word term simple particle to pertain to each entry in table 23 other than G-family entries and U-family entries. We correlate the two-word term root force with each G-family entry in table 23 and with the U-family entry in table 23. This use of the word root reflects the notion that some ongoing modeling PDE mathematics-based modeling, which has bases in ongoing modeling KMS aspects of root forces, outputs solutions that correlate with known and suggested simple particles. (See discussion related to equation (58). This essay does not necessarily suggest physics meaning for such

Table 23: Elementary particles (or simple particles and root forces)

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

Spin (S)	Σ	$m\gtrsim0$	$m\doteq0$
0	0	0H (1), 0P (1)	0I (1)
1/2	1	1C (3), 1Q (6)	1N (3), 1R (6)
1	2	2W (2), 2T (4)	2J (3)
1	2		2G ((2)), 2U (8)
2	4		4G ((2))
3	6		6G ((2))
. . .	. . .		. . .
$\Sigma_{max}/2$	Σ_{max}		Σ_{max}G ((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 (S)	Σ	$m\gtrsim0$	$m\doteq0$
0	0	Higgs boson (1), Pie* (1)	Aye* (1)
1/2	1	Charged leptons (3), Quarks (6)	Neutrinos (3), Arcs* (6)
1	2	Z and W bosons (2), Tweaks* (4)	Jays* (3)
1	2		Photon ((2)), Gluons (8)
2	4		Graviton* ((2))
3	6		TBD* ((2))
. . .	. . .		. . .
$\Sigma_{max}/2$	Σ_{max}		TBD* ((2))

use of the word root. Beyond the modeling-based contrast with the term root force, this essay does not necessarily suggest physics meaning for such use of the word simple.) We correlate the three-element term long-range root forces with the G family.

Particle counts in table 23 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. (See table 22a.)

We discuss the elementary particles for which the spin is zero (or, $\Sigma = 0$).

The 0H particle is the Higgs boson.

The 0P, or so-called pie, possible particle would correlate with a core ongoing modeling notion of an attractive component of the residual strong force.

The 0I, or so-called aye, particle is a possible zerolike-mass relative of the Higgs boson. Proposed modeling suggests that the aye particle is a candidate for the ongoing modeling notion of an inflaton.

We discuss the elementary particles for which the spin is one-half (or, $\Sigma = 1$).

The three 1C particles are the three charged leptons - the electron, the muon, and the tauon.

The six 1Q particles are the six quarks.

The three 1N particles are the three neutrinos. Some aspects of ongoing modeling 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 modeling, such as some aspects of the Standard Model, suggest that all neutrino masses are zero. Proposed modeling suggests that effects of 8G forces might fully explain neutrino oscillations and the relevant astrophysics data. For example, proposed modeling suggests that 8G forces lead to effects that ongoing astrophysics modeling 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 modeling attributes to observed data. (See equations (142) and (143).) The 8G forces do not interact with the property of mass. Proposed modeling suggests the possibilities that each neutrino has zero mass or that neutrinos have non-zero (zerolike) masses that are significantly smaller than $\alpha^2 m_\epsilon$.

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 the elementary particles, other than G-family elementary particles, for which the spin is one (or, $\Sigma = 2$).

The two 2W particles are the two weak interaction bosons - the Z boson and the W boson.

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 modeling notions of leptoquarks.

The 2J particles, or so-called jays, are possible zerolike-mass bosons. The jay particles would correlate with a core ongoing modeling notion of a repulsive component of the residual strong force. (The jay particles would correlate with a core ongoing modeling notion of a Pauli exclusion force.) Proposed modeling suggests that the jay particles played roles that ongoing modeling correlates with times just before the inflationary epic and with times during the inflationary epoch.

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

We discuss additional roles for the aye boson and jay bosons.

Some proposed modeling models correlating with the aye particle and the jay particles might correlate with some ongoing modeling models that include notions of interactions with a quantum vacuum.

We discuss G-family forces.

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 correlates with right circular polarization. For 2G, ongoing modeling suggests classical physics models and quantum physics models. The word electromagnetism can pertain. Proposed modeling suggests modeling that provides for 2G aspects that include and complement ongoing modeling electromagnetism. Regarding gravitation, ongoing modeling suggests classical physics models. Proposed modeling suggests modeling for 4G aspects that include and complement ongoing modeling gravitation. Proposed modeling regarding 4G includes classical physics aspects and quantum physics aspects. Proposed modeling regarding 4G includes aspects that ongoing modeling correlates with the four-word term dark energy negative pressure. Proposed modeling suggests that quantum interactions, involving simple fermions, mediated by 4G can correlate with a notion of rebuttable somewhat conservation of fermion generation. Ongoing modeling does not include 6G aspects and does not include 8G aspects. Proposed modeling suggests that 8G interacts with lepton number minus baryon number.

Regarding G-family forces, proposed modeling 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 modeling can address the topics of properties and interactions without necessarily selecting an ongoing modeling model for motion. (See, for example, discussion regarding table 61 and discussion regarding table 62.) The notion of components is essential for proposed modeling 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 89 and discussion regarding tables 92 and 93.)

Proposed modeling suggests that one of equation (48) and equation (49) pertains. Proposed modeling includes the possibility that nature includes 10G, 12G, 14G, 16G, 18G, and 20G bosons. (See discussion related to table 48 and discussion related to equation (135).) G-family bosons for which $\Sigma \geq 10$ 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 modeling anomalous property is anomalous magnetic dipole moment. Detecting effects of ΣG for which $\Sigma \geq 10$ might be difficult. (See discussion related to equation (140).) This essay does not necessarily recommend which one of equation (48) and equation (49) pertains to nature. (See discussion regarding equation (134) and equation (135).)

$$\Sigma_{max} = 8 \tag{48}$$

$$\Sigma_{max} = 20 \tag{49}$$

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. (See table 23.)

We provide perspective regarding processes leading to 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 23 point to possibilities for the scenario that we just described. The table exhibits organizing principles. One principle features a choice between values of Σ. One principle features a choice between non-zero mass and zerolike mass.

Some aspects of table 23 point to possible difficulties regarding the scenario that we just described. The notion of zerolike mass correlates with ongoing modeling KMS modeling. For some models, zerolike means zero. For some models zerolike means - for some elementary particles - non-zero. More generally, ongoing modeling KMS modeling includes models that use the notion of potential energy and, thereby, might 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 [5].) People originally did not understand bases for those principles. Neither principle proved to be strictly rigorous. After people developed nuclear physics modeling and atomic physics modeling, 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 23.)

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 modeling uses for KMS PDE modeling, seem to encode information correlating with ongoing modeling KMS modeling for potentials that correlate with electromagnetism and with the strong interaction. Use the equation in a context of proposed modeling PFS PDE modeling. Anticipate that solutions correlating with the equation will correlate with simple particles. This duality - that some particles (which correlate with root forces) correlate with the equation and some particles (which correlate with simple particles) correlate with solutions to the equation - portends some complexity regarding the method.

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

The method has iterative aspects. Look at data and modeling. Reuse, extend, create, or integrate modeling. 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. (Here, this essay uses the two-word phrase truly elementary advisedly, from a standpoint of modeling. This essay de-emphasizes the topic of the extent to which nature might exhibit aspects that people might consider to be more elementary than elementary particles.) New understanding could feature new modeling. Aspects of UMS modeling might point to how to develop a so-called theory of everything. (See discussion related to table 110.) UMS modeling might point not only to all elementary particles and their properties but also to an adequately encompassing set of quantum mechanics modeling regarding motion and classical mechanics modeling regarding motion.

We provide perspective regarding aspects of the table of elementary particles (or, table 23).

Table 24 summarizes some possible correlations between observed phenomena, ongoing modeling, and proposed modeling. For each row in the table, proposed modeling 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 62 and specifically see table 62b. Regarding the notion of isomers, see tables 20, 27b, 27d, 62b, and 63.)

Table 25 reviews and previews correlations that core proposed modeling includes. (See tables 12b, 19, 20, and 58.) We provide table 25 to provide context and perspective for our discussing how proposed

Table 24: Some possible correlations between observed phenomena, ongoing modeling, and proposed modeling (with specifics about 4G forces correlating with the notion of isomers and with the notion of components)

Phenomenon	Ongoing modeling	Proposed modeling
	Quantum vacuum	Aye and jays
	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	Jays

Table 25: Some possible correlations between root forces and phenomena (with the three-word term conserved and additive referring to a sum - across objects - of values of the property)

ΣΦ	Property of an object	Conserved and additive	XA oscillator pair
2G	Charge	Yes	1, 2
4G	Rest energy	No	3, 4
6G	Freeable energy (which, for simple fermions only, correlates with generation)	No	5, 6
8G	3LB number	Yes	7, 8
2U	Color charge	No	9, 10

modeling develops table 23.

For 2G, 4G, and 2U, table 25 shows seemingly expected correlations between proposed modeling and ongoing modeling. For example, in each of core proposed modeling and core ongoing modeling, photons (or, regarding proposed modeling, 2G) interact with charge and nominal magnetic moment.

Core ongoing modeling (and, as far as we know, also unverified ongoing modeling) does not include aspects that would correlate directly with 6G or 8G. Core ongoing modeling includes the notion of internal energy above a ground state energy.

3.2.1. Proposed elementary particle modeling (or, PEPM)

We continue discussion regarding proposed elementary particle modeling (or, PEPM). (See discussion related to tables 5 and 6.)

Mathematics and ongoing modeling 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).) We consider KMS modeling. (See table 17.) The symbol r denotes a radial spatial coordinate. The r^{-2} operator in equation (4) can model aspects correlating with the square of an electrostatic potential. The potential correlates with r^{-1} and can be either attractive or repulsive. The force correlates with r^{-2} and can be either attractive or repulsive. 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 25.) The r^2 operator in equation (3) can model aspects correlating with the square of a strong interaction potential. Ongoing modeling includes the concept of asymptotic freedom. The potential correlates with r^1. The force correlates with r^0. (Apparently, over time, ongoing modeling 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.) This strong interaction potential would correlate with excitations related to the 2U subfamily (or, gluons) and with interactions within hadron-like particles. (Ongoing modeling 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 modeling suggests correlating an attractive component of the residual strong force with the so-called 0P - or, pie - simple boson. Proposed modeling suggests correlating a repulsive component of the residual strong force with the so-called 2J - or, jay - simple bosons.)

Equations (3) and (4) seem to encode information (about potentials and forces) that correlate with G-family and U-family elementary particles. We pursue the notion that solutions to equations (3) and (4) might correlate with aspects that pertain to some elementary particles. Our use of equations (3) and (4) to match and predict elementary particles correlates with PFS modeling. (Technically, such use

of equations (3) and (4) to match and predict elementary particles does not necessarily depend on the extent to which either of the electromagnetic interaction or the gravitational interaction correlates with a potential that correlates with r^{-1}. Technically, such use of equations (3) and (4) to match and predict elementary particles does not necessarily depend on the extent to which the strong interaction correlates with a potential that correlates with r^1. We might anticipate that people will develop integrative modeling that better integrates modeling that we use. Perhaps, people will - to develop such integrative modeling - use notions that correlate with information that table 57 shows. Perhaps, people will - to develop such integrative modeling - use notions that people would correlate with UMS modeling and with results from UMS modeling. This essay de-emphasizes developing such integrative modeling.)

Proposed modeling PFS 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 necessarily correlate with all non-residual aspects of the strong interaction.)

Table 26 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 column lists items that correlate with inputs to the step. The next column notes modeling concepts that are key to taking the step. The rightmost column lists items that correlate with outputs from the step. PFS modeling pertains. (See table 17.) In table 26a, 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 26b, steps output masses. Table 26c shows possible steps that this essay generally de-emphasizes. Table 26d discusses symbols that appear in tables 26a, 26b, and 26c. Equation (50) explains the notation $|\iota_{3CH}| \doteq n$. (Each one of tables 26a, 26c, and 26d exhibits use of this notation.)

$$|\iota_{3CH}| \doteq n \quad \text{denotes} \quad |\iota_{3CH}| = n \text{ or } 0 \tag{50}$$

We discuss objects and properties.

Each of ongoing modeling and proposed modeling includes the notion of an object. (See table 14.) 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 the 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 27 lists some properties that people attribute to objects. PEPM tends to work from table 27a toward table 27e. In contrast, development of aspects of ongoing modeling, including QFT (or, quantum field theory), has emphasized - from early on in the development of ongoing modeling - aspects correlating with table 27e. The symbol q_ϵ denotes the charge of an electron. The symbol c denotes the speed of light. In table 27a, S correlates with the S in the expression $S(S+1)\hbar^2$ and not necessarily with a notion of spin with respect to a particular axis. In tables 27b and 27d, the notion of isomers correlates with the topic of dark matter and with aspects of tables 62b, 63, and 89. In table 27c, the use of the symbol S does not correlate with notions of spin. (Compare with, for example, table 27a.) 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.

Each of the symbols, except m, in table 27a denotes a quantity that is always an integer. Each of the quantities in table 27a pertains for each elementary particle. Each - except generations - of the quantities in table 27a can pertain for objects that contain more than one elementary particle. In terms of measurements, equation (51) pertains. The symbol ε_0 denotes the vacuum permittivity.

$$\iota_{3CH} = 1 \text{ correlates with } (|q_\epsilon|/3)/(4\pi\varepsilon_0)^{1/2} \tag{51}$$

Table 28 lists aspects correlating with some symmetries that table 13 lists. (See table 18. Perhaps, compare with table 19. Perhaps, note table 34. Perhaps, note table 40.)

We discuss the notion of double-entry bookkeeping.

Ongoing modeling includes modeling, for photons, that features mathematics correlating with two harmonic oscillators. Ongoing modeling 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 KMS modeling.

Table 26: Steps, regarding modeling

(a) Steps that output elementary particles

From	Via	To
ΣG, 2U	PFS PDE, PFS ALG	0H, 1C, 1N, 2W
1C, 1N, 2W	$\lvert \iota_{3CH}\rvert \doteq 3 \;\rightarrow\; \lvert \iota_{3CH}\rvert \doteq (2 \text{ or } 1)$	1Q, 1R, 2T
2W	UMS ALG	2J
0H	$n_{XA0} = 0 \;\leftarrow\; n_{XA0} = -1$	0I
2U	$SU(3) \;\rightarrow\; SU(3) \uplus I$	0P

(b) Steps that output boson masses

From	Via	To
ΣG	PFS ALG, PFS PDE	0H, 2W
0H, 2W	$n_{XA0} = 0 \;\leftarrow\; n_{XA0} = -1$	0I, 2J
ΣG	PFS ALG, PFS PDE	2T
Ongoing	m_π	0P

(c) Possible steps that the modeling de-emphasizes

From	Via	To
2U	PFS ALG	(≥ 4)U̸
0H	$\lvert \iota_{3CH}\rvert \doteq 3 \;\rightarrow\; \lvert \iota_{3CH}\rvert \doteq (2 \text{ or } 1)$	7̸

(d) Explanations regarding some symbols

Discussion
• The symbol ι denotes an integer.
• The symbol ι_{3CH} 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).
• $\lvert \iota_{3CH}\rvert \doteq 3 \;\rightarrow\; \lvert \iota_{3CH}\rvert \doteq (2 \text{ or } 1)$ denotes extending results for $\lvert \iota_{3CH}\rvert \doteq 3$ to results for $\lvert \iota_{3CH}\rvert \doteq 2$ and to results for $\lvert \iota_{3CH}\rvert \doteq 1$.
• The expression $n_{XA0} = 0 \;\leftarrow\; n_{XA0} = -1$ denotes - for each of XA equals TA and XA equals SA - substituting the number minus one for the number zero.
• $SU(3) \;\rightarrow\; SU(3) \uplus I$ 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 modeling 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 X̸ denotes the notion that this essay generally de-emphasizes the concept X.

Table 27: Some properties of objects

(a) Invariant properties of objects

Symbol	Definition	Concept	Related symbol (ongoing modeling)
ι_{3CH}		3CH (charge, in units of $|q_\epsilon|/3$)	q - charge
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 (or, 3LB)	

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

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

(c) Other properties

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

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

Symbol	Definition	Concept	Related symbol (ongoing modeling)
ι_I	$= $ NR, 1, 6, or 36	number of isomers of charge (or, number of isomers of simple particles)	-

(e) Observer-centric properties

Symbol	Concept	Related symbol (ongoing modeling)
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 28: Aspects - of modeling - that correlate with some TA-side aspects and some SA-side aspects

Aspect
• A TA0 $n_{TA0} = 0$ or a TA0 $n_{TA0} = n$ (with nonnegative integer n) correlates - for PFS models for elementary bosons - with a $U(1)$ symmetry. One generator correlates with excitation. One generator correlates with de-excitation.
• A TA-side $\pi_{@_0,@_{-1}}$ correlates - for UMS models - with a $U(1)$ symmetry and with a quantity that sums across objects (including elementary particles) that a so-called larger object includes. Here, regarding summing across objects, one might think of the symbol $\pi_{0,@_{-1}}$ and of the notion that the zero correlates with the $U(1)$ symmetry. (Perhaps, compare with tables 20a, 58a, and 111a.) One generator correlates with adding to a value of a property of a larger object. One generator correlates with subtracting from a value of a property of a larger object.
• A TA-side $\pi_{@_0,@_{-1}}$ correlates - for PFS models and for UMS models - with a rebuttable always conservation law. (See, for example, table 18 and table 40.)
• A TA-side $\kappa_{@_0,@_0}$ or $\kappa_{@_{-1},@_{-1}}$ correlates - for PFS models for elementary bosons and for UMS models for elementary bosons - with an $SU(2)$ symmetry and with a rebuttable somewhat conservation law.
• A TA-side $\kappa_{@_0,@_0}$ or $\kappa_{@_{-1},@_{-1}}$ correlates - for PFS models for elementary fermions and for UMS models for elementary fermions - with (for TA5-and-TA6) an $SU(2)$ symmetry and with a rebuttable always conservation law.
• A TA-side $\kappa_{@_0,@_{-1}}$ correlates - for PFS models for elementary bosons and for UMS models for elementary bosons - no symmetry and with a so-called not necessarily conservation law. (See table 18 and table 40.)
• A TA-side $\kappa_{@_0,...,@_0}$ ($SU(j)$) - with j being at least four - correlates - for PFS models for G-family elementary bosons - with a not necessarily conservation law regarding fermion generation. (See, for example, table 48b. Technically the notation correlates with j - not two - TA-side oscillators.)
• A TA-side $\kappa_{@_{-1},...,@_{-1}}$ ($SU(3)$) - correlates - for PFS models for U-family elementary bosons - with a rebuttable always conservation law regarding fermion generation. (See discussion regarding table 54. Technically the notation correlates with three - not two - TA-side oscillators.)
• An SA-side $\pi_{n,@_0}$ or $\pi_{0,@_0}$ correlates - for PFS models for G-family elementary bosons - with two modes. One mode correlates with left circular polarization. One mode correlates with right circular polarization.
• An SA-side $\pi_{@_0,@_{-1}}$ correlates - for PFS models for elementary fermions and for UMS models for elementary fermions - with (for SA1-and-SA2) particle and antiparticle and with (for SA7-and-SA8) positive 3LB number and negative 3LB number.
• An SA-side $\kappa_{@_0,@_0}$ or $\kappa_{@_{-1},@_{-1}}$ correlates - for PFS models for elementary fermions and for UMS models for elementary fermions - with an $SU(2)$ symmetry and with (for SA5-and-SA6) three generations or (for SA9-and-SA10) three color charges.
• An SA-side $\kappa_{@_0,@_{-1}}$ correlates - for PFS models for elementary bosons - with no dependence (regarding interaction strengths) regarding the property that correlates with the relevant oscillator pair. (For example, the Higgs boson does not interact with charge. See table 47.)
• An SA-side $\pi_{@_0,@_0}$ correlates - for PFS models for G-family elementary bosons - with no dependence (regarding interaction strengths) regarding the property that correlates with the relevant oscillator pair. (For example, the graviton - or 4G - does not interact with charge. See table 48a.)
• An SA-side $\kappa_{@_0,@_0}$, $\kappa_{0,0}$, $\kappa_{@_{-1},@_{-1}}$, or $\kappa_{-1,-1}$ might correlate - for UMS models - with an $SU(2)$ symmetry and with a trio of degrees of freedom for aspects that sum across objects. For example, regarding charge, the three degrees of freedom correlate with negative charge, zero charge, and positive charge. Regarding 3LB, the three degrees of freedom correlate with negative 3LB, zero 3LB, and positive 3LB. Regarding momentum, ongoing modeling correlates with three spatial dimensions. Also, regarding the jay (or, 2J) bosons, the three degrees of freedom correlate with three simple elementary particles. (For the jay bosons, the notion of summable property correlates with 3LB. See table 52.)

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Proposed modeling PFS ALG modeling has bases in the concept that modeling photons based on four harmonic oscillators has uses. The concept has bases in the ongoing modeling notion of KMS 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 (38) 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 modeling 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 (31).)

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 [5].) 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 23.)

Table 29 reflects a concept that - for particles for which $m \gtrless 0$ pertains - the number of elementary particles in a subfamily correlates with the spin of the elementary particles in the subfamily. Table 29b explains notation that table 29a 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-element label sub-hadronic correlates with a magnitude of charge that differs from the magnitude of charge pertaining to the other two columns labeled sub-hadronic.

Equation (52) pertains for known elementary particles for which $m \gtrless 0$. (See table 29c.) Spin and the number of particles relate to each other.

$$\iota_S + 1 = \sum n \tag{52}$$

3.2.3. Some applications of PDE mathematics

Table 30 notes some applications of modeling that people can base on the mathematics that underlies PDE modeling. (See table 17.) Applications for which the table shows the symbol † pertain regarding supplementary proposed modeling. Applications for which the table shows the symbol † are generally not directly necessary for core proposed modeling work regarding elementary particles, astrophysics, and cosmology. We assume that ongoing modeling kinematics and dynamics modeling generally suffices. Each of ongoing modeling and proposed modeling can use KMS applications.

Table 17 discusses some aspects regarding PDE modeling. (Perhaps, note work leading to equation (31).) For KMS modeling, the variable t can correlate with ongoing modeling notions of temporal aspects and the variable r can correlate with ongoing modeling notions of spatial aspects. Solutions Ψ can correlate with wave functions. For PFS modeling, the variable t does not necessarily correlate with ongoing modeling notions of temporal aspects and the variable r does not necessarily correlate with ongoing modeling notions of spatial aspects. Solutions Ψ do not necessarily correlate with the ongoing modeling notion of wave functions.

3.2.4. PDE aspects of proposed elementary particle modeling

We discuss modeling correlating with the first row in table 30. The notion of PFS modeling pertains. The expression $\nu_{SA} < 0$ pertains.

This work features the numbers of dimensions that equations (53) and (54) show. Even though our work here features PFS modeling, people might want to consider the extent to which equation (53) correlates with a KMS modeling notion of three spatial dimensions. A possible SA-side aspect features correlations between numbers of simple particles, which would be a PFS modeling topic, and numbers of spin states, which would be a KMS modeling topic. (See discussion related to table 29 and equation (52).)

$$D_{SA}^* = 3 \tag{53}$$

Table 29: Known elementary particles

(a) Elementary particles

$\iota_S = 2S$	Can be free $m\dot{>}0$	Can be free $m\doteq0$	Sub-hadronic $m\dot{>}0$	Sub-hadronic $m\dot{>}0$	Sub-hadronic $m\doteq0$
0	$0\mathrm{H}^0{:}1$				
1	$1\mathrm{C}_j^3{:}2$	$1\mathrm{N}_j^0{:}\{1\text{ or }2\}$	$1\mathrm{Q}_j^2{:}2$	$1\mathrm{Q}_j^1{:}2$	
2	$2\mathrm{W}^0{:}1$				
2	$2\mathrm{W}^3{:}2$				
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 $\hbar$
	Can be free	Can move independently of hadrons (Perhaps, see table 37.)
	Sub-hadronic	Found only (in today's universe) in hadrons
$m\dot{>}0$	Non-zero mass	The mass is at least the mass of an electron
$m\doteq0$	Zerolike mass	Models (in some models) as having zero mass
$\iota_S\Phi^{\lvert\iota_{3CH}\rvert}_{\underline{}}$	$\iota_S\Phi$	A subfamily of the Φ family of elementary particles
	$\lvert\iota_{3CH}\rvert$	|Charge| in units of one-third the charge of a positron
	$\lvert x\rvert$	The absolute value of x
	$\underline{}$	Generation, for fermions, with $1 \leq j \leq 3$; NR for bosons
	NR	Not relevant
$:n$	$n = 1$ or 2	n particles plus antiparticles
	$\{1\text{ or }2\}$	Majorana fermion or Dirac fermion, respectively
	8	Number of gluons
$:((2))$		One particle with two modes
$\{\iota_S\Phi^{\iota_{3CH}}_{\underline{}}\}$		Hypothetical subfamily (hypothesized, but not yet found)
	$\{4\mathrm{G}^0{:}((2))\}$	Graviton (hypothesized, but not yet found)

(c) Subfamilies for which $m\dot{>}0$ (with the one-element term gen denoting the word generation)

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

(d) Subfamilies for which $m\doteq0$ (with the one-element term gen denoting the word generation)

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

(e) A note regarding neutrinos

Note
● Tables 29a, 29b, and 29d comport with ongoing modeling notions that neutrinos might model either as Majorana fermions or as Dirac fermions. Proposed modeling suggests that lepton number minus baryon number is a conserved quantity. As a result, proposed modeling suggests that neutrinos model as Dirac fermions and not as Majorana fermions. (See, for example, equation (179).) Regarding each one of tables 29a, 29b, and 29d, proposed modeling suggests that the replacement $\{1\text{ or }2\} \leftarrow 2$ is appropriate.

Table 30: Some applications of modeling that people can base on the mathematics that underlies PDE modeling (with the symbol $\dagger$ denoting applications that pertain regarding supplementary proposed modeling and generally are not directly necessary for core proposed modeling work regarding elementary particles, astrophysics, and cosmology)

Application	... modeling	PFS or KMS	ν_{SA}	Focus
Simple particles that nature embraces	Proposed	PFS	< 0	One simple particle
Interaction vertices that modeling includes $\dagger$	Proposed	PFS	< 0	Multiple elementary particles
Modeling for some aspects of excitations	Ongoing or proposed	KMS	≥ 0	Multi-object system
Modeling for some aspects of dynamics	Ongoing or proposed	KMS	≥ 0	Multi-object system

Table 31: PDE notions that pertain for some PFS modeling applications

Notion
$\bullet$ The symbol S denotes spin divided by $\hbar$. The symbol $\hbar$ denotes the reduced Planck's constant.
$\bullet$ For some solutions - which comport with equation (55) - to equation (8), $D_{SA} \neq D_{SA}^*$.
$\bullet$ Solutions for which $\nu_{SA} = -1/2$ can correlate with notions of fields for simple fermions.
$\bullet$ Solutions for which $\nu_{SA} = -1$ can correlate with notions of fields for simple bosons.
$\bullet$ Solutions for which $\nu_{SA} = -3/2$ can correlate with notions of particles for simple fermions.
$\bullet$ TA-side PDE solutions are radial with respect to t, the TA-side analog to the SA-side radial coordinate r.
$\bullet$ For some TA-side PDE solutions, $D_{TA} \neq D_{TA}^*$.

$$D_{TA}^* = 1 \tag{54}$$

We anticipate making PFS modeling uses of equations (55) and (56). 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 (55), $\sigma_{SA} = +1$, and $S = \nu_{SA}$ is a restating of equation (8). (Ongoing modeling KMS modeling features expressions of the form that equation (57) shows.) The case that features equation (55) and $\sigma_{SA} = -1$ correlates with some aspects of proposed modeling models. (See discussion related to table 76.) Similar concepts pertain regarding equation (56) and σ_{TA}.

$$\Omega_{SA} = \sigma_{SA}S(S + D_{SA}^* - 2) = \sigma_{SA}S(S + 1), \text{ for } \sigma_{SA} = \pm 1 \tag{55}$$

$$\Omega_{TA} = \sigma_{TA}S_{TA}(S_{TA} + D_{TA}^* - 2) = \sigma_{TA}S_{TA}(S_{TA} - 1), \text{ for } \sigma_{TA} = \pm 1 \tag{56}$$

$$\hbar^2 S(S + 1), \text{ for nonnegative integer } 2S \tag{57}$$

Table 31 lists notions that pertain for some PFS modeling 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 $D'' = 2$. (For example, discussion above does not adequately cover the topic of notions of particles for simple bosons. The case of $D'' = 2$ is relevant to - at least - notions of particles for simple bosons.)

Table 32 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. For table 32b, we use equation (25) to develop the relevant expressions for D and to calculate values of D. Similar methodology pertains regarding D in tables 32c, 32d, and 32e. (When considering tables 32b, 32c, 32d, and 32e, perhaps note that calculations of D do not involve values of D_{SA}^*, D_{TA}^*, and D''.)

3.2.5. PDE modeling regarding simple particles

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

Table 32: Relationships between some PDE parameters

(a) Relationships relevant to D_{XA}^* and D'' (with XA denoting either SA or TA)

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

Table 33: Aspects that PEPM posits to correlate with modeling for simple elementary particles

Aspect
• Each simple elementary fermion correlates with a subfamily for which a $\nu_{SA} = -1/2$ solution exists. The solution correlates with the notion of fields for the elementary particles in the subfamily. The solution correlates with the notion of volume-like.
• Each simple elementary fermion correlates with a subfamily for which a $\nu_{SA} = -3/2$ solution exists. The solution correlates with the notion of particles for the elementary particles in the subfamily. The solution correlates with the notion of point-like.
• Each simple elementary boson correlates with a subfamily for which a $\nu_{SA} = -1$ solution exists. The solution correlates with the notion of fields for the elementary particles in the subfamily. The solution correlates with the notion of volume-like.
• Each simple elementary boson correlates with a subfamily for which a $\nu_{SA} = -1$ solution exists for each of three oscillator pairs. The trio of solutions correlates with the notion of particles for the elementary particles in the subfamily. The solutions correlate with the notion of point-like.
• For each such solution, the relevant $\Omega_{\dots}$ is nonnegative, the relevant $\sigma_{\dots}$ is plus one, the relevant $2S_{\dots}$ is a nonnegative integer, and the relevant D is a positive integer.

Table 33 lists aspects that PEPM posits to correlate with modeling for simple elementary particles. (See table 31.) The table limits the range of relevant subfamilies. The table does not specify the number of subfamilies that nature embraces.

The order of rows in table 32b correlates with non-decreasing values of Ω_{SA}. A value of spin S correlates with the value of Ω_{SA}. Proposed modeling posits that each simple elementary particle correlates with a field. Proposed modeling posits that D must be a positive integer. (Also, note that, for this discussion, $D = D_{SA}$.) No larger values of S comport with equation (58). (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 (59) correlates with a limit that pertains regarding simple particles. (See table 33. Also, our assumptions regarding the existence of simple particles include excluding solutions for which $\sigma_{SA} = -1$. See table 32d. If we included solutions for which $\sigma_{SA} = -1$, table 32d 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.

$$S \geq 0 \text{ and } D \geq 1 \tag{58}$$

$$0 \leq S \leq 1 \tag{59}$$

We explore modeling regarding the simple particles that proposed modeling suggests. This exploration pertains within the bounds that equations (58) and (59) imply.

Tables 32b and 32c show solutions that correlate with fields for all relevant cases. Tables 32b and 32c show solutions that correlate with particles for all relevant elementary fermion cases. The tables do not discuss particles for relevant elementary boson cases.

Table 32b includes a column with label $D_{SA}^* + 2\nu_{SA}$. We use the symbol D' to denote D_{SA}^*. Table 32c includes a column with label $3 + 2\nu_{TA}$. We use the symbol D' to denote the three. These two 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 32b and 32c, $D' = 3$.

We pursue discussion based on relevance of the three TA-side oscillators TA0, TA1, and TA2 and three SA-side oscillators SA0, SA1, and SA2. (Compare with equation (37).)

In general, use of equation (37) allows separation of terms into clusters. Equation (37) 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 anticipate aspects regarding modeling - for fields and particles - for simple bosons and simple fermions.

For each of fields for simple bosons and fields for simple fermions, modeling points to the notion that, for relevant choices of sets of oscillators and of D, equation (60) pertains. For fields for simple bosons,

$\nu_{SA} = -1$. For fields for simple fermions, $\nu_{SA} = -1/2$. The notion of volume-like correlates with equation (60).

$$D + 2\nu_{SA} = 1 \qquad (60)$$

For each of particles for simple bosons and particles for simple fermions, modeling points to the notion that, for relevant choices of sets of oscillators and of D, equation (61) pertains. For particles for simple bosons, $\nu_{SA} = -1$. For particles for simple fermions, $\nu_{SA} = -3/2$. The notion of point-like correlates with equation (61).

$$D + 2\nu_{SA} = 0 \qquad (61)$$

We anticipate that, for some purposes, the substitutions that equations (62) and (63) show are useful. (The notation a←b denotes the notion that b replaces - or substitutes for - a.)

$$\text{TA1} \leftarrow \text{TA5, TA2} \leftarrow \text{TA6} \qquad (62)$$

$$\text{SA1} \leftarrow \text{SA5, SA2} \leftarrow \text{SA6} \qquad (63)$$

We discuss modeling for fields for simple bosons.

Regarding modeling for fields for $\iota_S = 2$ simple bosons, one can use the notion of mapping the $D = 1$ solutions - that tables 32b and 32c show - into the three dimensions that correlate with $D' = 3$. (For each of PFS modeling and KMS modeling, the $D = 1$ solution has or would have no dependence on angular coordinates.) Here, each one of the SA-side solution and the TA-side solution normalizes and correlates with equation (60). ($D_{SA}^* + 2\nu_{SA}$ is one. $3 + 2\nu_{TA}$ is one.) We correlate the three oscillators SA0, SA1, and SA2 with the SA-side solution. The following sentences pertain regarding the weak interaction (or, Z and W) bosons. (Similar remarks pertain regarding tweak bosons.) SA-side use of $D' = 3$ is compatible with (PFS modeling and) the existence of three elementary boson states (the Z boson, the negatively charged W boson, and the positively charged W boson). (See table 42.) SA-side use of $D' = 3$ is compatible with (KMS modeling and) the existence of three spin states. Also, SA-side use of $D' = 3$ is compatible with (UMS modeling and) the existence of three elementary boson states (the Z boson, the negatively charged W boson, and the positively charged W boson). (See the XA1-XA2 row in table 58.) TA-side use of $D' = 3$ is compatible with (PFS modeling and) rebuttable somewhat conservation of fermion generation. (See table 34 and discussion related to table 42.) We invoke equation (62). The oscillator pair TA5-and-TA6, correlates with and, in effect, contains the $\kappa_{@_0,@_0}$ (or, $SU(2)$) symmetry that is relevant to rebuttable somewhat conservation of fermion generation.

Regarding modeling for fields for $\iota_S = 0$ simple bosons, one can use results that tables 32b and 32c show. For each of XA equals SA and XA equals TA, $D' = 3$ and $D' + 2\nu_{XA} = 1$. For each of XA equals SA and XA equals TA, equation (60) pertains. We invoke each of equations (62) and (63). (See, for example, table 47.) Rebuttable somewhat conservation of fermion generation pertains.

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 tables 33 and 32e.) 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 equation (61) and tables 32b and 32c.)

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 (or, after applying equation (62), TA5-and-TA6), 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 $\iota_S = 2$ simple bosons, notions - such as three oscillator pairs and rebuttable somewhat conservation of fermion generation - that pertain for fields for $\iota_S = 2$ simple bosons continue to pertain. Paralleling work regarding fields for $\iota_S = 2$ simple bosons, we invoke equation (62).

Regarding modeling for particles for $\iota_S = 0$ simple bosons, the two perhaps seemingly extra oscillator pairs - TA1-and-TA2 and SA1-and-SA2 - correlate with the notion of rebuttable somewhat conservation of fermion generation. Paralleling work regarding fields for $\iota_S = 0$ simple bosons, we invoke equations (62) and (63).

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 32b shows a value of two. The $3 + 2\nu_{TA}$ column in table 32c shows a value of two. Seemingly, equation (60) might not pertain.

Table 34: Some symmetries and interpretations that pertain to all elementary fermions

Pair	Symmetry	Interpretation
SA1-and-SA2	$\pi_{@_0,@_{-1}}$	This symmetry correlates with matter and antimatter.
SA5-and-SA6	$SU(2)$	The three generations of elementary fermions correlate with the three generators of $SU(2)$. For ALG modeling, each of the symbols $\kappa_{@_0,@_0}$ and $\kappa_{@_{-1},@_{-1}}$ can correlate with the $SU(2)$ symmetry.

We focus on aspects that correlate with fields that correlate with fermion subfamilies 1Φ.

Regarding fields for elementary fermions, modeling can feature an effective $D_\dagger = 2$ instead of $D' = 3$. (Each elementary fermion correlates with one - not two - values for handedness. For example, each known matter elementary fermion correlates with left handedness and not with right handedness. Each known antimatter elementary fermion correlates with right handedness and not with left handedness. A reduction from $D' = 3$ dimensions to $D_\dagger = 2$ correlates, in effect, with the lack - for each particle - of a second handedness. Perhaps, note discussion - regarding photon modes - related to table 35. Also, perhaps, note table 10.) For $D_\dagger = 2$, $D_\dagger + 2\nu_{SA} = D_\dagger + 2\nu_{TA} = 1$. The notions of volume-like and field still pertain. Equation (60) pertains.

We focus on aspects that correlate with fields that correlate with individual elementary particles (or, individual generations) within fermion subfamilies 1Φ.

We shift our attention to aspects that are somewhat separate from aspects correlating with $D_\dagger = 2$. From $D_1 = D' = 3$, proposed modeling applies the transformation that correlates with equation (19). (Perhaps note that, in equation (19), $j = 2$ and that, regarding discussion here, $j\nu_{SA}$ is an integer.) The result $D_2 = (2 \cdot 3) - 2 = 4$ pertains. We bring together aspects correlating with $D_\dagger = 2$ and aspects correlating with $D_2 = 4$. The result $D_2 - D_\dagger = 4 - 2 = 2$ pertains. In effect, the transformation - from D_1 to D_2 adds - compared to models for which $D_\dagger = 2$ pertains - two TA-side oscillators and two SA-side oscillators. Each new oscillator pair can correlate with an $SU(2)$ symmetry. (See table 13.) Equation (60) pertains for each of $D = D_\dagger = 2$ and $D = D_2 - D_\dagger = 2$. 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 58.) We invoke equations (62) and (63). The SA5-and-SA6 pair correlates with - for each elementary fermion - three generations.

Table 34 shows and interprets symmetries that pertain to all elementary fermions. (Note tables 28 and 58.) For each elementary fermion, either $@_0$ correlates with three of the four relevant oscillators or $@_{-1}$ correlates with three of the four relevant oscillators.

We discuss modeling for particles for $\iota_S = 1$ simple fermions.

Table 32b shows $D = 3$ and $D + 2\nu_{SA} = 0$. Table 32c shows $D = 3$ and $D + 2\nu_{TA} = 0$. Equation (61) pertains. The number $D = 3$ correlates - regarding table 34 - with one of the number of SA-side $@_0$ and the number of SA-side $@_{-1}$. Results that table 34 features pertain. One can reuse results that pertain for fields for $\iota_S = 1$ simple fermions.

3.2.6. Concepts regarding representations for photons

We discuss notions that, with respect to ongoing modeling, correlate with KMS modeling.

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

Why not describe photon states via four harmonic oscillators?

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

The four-oscillator models correlate with PFS 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 (35).)

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

3.2.7. ALG representations for elementary particles

We discuss aspects of ALG 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

Table 35: A PFS-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 36: A PFS-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	$\pi_{n, @_0}$							

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 (35).) 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 35 shows excitations for the left circular polarization mode of a photon. (See table 12b. Perhaps, compare with table 20a.) The two-element term PFS-centric representation correlates with the notion that a more complete PFS representation exists. In the case of table 35, a more complete PFS representation would show information correlating with, for example, conservation of charge and conservation of 3LB. (See, for example, table 41.)

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

Table 36 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. Photons do not change the charges of objects with which photons interact. Per table 28, the TA1-and-TA2 entry in table 35 correlates with rebuttable always conservation of charge. Per table 13, this term makes a zero contribution to A_{TA}^{ALG}. Proposed modeling does not correlate the TA1-and-TA2 entry in table 35 with excitation of photons or with de-excitation of photons.

For each mode, for the TA0 oscillator, raising operators and lowering operators that correlate with $U(1)$ symmetry pertain. (Perhaps, note table 28.) One generator correlates with excitation. One generator correlates with de-excitation. This essay does not fully explore the extent to which this $U(1)$ symmetry correlates with the $U(1)$ symmetry that the elementary particle Standard Model associates with photons. (Perhaps, note discussion regarding equation (173).)

The representation that table 36 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 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 prepare to explore representations for elementary particles other than photons.

Table 37 discusses our uses - regarding elementary particles, regarding objects in general, and regarding environments in which elementary particles and other objects exist - of the word unfree and of the word free.

Table 38 discusses aspects regarding modeling for elementary bosons for which $n_{TA0} = -1$. Absent such aspects, models might correlate with the notion that such bosons would not excite. (Note equation (35).)

Table 39 lists questions that, for this immediate discussion, we de-emphasize fully addressing.

Table 40 discusses aspects regarding elementary boson TA-side symmetries. (See table 18. Perhaps, see table 28.) We interpret core ongoing modeling as correlating with the proposed modeling TA7-and-TA8 notion of always - when summed over interacting objects - conservation of 3LB number. (Core ongoing modeling does not include aspects correlating with the proposed modeling notion of the 2T subfamily. Reference [6] discusses observational evidence that we interpret as supporting the proposed modeling TA7-and-TA8 notion of always conservation of 3LB number.) Elsewhere, we discuss aspects that correlate with the explicit mentions, in table 40, of 2W (See table 42.), 4G (See table 48a.), 6G (See

Table 37: The word unfree and the word free - regarding elementary particles, objects in general, and environments

Aspect
• Regarding elementary particles, we use the word unfree to correlate with the notion that an elementary particle models - in PFS modeling - only as if the particle and its environment entangle with each other. The unfree elementary fermions are the quarks and the arcs. The unfree elementary bosons are the gluons, the aye boson, and the jay bosons. The notion of unfree elementary boson correlates with $n_{TA0} = -1$. • Regarding elementary particles, we use the word free to correlate with the notion that an elementary particle can model - in PFS modeling - as if the particle exists without entanglement with its environment. (See, for example, table 29a and table 29b.) The free elementary fermions are the charged leptons and the neutrinos. The free elementary bosons are all the elementary bosons except gluons, the aye boson, and the jay bosons. The notion of free elementary boson correlates with $n_{TA0} = 0$. • Regarding objects in general, we use the word unfree to correlate with modeling for which at least one of conservation of energy, conservation of momentum, and conservation of angular momentum does not pertain. For example, regarding one planet in a solar system, conservation of momentum does not pertain. • Regarding objects in general, we use the word free to correlate with modeling for which each of conservation of energy, conservation of momentum, and conservation of angular momentum pertains. • Regarding environments in which elementary particles exist, we use the word unfree to allude to environments that correlate with the presence of unfree elementary particles.

Table 38: Aspects regarding modeling elementary bosons for which $n_{TA0} = -1$

Aspect
• Elementary bosons that correlate with $n_{TA0} = -1$ can excite based on - to use a word from ongoing modeling - entanglement with their environments. • Modeling for excitations can correlate with a notion of $n_{TA0} = (-1)^+$. (See, for example, discussion related to table 68 and equation (81).)

Table 39: 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 modeling associates with the SA0 oscillator?

Table 40: Aspects regarding elementary boson TA-side symmetries (with the assumption that each elementary fermion correlates - for each relevant TA-side oscillator pair - with the notion of exact symmetry)

Aspect				
● The following correlations pertain regarding the TA1-and-TA2 oscillator pair.				
Symbol	Symmetry	Conservation	If this symmetry is the least exact symmetry, elementary fermions ...	Elementary boson subfamilies
$\pi_{@_0,@_{-1}}$	Exact	Rebuttable always	do not change charge.	All but ...
-	Approximate	Rebuttable somewhat	(not relevant)	-
$\kappa_{@_0,@_{-1}}$	No	Not necessarily	can change charge.	2W, 2T
● The following correlations pertain regarding the TA5-and-TA6 oscillator pair.				
Symbol (group)	Symmetry	Conservation	If this symmetry is the least exact symmetry, elementary fermions ...	Elementary boson subfamilies
$\kappa_{@_{-1},\cdots,@_{-1}}$ ($SU(3)$)	Exact	(Rebuttable) always (See table 113a.)	do not change generations.	2U
$\pi_{@_0,@_{-1}}$ (-)	Exact	Rebuttable always	do not change generations.	All but ...
$\kappa_{@_0,@_0}$ ($SU(2)$)	Approximate	Rebuttable somewhat	might change generations.	2W, 2T, 4G
$\kappa_{@_0,\cdots,@_0}$ ($SU(4)$)	In effect, no	Not necessarily	can change generations.	6G
$\kappa_{@_0,\cdots,@_0}$ ($SU(6)$)	In effect, no	Not necessarily	can change generations.	8G
● The following correlations pertain regarding the TA7-and-TA8 oscillator pair.				
Symbol	Symmetry	Conservation	If this symmetry is the least exact symmetry, elementary fermions ...	Elementary boson subfamilies
$\pi_{@_0,@_{-1}}$	Exact	Rebuttable always	do not change 3LB numbers.	All but ...
-	Approximate	Rebuttable somewhat	(not relevant)	-
$\kappa_{@_0,@_{-1}}$	No	Not necessarily	can change 3LB numbers.	2T

table 48b.), 8G (See table 48c.), and 2T (See table 52.). Regarding 6G, the three-word phrase in effect no correlates with notions of two - not one - oscillator pairs. Regarding 8G, the three-word phrase in effect no correlates with notions of three - not one - oscillator pairs. Extrapolating backwards, regarding 2G and the TA5-and-TA6 oscillator pair, an exact symmetry pertains. (See table 41.) We assume that each elementary fermion correlates - for each relevant TA-side oscillator pair - with the notions of exact symmetry and rebuttable always conservation of property. (Note discussion in table 18 about modeling for interactions and about the roles of conservation of property.)

For PFS-centric representations for elementary particles, equation (64) pertains - with the proviso that, for representations for elementary fermions, one does not count the two oscillators that correlate with an $SU(2)$ symmetry that correlates with three generations. Here, N_{SA} denotes a number of relevant SA-side oscillators. (Perhaps, compare equation (64) with equation (52). Also, note that, for each elementary fermion, only one of the two oscillators SA1 and SA2 is relevant. See, for example, discussion - related to table 34 - regarding $D_\dagger = 2$ and $D' = 3$.)

$$N_{SA} = 2S + 1 \tag{64}$$

We return to discussing photons.

Table 41 updates table 36 to take into account aspects that table 40 mentions. Reference [7] discusses observational evidence that we interpret as supporting the TA5-and-TA6 notion that correlates with rebuttable always conservation of fermion generation regarding the 2G subfamily. The TA7-and-TA8 entry correlates with rebuttable always conservation of 3LB number.

We turn our attention to elementary particles other than photons. (We anticipate roughly following steps that table 26a shows.)

We discuss modeling pertaining to the weak interaction (or, Z and W) bosons.

We note that ongoing modeling interrelates photons and weak interaction bosons.

Table 41: A PFS-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	$\pi_{@_0,@_{-1}}$		$\pi_{@_0,@_{-1}}$	$\pi_{@_0,@_{-1}}$				
SA	-1	$\pi_{n,@_0}$							

Table 42: A PFS-centric representation for the ground state for weak interaction bosons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA7-and-TA8)

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

Table 42 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 [8].) Interactions with W bosons change the charges of elementary fermions. The TA1-and-TA2 entry does not show a symmetry that correlates with conservation of charge. (Perhaps, note the equivalence - per table 13 - of [blank] and $\kappa_{0,-1}$.) Placement of $\kappa_{0,0}$ with the TA5-and-TA6 oscillator pair comports with equation (62) and table 20a.

We discuss W-family excitations and we discuss the notion of rebuttable 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 26d.) 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 (perhaps, in the sense of some aspects of ongoing modeling, virtual) W bosons, with one W boson being a W^{-3} and the other W boson being a W^{+3}. Ongoing modeling results suggest that conservation of fermion generation need not pertain for the relevant quarks. Regarding proposed modeling, a transition from the state that table 42 shows to the state characterized by $n_{TA0} = 2$, $n_{SA0} = 0$, $n_{SA1} = 1$, and $n_{SA2} = 1$ would violate equation (40). 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 (40) and (41) imply that one of oscillators TA5 and TA6 participates. There are three generations of quarks. Three is the number of generators of $SU(2)$. (See table 13.) We posit that an approximate $SU(2)$ symmetry pertains. We use the five-word term rebuttable somewhat conservation of generation (or, the six-word term rebuttable somewhat conservation of fermion generation). Ongoing modeling seems to correlate this proposed modeling notion of non-conservation of generation with the ongoing modeling notion of CP violation. (See, for example, reference [9].) Proposed modeling suggests the possibility that people might be able to detect non-conservation, induced by W-family effects, of lepton generation. (Reference [9] suggests that people may be on the verge of observing evidence of lepton CP violation.)

Combining the TA5-and-TA6 $SU(2)$ symmetry with the TA0 $U(1)$ symmetry yields an $SU(2) \times U(1)$ symmetry. (See tables 13 and 42.) This essay does not fully explore possible correlations between this proposed modeling $SU(2) \times U(1)$ symmetry and the $SU(2) \times U(1)$ symmetry that ongoing modeling correlates with the weak interaction. (Perhaps, note discussion regarding equation (173).)

Table 43 shows a UMS-centric representation for the weak interaction bosons. The SA1-and-SA2 $\kappa_{@_0,@_0}$ correlates with 3 generators, three spin states, and with three charge states. The TA5-and-TA6 $\kappa_{@_0,@_0}$ correlates with rebuttable somewhat conservation of fermion generation. (See table 18 and table 40.)

We discuss representations for charged leptons and for neutrinos.

For elementary fermions, we posit that ALG modeling does not necessarily need to correlate with excitations.

Table 43: A UMS-centric representation for the weak interaction bosons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA7-and-TA8)

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

Table 44: A PFS-centric representation for the subfamily of charged leptons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA7-and-TA8)

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

Table 44 shows a representation for the 1C subfamily of charged leptons. The representation comports with the notions of $D' = 3$ and $D_\dagger = 2$. (See discussion related to tables 32b, 32c, and 34.) For each of SA1-and-SA2 and TA1-and-TA2, effectively only one oscillator pertains. For SA1-and-SA2, the symbol $\pi_{@_0,@_{-1}}$ correlates with the notion of matter particles and antimatter particles. For TA1-and-TA2, the symbol $\pi_{@_0,@_{-1}}$ correlates with a symmetry that correlates with rebuttable always conservation of charge. For SA0, the symbol $@_0$ correlates with non-zero mass and non-zero charge. For TA0, the symbol $@_0$ pertains based on double-entry bookkeeping.

Table 45 shows a representation for individual charged leptons. The representation comports with the notions of $D_1 = D' = 3$ and $D_2 = 4$. (See discussion related to tables 32b, 32c, and 34.) For SA5-and-SA6, the notation $\kappa_{@_0,@_0}$ correlates with the notion of three generations. Per table 28, the TA5-and-TA6 information that table 45 shows correlates with a notion of rebuttable always conservation of fermion generation. (Note interpretations that table 40 describes.)

Table 46 shows a representation for individual neutrinos. Some differences between table 46 and table 45 correlate with two applications of equations (42) and (43). (These applications correlate with interactions that transform a fermion from one of $m \gtrsim 0$ and $m \doteq 0$ to the other of $m \gtrsim 0$ and $m \doteq 0$. Regarding notation, see discussion related to table 23. Here, the difference between 0 and $@_0$ is not material. Here, the difference between -1 and $@_{-1}$ is not material.) One application correlates with oscillator SA0. One application correlates with oscillator TA0. For SA0, the symbol $@_{-1}$ correlates with zerolike mass and zero charge. For TA0, the symbol $@_{-1}$ pertains based on double-entry bookkeeping. Other differences correlate with two substitutions of the form $\kappa_{@_0,@_0} \leftarrow \kappa_{@_{-1},@_{-1}}$ and do not correlate with changes in relevant symmetries. The two $\kappa_{@_0,@_0} \leftarrow \kappa_{@_{-1},@_{-1}}$ substitutions correlate with the notion that additional oscillators correlate with $n_{XA_{-}} = n_{TA0}$. The notion of $n_{XA_{-}} = n_{TA0}$ is relevant to proposed modeling models regarding refraction. (See discussion related to table 68.)

We return to discussing elementary bosons.

Table 47 shows a PFS-centric representation for the ground state for the Higgs boson. Per discussion related to tables 32b and 32c, three TA-side oscillators and three SA-side oscillators pertain. The SA-side instance of $\kappa_{@_0,@_{-1}}$ correlates with no interactions with charge. Unlike for the weak interaction bosons, no excitements can correlate with a mismatch between n_{TA0} and a relevant $n_{SA_{-}}$. (Note discussion related to table 42.) For Higgs bosons, interactions with elementary fermions correlate with rebuttable always conservation of fermion generation. Hence, table 47 shows $\pi_{@_0,@_{-1}}$ regarding TA5-and-TA6.

Table 48 shows PFS-centric representations for 4G, 6G, and 8G root forces. Each representation comports with equation (64). Each representation extrapolates from a representation for a photon. (See table 41.) Regarding 4G and paralleling results regarding the 2W subfamily, the TA5-and-TA6 appearance of $\kappa_{@_0,@_0}$ in table 48a correlates with rebuttable somewhat conservation of fermion generation. (This leaves the possibility that either modeling that correlates with ongoing modeling notions of virtual interactions or occurrences of multiple close-by interactions could explain neutrino oscillations. However, proposed modeling offers another explanation. See discussion related to equation (142). The proposed modeling treatment seems to explain observed data. Proposed modeling does not necessarily preclude contributions - toward such data - from other phenomena.) Regarding each of table 48b and table 48c,

Table 45: A PFS-centric representation for charged leptons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA7-and-TA8)

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	$@_0$	$\pi_{@_0,@_{-1}}$		$\kappa_{@_0,@_0}$					

Table 46: A PFS-centric representation for neutrinos (with $\pi_{@_0,@_{-1}}$ omitted regarding TA7-and-TA8)

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 47: A PFS-centric representation for the ground state for the Higgs boson (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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	$\kappa_{@_0,@_{-1}}$							

we use the TA5-and-TA6 item to point to a symmetry that technically correlates with more than just two oscillators.

Table 48 points to the possibility that $\Sigma_{max} = 8$ pertains (Perhaps, see equation (48).) We consider the notion that $n_{TA0} = 0$ correlates with $n_{TA0} = @_0$. We consider the notion that - regarding 4G, 6G, and 8G respectively - the respective symmetries $SU(3)$, $SU(5)$, and $SU(7)$ pertain. We consider the notion that a limit of $SU(7)$ might pertain. (See, for example, discussion related to equation (46) and discussions related to tables 62a and 64. Perhaps, also consider that 20G does not correlate with $SU(17)$.)

We turn our attention to elementary particles that correlate with $|\iota_{3CH}| \dot{=} 2$ or $|\iota_{3CH}| \dot{=} 1$. (See table 26d and equation (50).)

Table 49 notes concepts regarding values, for objects, of charge, of ι_{3LB}, of L, and of 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.

Proposed modeling suggests a symmetry regarding ι_{3CH}. The symmetry suggests that each of the cases $\iota_{3CH} = 2$ and $\iota_{3CH} = 1$ is similar to the case $\iota_{3CH} = 3$. For the 1C subfamily, the cases $\iota_{3CH} = 2$ and $\iota_{3CH} = 1$ correlate with the six 1Q (or, quark) elementary fermions. Quarks have fractional charges.

Table 50 shows, simple particles that proposed modeling suggests based on the symmetry related to ι_{3CH}. For the zero-charge 1R and 2T particles that table 50 shows, the number of tick marks in a symbol $\Sigma\Phi^0-$ equals $|\iota_{3CH}|$.

A representation for each 1Q particle to which table 50 alludes equals the representation for the corresponding 1C particle. Table 45 provides a PFS-centric representation for quarks.

A representation for each 1R particle to which table 50 alludes equals the representation for the corresponding 1N particle. Table 46 provides a PFS-centric representation for arcs.

Table 51 provides a UMS-centric representation for tweak bosons. The representation amends the representation that table 43 shows for the weak interaction bosons so as to include not necessarily conservation of fermion 3LB number. (See table 40.)

We discuss the jay bosons.

Table 52 shows a UMS-centric representation for the jay (or, 2J) bosons. The table shows results of applying equations (42) and (43) to a representation for the weak interaction bosons. (See table 43.) The result $n_{SA0} = -1$ correlates with zero charge and zerolike mass. Paralleling results pertaining to the 2W subfamily, the SA7-and-SA8 $SU(2)$ symmetry correlates with three elementary particles and with three spin states. The SA7-and-SA8 and TA5-and-TA6 items comport with notation-centric conventions regarding $n_{XA\_} = n_{TA0}$.

We use the following notation and posit the following notions regarding the three 2J bosons. $2J_0$ can exhibit left circular polarization and right circular polarization. $2J_-$ can exhibit (say) left circular polarization and cannot exhibit right circular polarization. $2J_+$ can exhibit right circular polarization and cannot exhibit left circular polarization. (Elsewhere, we more fully discuss aspects of jay physics. See table 70.)

We discuss the aye boson.

Table 53 shows a PFS-centric representation for the ground state for the aye boson. Table 53 differs from table 47 - which pertains for the Higgs boson - based on two substitutions - one for TA0 and one for SA0 - of the form $n_{XA0} = 0 \leftarrow n_{XA0} = -1$.

We discuss gluons.

Table 54 shows a UMS-centric representation for 2U forces. (Regarding the use of the oscillator pair

Table 48: PFS-centric representations for ground states for the 4G, 6G, and 8G root forces

(a) A PFS-centric representation for ground states for 4G bosons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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

(b) A PFS-centric representation for ground states for 6G bosons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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

(c) A PFS-centric representation for ground states for 8G bosons (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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

Table 49: Values, for objects, of ι_{3LB}, of L, and of B

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

Table 50: Simple particles for which $|\iota_{3CH}|\doteq2$ or $|\iota_{3CH}|\doteq1$ (with two columns showing some simple particles for which $|\iota_{3CH}|\doteq3$)

$\iota_S = 2S$	$\begin{array}{c}\|\iota_{3CH}\|\doteq3\\m\dot{>}0\end{array}$	$\begin{array}{c}\|\iota_{3CH}\|\doteq3\\m\doteq0\end{array}$	$\begin{array}{c}\|\iota_{3CH}\|\doteq2\\m\dot{>}0\end{array}$	$\begin{array}{c}\|\iota_{3CH}\|\doteq2\\m\doteq0\end{array}$	$\begin{array}{c}\|\iota_{3CH}\|\doteq1\\m\dot{>}0\end{array}$	$\begin{array}{c}\|\iota_{3CH}\|\doteq1\\m\doteq0\end{array}$
1	$1C_j^3{:}2$	$1N_j^0{:}\{1\text{ or }2\}$	$1Q_j^2{:}2$	$1R_j^{0''}{:}\{1\text{ or }2\}$	$1Q_j^1{:}2$	$1R_j^{0'}{:}\{1\text{ or }2\}$
2	$2W^0{:}1$		$2T^{0''}{:}1$		$2T^{0'}{:}1$	
2	$2W^3{:}2$		$2T^2{:}2$		$2T^1{:}2$	

Table 51: A UMS-centric representation for the tweak bosons

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

Table 52: A UMS-centric representation for the jay bosons

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

Table 53: A PFS-centric representation for the ground state for the aye boson (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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	$\kappa_{@_0,@_{-1}}$							

Table 54: A UMS-centric representation for 2U (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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

Table 55: Possible correlations between U-family mathematics and simple bosons that do not belong to the U-family of root forces

Subfamily	Concept	Aspect	KMS SA-side aspect	0Φ	0Φ mass	Residual strong force
2U	$SU(3) \uplus I$	I operator	$-\exp(r/(|\eta_{SA}|))$	0P	$m \grave{>} 0$	Attractive

SA9-and-SA10, see table 20a.) The representation includes a TA-side $SU(3)$ symmetry that correlates, in PFS-centric models, with oscillators TA0, TA9, and TA10. (Perhaps, regarding the seeming use of three - not two - instances of $n_{TA_-} = -1$ for aspects that seemingly correlate with just two oscillators, compare with the $SU(4)$ and $SU(6)$ items in table 40.) The TA-side $SU(3)$ symmetry comports with rebuttable always conservation of fermion generation. (Perhaps, see table 40.) As far as we know, each one of observations and core ongoing modeling does not correlate the (non-residual) strong interaction with either changes in elementary fermion generation or violation of CP symmetry. (Perhaps, see discussion regarding table 113.) This essay does not fully explore the extent to which this TA-side $SU(3)$ symmetry correlates with the notion of an $SU(3)$ symmetry that ongoing modeling correlates with the strong interaction. (Perhaps, note discussion regarding equation (173).) The SA-side $SU(2)$ symmetry correlates with the notion of three color charges. (See table 58a.) Discussion regarding table 69 shows, from a PFS-centric perspective, modeling pertaining to the excitation and de-excitation of gluons.

We discuss the pie boson.

We explore correlations between the 2U solution and the pie (or, 0P) boson.

Table 55 alludes to modeling that correlates the pie boson with U-family forces. Tables 26a and 26d discuss the notion of $SU(3) \uplus I$. Table 55 focuses on the identity operator aspect of the notion of $SU(3) \uplus I$. Proposed modeling suggests that pie particles correlate with the ongoing modeling notion of a Yukawa potential that, in atomic nuclei, attracts hadrons to each other. (See discussion related to equation (186).) Whereas, 2U particle interactions correlate with color charges, 0P particles - in effect - interact with clear (or, white) color charge.

Table 56 shows a PFS-centric representation for the 0P boson. The 0P simple particle does not interact with simple fermions.

The mass of the pie simple boson might approximate the masses of pions. (We base that notion on ongoing modeling - regarding nuclear physics - that features virtual pions.) This essay does not further explore modeling that might correlate with the mass of the pie boson.

3.2.8. Some PEPM concepts re models that output the list of elementary particles

Table 57 summarizes some PEPM concepts regarding models that output the list of elementary particles. (Perhaps, compare table 57 with table 72.)

4. Results: properties of elementary particles and multicomponent objects

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

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

Table 58 lists properties that pertain to elementary particles and that may pertain to objects that contain more than one component object. (See table 20.)

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

Table 56: A PFS-centric representation for the 0P simple boson (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2 and regarding TA7-and-TA8)

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

Table 57: Some PEPM concepts regarding models that output the list of elementary particles

Type of elementary particles (with respect to PDE modeling)	PDE correlation	Subfamilies	ALG correlation
Long-range root forces	r^{-2}	ΣG	$n_{TA0} = 0$, $n_{SA0} = -1$
Other root forces	r^2	2U	$n_{TA0} = (-1)^+$
Simple particles	r^0	All others	$n_{TA0} = n_{SA0}$

Elsewhere, we speculate that aspects of table 58a correlate with the group $SU(17)$. (See discussion related to table 20.) Elsewhere, we speculate that people might want to consider the notion that table 58a correlates with - at least a key component of - a so-called theory of everything. (See discussion related to table 111.)

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 modeling, 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-excitation of 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 modeling models for ΣG (or, G-family) fields reflect encoded information.

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

Ongoing modeling 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 motions of objects.

We discuss symmetries that ongoing modeling and proposed modeling correlate with conservation laws related to motion.

Table 59 summarizes symmetries correlating with kinematics conservation laws. Ongoing modeling 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. Core proposed modeling PFS modeling pertains to the existence of elementary particles and multicomponent objects and pertains to interactions between elementary particles and multicomponent objects. Supplementary proposed modeling includes KMS modeling for motion. Supplementary proposed modeling KMS modeling for motion includes the kinematics symmetries that table 58 shows.

The following concepts pertain regarding proposed modeling.

- Models for the kinematics of objects in free environments 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.

- 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. The two-word term confined environment can pertain.

- Models regarding the kinematics (or, dynamics) of objects in unfree (or, confined) environments do not necessarily need to embrace all three kinematics conservation laws. Unfree objects can model as existing in the contexts of larger free objects.

- For a proposed modeling 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 modeling suggests that, for each of the eight added oscillators, $n_{\_} = n_{TA0}$.

Table 58: 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 (* denotes SA-side and TA-side)	Properties	SA-side count	TA-side symmetry (summable and conserved)
0	-	Positive or zerolike rest energy	-	-
1, 2	$SU(2)$	Charge	3 (−,0,+)	$U(1)$
3, 4; 5, 6	$SU(4)$	Rest energy minus freeable energy	-	$U(1)$
3, 4	$SU(2) \times U(1)$ *	Rest energy. Isomers (See table 58c.)	6	-
5, 6	$(SU(2))$	Freeable energy (Gens, re simple fermions)	(3 gens)	(-)
7, 8	$SU(2)$	3LB number	3 (−,0,+)	$U(1)$
9, 10	$SU(2)$	Color charge	3 (r, b, g)	-
11, 12	$SU(2)$	Momentum	3 DoF	$U(1)$
13, 14	$SU(2)$	Angular momentum	3 DoF	$U(1)$
15, 16	$SU(2) \times U(1)$ *	Isomers (See table 58c.)	6	-

(b) Notes about columns that pertain for the catalog

Note
• The column labeled XA displays sets of oscillators. Here, XA includes each of TA and SA.
• The column labeled SA-side symmetry (generally, with two marked exceptions) lists SA-side symmetries. The symbol * correlates with an exception. For the exceptions, the column combines SA-side and TA-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.

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

Note
• 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 just the integers three and four is a sub-case of the row immediately above that row.
• The row for which the XA column shows just the integers five and six is a sub-case of the row two rows above that row.
• The one-element item gens abbreviates the word generations. The notion of generations pertains for elementary fermions only.
• 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 58a 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.
• Each of the two notions of six isomers might correlate with a physics-relevant concept. (See table 21a.) The notion that correlates with SM6a might correlate with six isomers of charge (and of simple particles), with PR6ISP modeling, and with explanations for observed ratios of dark matter effects to ordinary matter effects. (See table 21b.)

Table 59: Symmetries correlating with kinematics conservation laws

Conservation law	Ongoing modeling KMS models	Core proposed modeling PFS models		Proposed modeling UMS/KMS models	
		TA-side	SA-side	TA-side	SA-side
Conservation of energy	$S1G$	$SU(5)$		$U(1)$ or $S1G$	$SU(4)$
Conservation of momentum	$SU(2)$		$SU(2)$	$U(1)$	$SU(2)$
Conservation of angular momentum	$SU(2)$		$SU(2)$	$U(1)$	$SU(2)$

Table 60: Possible 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						$\kappa_{-1,-1}$	$\kappa_{-1,-1}$	

– For some modeling, proposed modeling suggests combining the four TA-side oscillators with the TA0 oscillator to correlate with an $SU(5)$ symmetry. For such modeling, proposed modeling suggests that the TA-side $SU(5)$ symmetry correlates with conservation of energy. (See table 59.)

– For some modeling, it might be appropriate to use $SU(4)$ plus $S1G$.

– For some modeling, it might be appropriate to use $SU(4)$ plus $U(1)$.

– In proposed modeling, each of $S1G$ and $U(1)$ can correlate with one harmonic oscillator. (See table 13.) In ongoing modeling, $S1G$ correlates with one dimension with respect to space-time coordinates. This essay de-emphasizes discussing details of mathematical relationships between $S1G$ and $U(1)$.

• Table 60 shows possible proposed modeling 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 modeling uses for oscillators XA0-through-XA10. A choice of oscillator pairs XA11-and-XA12 and XA13-and-XA14 correlates with the modeling that table 58a shows.) For - at least - convenience regarding notation, this essay chooses the oscillator pairs XA11-and-XA12 and XA13-and-XA14. (For representations for the case of $\Sigma_{max} = 20$, 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 KMS modeling. Core proposed modeling does not necessarily need to accommodate boost symmetry.

• A contrast between table 48 and table 60 pertains. Some information in table 48 correlates with symmetries and conservation laws (or with approximate symmetries and rebuttable somewhat conservation laws) that pertain regarding fields and quantum excitations. Some information in table 60 correlates with interactions and with conservation laws that pertain regarding kinematics.

• The following proposed modeling aspects 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 modeling KMS 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 PFS modeling that encodes, regarding 2G modes, information about excitations of the overall 2G field. We anticipate that PFS modeling points to encoded information to which ongoing modeling KMS 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 58. See discussion leading to table 88. Perhaps note, for example, discussion - pertaining to isomers and spans - related to equation (149) and discussion related to table 93.)

We consider the left circular polarized mode. Modeling for some excitations correlates with aspects of table 35.

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 (65) provides notation that we use for such combinations. The symbol ΣG denotes a subfamily of the G-family of solutions to equation (38). 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 62.) For the above example of subtracting spin-1 from spin-2, the notation $\Gamma = 24$ pertains and equation (66) pertains.

$$\Sigma G \Gamma \tag{65}$$

$$\Sigma = |-2 + 4| = 2 \tag{66}$$

Table 61 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 73.) 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$\emptyset$ solution. The symbol $\emptyset$ denotes the empty set.

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

Table 61: 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		

So far, proposed modeling 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 modeling KMS Newtonian modeling, with force laws. Ongoing modeling 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 KMS 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 66 shows relationships between some solutions that table 61 lists and aspects of ongoing modeling. For example, 2G2 correlates with interactions with charge. 2G24 correlates with interactions with nominal magnetic dipole moment.)

Table 62 shows representations for the G-family solutions that table 61 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 36 alludes. For the cases of Σ being four, six, or eight, excitations comport with the type of ΣG excitations to which table 48 alludes. In table 62, 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 13.) In table 62a, the column regarding span pertains regarding aspects of dark matter specifically and, generally, aspects of astrophysics and cosmology. (See table 93 and table 62b.) Regarding each $\Sigma > 0$ solution that the table shows, the KMS radial behavior of the potential is $r^{n_{SA0}}$. The RSDF is $r^{n_{SA0}-1}$.

Table 63 generalizes from table 62b.

Table 64 lists notions that might correlate with a limit of $\lambda \leq 8$. Possibly, each one of the notions is relevant.

Table 65 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 (67).) 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 (68).)

$$\Sigma\gamma = \{\Sigma G\Gamma | \Sigma \in \Gamma\} \tag{67}$$

$$\gamma\lambda = \{\Sigma G\Gamma | \lambda \in \Gamma, \Sigma \notin \Gamma\} \tag{68}$$

Proposed modeling correlates the two-word term monopole gravity (or, the four-word term monopole component of gravity) with the 4G4 solution. (See table 63.) Proposed modeling 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 modeling might use the four-word term dark energy negative pressure. Solutions 4G2468a and 4G2468b correlate with some effects for which ongoing modeling uses the three-word term inflationary dark energy. Each one of solutions 4G48, 4G246, 4G2468a, and 4G2468b correlates also with - regarding ongoing modeling - effects for which people do not use either one of the terms dark energy negative pressure and inflationary dark energy.

Table 66 discusses aspects of table 65. Here, we anticipate possibilities for developing supplementary proposed modeling kinematics models. (See, for example, discussion related to table 119 and discussion related to table 123.) Here, we use wording that correlates with KMS 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

Table 62: PFS information, including TA-side symmetries, regarding G-family solutions

(a) $\Sigma\Phi\Gamma$, TA-side symmetries, and other aspects

$\Sigma\Phi\Gamma$	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
$0G\emptyset$	1	None	-1	-1				
$2G2$	1	None	0	-1	$\pi_{0,@_0}$			
$4G4$	6	$SU(3)$	0	-1	A0+	$\pi_{0,@_0}$		
$\Sigma G24$	1	None	0	-2	$\pi_{0,@_0}$	$\pi_{0,@_0}$		
$6G6$	2	$SU(5)$	0	-1	A0+	A0+	$\pi_{0,@_0}$	
$\Sigma G26$	6	$SU(3)$	0	-2	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	
$\Sigma G46$	6	$SU(3)$	0	-2	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
$\Sigma G246$	1	None	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
$8G8$	1	$SU(7)$	0	-1	A0+	A0+	A0+	$\pi_{0,@_0}$
$\Sigma G28$	2	$SU(5)$	0	-2	$\pi_{0,@_0}$	A0+	A0+	$\pi_{0,@_0}$
$\Sigma G48$	2	$SU(5)$	0	-2	A0+	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
$\Sigma G68$	2	$SU(5)$	0	-2	A0+	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
$\Sigma G248$	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
$\Sigma G268$	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
$\Sigma G468$	6	$SU(3)$	0	-3	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$
$\Sigma G2468$	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 $\Sigma G\Gamma$

Note
• An excitation of a ΣG field does not (directly) encode information about a relevant $\Sigma G\Gamma$.   • Proposed modeling includes so-called PRι_IISP 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 simple particles.   • In this respect, PR1ISP modeling correlates with core ongoing modeling. 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_IISP modeling for which $\iota_I \geq 6$, an excitation (for example, of a ΣG field) encodes information that specifies relevant isomers of simple particles. Here, the word relevant denotes relevant to the excitation. The word span denotes the number of relevant isomers.   • For PRι_IISP 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 63: Notes regarding excitations and regarding information that correlates with excitations, plus notes regarding PFS modeling and KMS modeling

Note
• 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, PFS 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, KMS 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 have a mass distribution that rotates.

Table 64: Notions that might correlate with a limit of $\lambda \leq 8$

Notion
• The limit might correlate with a scaling law. For the Γ of 2468$\llbracket 10 \rrbracket$, the one-element phrase hexadecimal-pole would pertain. Here, the symbol $\llbracket 10 \rrbracket$ denotes the number ten. Assuming KMS 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 objects. A ΣG2468$\llbracket 10 \rrbracket$ force would scale like $(v^3\rho)^2/(vr)^6$, in which v 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 $v = 1$, and r is the distance between the centers of the objects. The factor v^3 provides for scaling for an object that has three spatial dimensions. The force would be independent of v. 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 102.) Proposed modeling 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 62, 10G$\llbracket 10 \rrbracket$ correlates with a TA-side $SU(9)$ symmetry. We posit that remarks regarding equation (46) pertain. Here, we de-emphasize the notion that 16G$\llbracket 16 \rrbracket$ has relevance to physics. (See discussion related to table 123.) The solution 16G$\llbracket 16 \rrbracket$ would correlate with TA-side $SU(17)$ symmetry.
• The limit might correlate with the notion of channels. Discussion related to equation (135) suggests that a λ that exceeds eight is not relevant regarding G-family physics.
• The limit might correlate with modeling that correlates with aspects of table 20. This essay de-emphasizes this possibility.

Table 65: $\Sigma\gamma$ 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

Table 66: KMS-modeling interpretations regarding some $\Sigma\gamma$ 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

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 (69) and (70) symbolize. PFS modeling regarding quantum states and excitations does not necessarily involve modeling pertaining to translational motion. Equation (69) pertains. (See table 48.) Equation (70) 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 62.) Another aspect of such linking correlates with kinematics conservation laws. (See discussion related to table 59.)

$$\Sigma G \leftrightarrow \text{quantum excitations} \tag{69}$$

$$\Sigma G \Gamma \leftrightarrow \text{a bridge between quantum excitations and kinematics forces} \tag{70}$$

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

We combine aspects of equation (46), table 59, and table 62. We posit that TA-side aspects of table 59 and TA-side aspects of table 62 combine. For example, for 8G8, a TA-side $SU(11)$ symmetry would pertain. (In table 59, seven TA-side oscillators pertain. In table 62, 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 (46). We posit that each component that appears in table 62 and has a TA-side symmetry of None or $SU(3)$ can interact with simple particles. (Here, combining the TA-side symmetry that table 62 shows with the conservation of energy symmetry produces, respectively, $SU(5)$ or $SU(7)$.) We posit that components that appear in table 62 and have a TA-side symmetry of None or $SU(3)$ can interact with multicomponent objects. We posit that each component that appears in table 62 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 62 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 62 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 (162).) Generally, $6 \in \lambda$ can correlate with interactions regarding freeable energies of objects. (See discussion related to table 25.) Generally, $8 \in \lambda$ can correlate with interactions regarding rotations of objects or spins of objects. (See discussion related to table 25 and see table 66b.)

Table 67: G-family solutions for which $\lambda \leq 4$

Other	Monopole	Dipole
0G∅	2G2	ΣG24
	4G4	

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

Table 67 contrasts with table 61. Regarding table 67, we deploy PEPM techniques, but with an assumption that the maximum λ in any Γ is 4. Ongoing modeling does not necessarily include a particle that would correlate with the 0G∅ solution. Ongoing modeling includes classical physics modeling and quantum physics modeling that correlate with 2G2 and 2G24. Ongoing modeling does not directly include notions that would correlate with 6G24. Ongoing modeling includes classical physics models for gravity but does not (yet) include a complete statement regarding a graviton (or, regarding a quantum mechanical treatment correlating with 4G4).

4.2.3. Conservation of lepton number minus baryon number

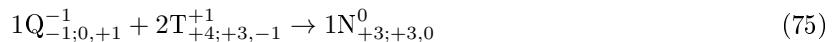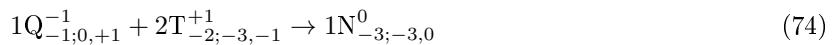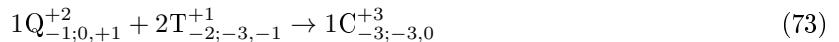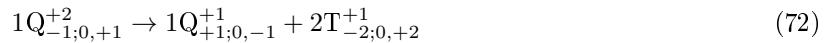We explore the notion of conservation of lepton number minus baryon number.

Equation (71) shows a quantity, N_{L-B} (or, lepton number minus baryon number). The symbol L correlates with the ongoing modeling notion of lepton number. The symbol B correlates with the ongoing modeling 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 modeling, N_{L-B} is a conserved quantity. Equation (71) defines the symbol ι_{3LB}.

$$N_{L-B} = L - B \ \text{ and } \ \iota_{3LB} = 3(N_{L-B}) \tag{71}$$

We correlate, with ι_{3LB}, the two-element term 3LB number. Sometimes, we use the one-element term 3LB to denote 3LB number. The four-element term conservation of 3LB number pertains.

Proposed modeling includes the notion of conservation of ι_{3LB}. (See, for example, table 58.)

Each of equations (72), (73), (74), and (75) shows an interaction that would involve the $2T^{+1}$ simple particle; transform a matter quark into another simple fermion; and conserve ι_{3LB}, L, and B. Here, for fermions, the notation $1\Phi^{\iota 3CH}_{\iota 3LB;3L,3B}$ pertains. Here, for bosons, equations show notation of the form $2\Phi^{\iota 3CH}_{\iota 3LB;3L,3B}$ and might suggest that each of L, conservation of L, B, and conservation of B is appropriate. However, discussion related to equation (76) 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 (that is, equations (72), (73), and (74)) correlates with transforming a matter quark into an antimatter simple fermion. Among those equations, the notion of $2T^{+1}_{-2;\_,\_}$ pertains. There are two forms of $2T^{+1}_{-2;\_,\_}$, namely $2T^{+1}_{-2;0,+2}$ and $2T^{+1}_{-2;-3,-1}$. The two forms, $2T^{+1}_{-2;0,+2}$ and $2T^{+1}_{-2;-3,-1}$, 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 modeling notion of leptoquarks.

$$1Q^{+2}_{-1;0,+1} \rightarrow 1Q^{+1}_{+1;0,-1} + 2T^{+1}_{-2;0,+2} \tag{72}$$

$$1Q^{+2}_{-1;0,+1} + 2T^{+1}_{-2;-3,-1} \rightarrow 1C^{+3}_{-3;-3,0} \tag{73}$$

$$1Q^{-1}_{-1;0,+1} + 2T^{+1}_{-2;-3,-1} \rightarrow 1N^{0}_{-3;-3,0} \tag{74}$$

$$1Q^{-1}_{-1;0,+1} + 2T^{+1}_{+4;+3,-1} \rightarrow 1N^{0}_{+3;+3,0} \tag{75}$$

More generally, equation (76) shows possible charged 2T simple bosons that convert simple fermions between matter and antimatter. Equation (77) 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.

$$2T^{\pm 1}_{\mp 2;} \ \text{ and } \ 2T^{\pm 2}_{\pm 2;} \tag{76}$$

Table 68: Cases - for zerolike rest mass elementary particles - for modeling regarding refraction and similar phenomena (with the symbol NR denoting the two-element term not physics-relevant)

n_{SA0}	n_{TA0}	Boson/Fermion	Example
-1	0	Boson	Photons
-1	-1	Fermion	Neutrinos
-1	-1	Boson	Gluons
-1	0	Fermion	NR

$$2\mathrm{T}^{\pm 1}_{\pm 4;} \quad \text{and} \quad 2\mathrm{T}^{\pm 2}_{\mp 4;} \tag{77}$$

This essay de-emphasizes the possibilities that equation (77) shows.

Regarding equation (76), 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 six-word phrase rebuttable somewhat conservation of lepton number and the six-word phrase rebuttable somewhat conservation of baryon number. One might deploy, regarding elementary fermions, the seven-word phrase rebuttable always conservation of fermion 3LB number.

4.2.4. 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 PFS modeling.) Known examples include photons in refractive media. We explore the notion that similar considerations pertain for neutrinos and for gluons.

Table 68 shows four mathematically possible cases. The case of boson and $n_{TA0} = 0$ pertains for G-family forces. The case of fermion and $n_{TA0} = -1$ pertains for (at least) neutrinos. The case of boson and $n_{TA0} = -1$ pertains for (at least) gluons. The case of fermion and $n_{TA0} = 0$ is not necessarily physics-relevant. (Proposed modeling does not predict the existence of fermion 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 PFS ALG modeling extends to include notions of non-isotropic harmonic oscillators.

Each of equations (78) and (79) 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 and not necessarily for other purposes. Regarding applications related to components of G-family forces, see table 62.) In the sense of KMS 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 PFS ALG TA-side set of harmonic oscillators and the PFS ALG SA-side set of harmonic oscillators is not necessarily isotropic.

$$n_{SA0} = -c^2 P^2 / E^2 \tag{78}$$

$$n_{SA0} = -v^2 / c^2 \tag{79}$$

For each of the three physics-relevant cases, each of equations (78) and (79) adds a positive amount to A^{ALG}_{SA}. For each of the three cases, we posit that, for each relevant oscillator, $-1 \leq n_{\_} \leq 0$ pertains.

For the case of boson and $n_{TA0} = 0$, for each relevant TA-side oscillator, $n_{TA\_} = 0$. One cannot satisfy double-entry bookkeeping by adding to A^{ALG}_{TA}. 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 modeling correlates this subtracting with aspects of refraction. Ongoing modeling 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 fermion and $n_{TA0} = -1$, for each relevant SA-side oscillator, $n_{SA\_} = -1$. One cannot satisfy double-entry bookkeeping by adding to A^{ALG}_{SA}. Satisfying double-entry bookkeeping correlates with adding something positive to at least one of the two TA-side oscillators that correlate with $SU(2)$ rebuttable somewhat conservation of generation symmetry or to at least one of the TA-side oscillators that correlate with conservation of energy symmetry. Assuming that conservation of energy pertains, (rebuttable always) conservation of generation does not pertain. This modeling comports with the notion

Table 69: PFS representation for SA-side aspects regarding 2U erase or paint ground states (with some aspects - for example, TA-side aspects related to conservation of charge - omitted)

Ground state	SA0	SA9	SA10
2U0	$(-1)^+$	-1	-1
2U9	-1	$(-1)^+$	-1
2U⟦10⟧	-1	-1	$(-1)^+$

of neutrino oscillations. This case correlates with neutrino oscillations. Observations suggest that rates at which neutrinos oscillate vary with the energies of the neutrinos. (See reference [10].) This essay does not pursue the notion that double-entry bookkeeping techniques and an equation such as equation (78) might correlate with a model - for symmetry breaking - that correlates with rates of neutrino oscillations.

For the case of boson and $n_{TA0} = -1$, equations (80), (81) and (82) can pertain. Here, the symbol $n_{SA\_}$ correlates with an oscillator for which $n_{SA\_} = -1$ originally pertained. (Perhaps, compare with discussion, pertaining to refraction, regarding equations (78) and (79).) 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 notion of $n_{SA\_} = (-1)^+$ correlates with concepts such as refraction and with modeling that correlates with non-isotropic harmonic oscillators. Here, discussion is not necessarily as straightforward as is discussion for the other two physics-relevant cases. Discussion related to table 69 pertains regarding gluons.

$$-1 < (-1)^+ < 0 \tag{80}$$

$$n_{TA0} = -1 \leftarrow n_{TA0} = (-1)^+ \tag{81}$$

$$n_{SA\_} = -1 \leftarrow n_{SA\_} = (-1)^+ \tag{82}$$

4.2.5. 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 PFS ALG modeling.

We denote three relevant PFS oscillators by the symbols SA0, SA9, and SA10. (Perhaps, compare with table 54.) Regarding quark or arc simple fermions, each of oscillators SA0, SA9, and SA10 correlates with a color charge. Relative to an ongoing modeling standard representation for gluons, one of SA9 and SA10 correlates with the color red, the other of SA9 and SA10 correlates with the color blue, and SA0 correlates with the color green.

Table 69 shows aspects regarding 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 quark or arc simple fermion that absorbs the gluon, a color. The paint part correlates with, in effect, an ability to paint, on to the quark or arc simple fermion that absorbs the gluon, a color. The value $n_{SA\_} = (-1)^+$ denotes an ability for a gluon to erase or paint the color charge correlating with the SA_ oscillator. Equation (83) shows an ongoing modeling 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 69, we make the following correlations. (Alternatively, without loss of generality or results, one might reverse the roles of SA9 and SA10.) The symbol r correlates with painting the color red and with a painting application of 2U⟦10⟧. The symbol $\bar{r}$ correlates with erasing the color red and with an erasing application of 2U⟦10⟧. The symbol b correlates with painting the color blue and with a painting application of 2U9. The symbol $\bar{b}$ correlates with erasing the color blue and with an erasing application of 2U9. 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.

$$(r\bar{r} + b\bar{b} - 2g\bar{g})/(6)^{1/2} \tag{83}$$

The expression $n_{TA0} = (-1)^+$ pertains. (See equation (81).) The expressions $n_{TA5} = -1$ and $n_{TA6} = -1$ correlate with a $\kappa_{-1,-1}$ (or, $SU(2)$) symmetry. (Regarding the choice of the oscillator pair TA5-and-TA6, see table 54.) That symmetry might correlate with (at least) rebuttable somewhat conservation of fermion generation. That symmetry might correlate with always conservation of fermion generation. (See discussion - related to the possibility for 2U strong interaction CP violation - in table 113.)

4.2.6. Numbers of color charges

Table 58 points to proposed modeling aspects that correlate with exactly three color charges. (Perhaps, see also, table 20.)

The notion of three color charges comports with the notion that $D = 3$ pertains regarding TA-side aspects of modeling for fermion elementary particles. (See table 32c.) This discussion might correlate with a notion that three (and no more than three) color charges pertain for each quark and each arc.

4.2.7. Interactions involving jay bosons

We note - as perspective - one observational result that might correlate with effects correlating with jay bosons.

Reference [11] reports a discrepancy between the observed energy correlating with one type of fine-structure transition in positronium and a prediction based on core ongoing modeling. (Perhaps, see also reference [12].) Equation (84) states a transition frequency. The observed value of transition frequency correlates with the energy that correlates with the transition. Equation (85) correlates with ongoing modeling. The observed energy exceeds the predicted energy. Reference [11] characterizes the transition via the expression $2^3S_1 \to 2^3P_0$.

$$18501.02 \pm 0.61 \text{ MHz} \tag{84}$$

$$18498.25 \pm 0.08 \text{ MHz} \tag{85}$$

We explore the topic of interactions and effects correlating with jay bosons.

Table 70 discusses aspects regarding physics, interactions, and modeling involving jay (or, 2J) simple bosons.

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. Equation (86) correlates with the Schwarzschild radius for an object of mass m. Equation (87) correlates with the Planck length and does not depend on m. Equation (88) includes a factor of m^{-1}. When applied to the mass of 2W bosons, equation (88) correlates somewhat with the range of the weak interaction. When applied to the mass of a charged pion, equation (88) 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 (89) shows the ratio between successive formulas. Equation (90) shows, for the electron, the ratio correlating with equation (89).

$$R_4(m) = (G_N)^1 m^1 \hbar^0 c^{-2} 2^1 \tag{86}$$

$$R_2(m) = (G_N)^{1/2} m^0 \hbar^{1/2} c^{-3/2} 2^0 \tag{87}$$

$$R_0(m) = (G_N)^0 m^{-1} \hbar^1 c^{-1} 2^{-1} \tag{88}$$

$$(G_N)^{-1/2} m^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \tag{89}$$

$$(G_N)^{-1/2} (m_\epsilon)^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \approx 1.1945 \times 10^{22} \tag{90}$$

4.2.9. Ranges for interactions that correlate with elementary bosons

Table 71 discusses ranges that pertain regarding interactions that correlate with elementary bosons. Generally, subsequent rows in table 71 correlate with smaller effective ranges than the effective ranges that correlate with previous rows. Some items in the table correlate with equation (88).

Table 70: Aspects regarding 2J bosons

(a) Aspects - correlating with observations and modeling - that might correlate with 2J bosons

Aspect
• Interactions - between identical fermions - that correlate with ongoing modeling notions of a Pauli exclusion force. (A pair of such identical fermions can be, for example, two hadrons in an atomic nucleus or two elementary particles. In ongoing modeling, the notion of identical can involve rest energy, charge, generation, and - for example, in an atom - spin orientation and orbital state. Aspects such as spin orientation and orbital state correlate with ongoing modeling KMS aspects. Perhaps note table 109. Proposed modeling would include - in the notion of identical - 3LB number. This inclusion would not necessarily add to the list that correlates with ongoing modeling. Proposed modeling would suggest - regarding the notion of identical - including a number that correlates with isomer. This inclusion would add to the list that correlates with ongoing modeling.)
• Forces correlating with some energy levels of positronium atoms. (See discussion related to equation (84).)
• Some interaction vertices that involve an incoming spin-one fermion, an incoming or outgoing ΣG for which $\Sigma \geq 4$, and an outgoing spin-one fermion. (See discussion related to equation (124). For this example, a 2J boson absorbs, in effect, one unit of spin that correlates originally with an incoming fermion. The unit correlates with $\hbar$.)
• Some interaction vertices that involve no fermions. (See discussion related to equation (163). For this example, a 2J boson might correlate with, in effect, two units of spin that correlates with an outgoing component of a graviton. The unit correlates with $\hbar$.)

(b) Suggested aspects regarding 2J bosons

Aspect
• For each of the three 2J bosons, the following sentences pertain. The equation $n_{SA0} = -1$ pertains. In a free environment, the longitudinal polarization state would not excite. In an unfree environment, the longitudinal polarization state can excite. (Perhaps, compare with modeling regarding gluons. See, for example, discussion regarding tables 68 and 69.)
• We use the following notation and posit the following notions regarding the three 2J bosons. $2J_0$ can exhibit left circular polarization and right circular polarization. $2J_-$ can exhibit (say) left circular polarization and cannot exhibit right circular polarization. $2J_+$ can exhibit right circular polarization and cannot exhibit left circular polarization. (See discussion related to table 52.)
• The Pauli exclusion force (in ongoing modeling) correlates with (in proposed modeling) a repulsive force based on the $2J_\pm$ bosons. The force, in effect, tries to flip the spin of a fermion. In so doing, the $2J_\pm$ boson would transit from circular polarization to longitudinal polarization.
• The positronium energy shift involves the notion that the two fermions - an electron and a positron - have identical properties (including spin orientation), except - essentially - for 3LB number. (The difference in 3LB number correlates with a difference in charge.) We posit that an energy level shift (regarding at least one positronium state) correlates with, in effect, aspects of $2J_\pm$ bosons. Presumably, the effect correlates with the notion of 2J boson transitions from longitudinal polarization to circular polarization or from circular polarization to longitudinal polarization. Here, at least with respect to ongoing modeling based on the Dirac equation, a notion of charge (or 3LB) exchange (between the electron and the positron) might be appropriate.
• We posit that $2J_\pm$ bosons correlate with some interaction vertices that involve an incoming spin-one fermion, an incoming or outgoing ΣG for which $\Sigma \geq 4$, and an outgoing spin-one fermion. (See, for example, equation (124).)
• We posit that the $2J_0$ boson can correlate with some interaction vertices that involve no fermions. (See, for example, discussion related to equation (163).)

Table 71: Ranges for interactions that correlate with elementary bosons

n_{TA0}	n_{SA0}	Subfamilies	Discussion regarding effective ranges regarding interactions mediated between elementary particles and hadron-like particles
0	−1	ΣG, $\Sigma \geq 2$	• The photon, graviton, and so forth have effectively unbounded ranges.
0	0	0P	• The pie has a range that correlates with the distance, within an atomic nucleus, between neighboring hadrons.
−1	−1	2U	• Gluons have a range of the size of a hadron-like particle.
0	0	0H, 2W	• The range of the weak interaction is about 10^{-18} meters, in the sense that 2G (if relevant) has more effect (than the weak interaction) at distances greater than about 10^{-18} meters.
0	0	2T	• Proposed modeling suggests that tweak masses are larger than the mass of the Higgs boson and that the range for tweak bosons is less than the range for the weak interaction.
−1	−1	0I	• The 0I particle may lose its effectiveness (at least, relative to effects of other relevant interactions) regarding interactions when densities are somewhat less than densities pertaining to the end of the inflationary epoch.
−1	−1	2J	• Regarding interactions with fermions, jay particles have effective ranges that are similar to the effective range of the ongoing modeling Pauli exclusion force. The ranges related to jay bosons might vary based on whether modeling pertains, for example, to interactions between elementary fermions or to interactions between fermion hadron-like particles. • Regarding interactions with elementary bosons, jay particles might lose their effectiveness (at least, relative to effects of other relevant interactions) regarding interactions when densities are less than densities pertaining to the start of the inflationary epoch.

Table 72: Correlations between 0G and 0U solutions and simple bosons

Direct basis (solutions)	Other basis	Subfamily	Bosons	Discussion related to ...
0G2468	-	0H	Higgs	Table 73
-	0H	0I	Aye	Table 53
0G246 and 0G268	-	2W	Z and W	Table 73
$0G\Gamma_{\lambda_{max}=14}$	-	2T	Tweaks	Equation (91)
$0G\emptyset$	-	2J	Jays	Table 74
0U	-	0P	Pie	Table 55

4.2.10. Correlations between simple particles and G-family and U-family ALG solutions

Work elsewhere discusses the notion that PDE equations and solutions correlate with all the elementary particles that proposed modeling suggests. (See table 57.)

Table 72 discusses, from a perspective of ALG modeling, the notion that 0G and 0U solutions might correlate with all simple bosons. The leftmost column points to G-family solutions ΣG that correlate with $\Sigma = 0$ and to one possible U-family solution. For each row, other than the row pertaining to the 0I subfamily, proposed modeling suggests the possibility that subfamilies and bosons correlate - from a perspective of some modeling - with the solutions that the table list for that row. Table 72 suggests a possible (indirect) correlation (via modeling for the Higgs boson) regarding the aye boson. For each row, the rightmost column points to aspects of this essay that discuss the suggested correlations.

We discuss the Higgs boson and the weak interaction bosons.

Table 73 posits correlations between all W-family and H-family bosons and all G-family $\Sigma = 0$ solutions - other than $0G\emptyset$ - that correlate with table 62. The symbol $j_{\lambda \in \Gamma}$ denotes the number of elements in the Γ in $\Sigma G\Gamma$. Elsewhere, we correlate $j_{\lambda \in \Gamma}$ with mass. (See discussion regarding table 76.)

Each of the $\Sigma = 0$ items that table 73 lists has a TA-side symmetry of none or $SU(3)$. (See table 62.)

We discuss the aye boson.

We correlate the mass of the aye (or, 0I) boson with the result $D + 2\nu'' = 0$ that pertains for the row

Table 73: Possible correlations between 0G solutions and all W-family and H-family bosons (with $j_{\lambda \in \Gamma}$ denoting the number of elements in the Γ in $\Sigma G\Gamma$)

Solutions	Bosons	Subfamily	$j_{\lambda \in \Gamma}$
0G246 and 0G268	Z and W	2W	3
0G2468	H^0 (or, Higgs)	0H	4

Table 74: Possible direct correlation between 0G solutions and jay bosons (with $j_{\lambda \in \Gamma}$ denoting the number of elements in the Γ in $\Sigma G\Gamma$)

Solution	Bosons	Subfamily	$j_{\lambda \in \Gamma}$
0G∅	Three 2J (or, jay) bosons	2J	0

- in table 32e - that pertains for $S'' = 1$ and $\Omega'' = 1$.

Proposed modeling correlates the aye boson with the Higgs boson. (See discussion related to table 53.) Thereby, proposed modeling suggests - per table 73 - a correlation between the aye boson and G-family solutions.

We discuss the tweak bosons.

Discussion immediately above involves (at least indirectly) $\Omega'' \leq 0$ rows in table 32e that correlate with values of S'' of zero, three, and four.

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 (91) shows the solutions. Here, we do not put brackets around values of λ that exceed eight. Equation (92) shows the same four solutions, but with a different grouping. For each of equation (91) and equation (92), the first item (and, hence, the first two solutions) correlates with the expression 0 ± 0.

$$(14 - 10 - 6 + 2) \pm (12 - 8 - 4); \quad 14 - 12 - 10 + 8 + 6 - 4 - 2; \quad 14 - 12 + 10 - 8 - 6 + 4 - 2 \quad (91)$$

$$(14 - 12 - 10 + 8) \pm (6 - 4 - 2); \quad 14 + 12 - 10 - 8 - 6 - 4 + 2; \quad 14 - 12 + 10 - 8 - 6 + 4 - 2 \quad (92)$$

Proposed modeling suggests that $2T^{0''}$ and $2T^{0'}$ correlate with two solutions that equation (91) 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 equations (98) and (99).)

We discuss the jay bosons.

Table 74 notes a possible direct correlation between 0G solutions and jay bosons. (See, also, discussion related to equation (95).) We correlate the mass of jay bosons with the result $D + 2\nu'' = 1$ that pertains for the row - in table 32e - that pertains for $S'' = 0$ and $\Omega'' = 0$.

We discuss the pie boson.

Table 55 suggests correlating the 0P boson with the U-family and not necessarily with the G-family. This essay does not explore mathematics that might correlate modeling for the 0P boson with a notion of a 0U solution.

We discuss the possibility of correlations between 0G solutions and simple fermions.

Table 75 suggests correlations between 2W solutions (and hence, via table 72, 0G solutions) and solutions that correlate with all simple fermions. Table 75b restates - for W bosons - table 42. Table 75c reflects aspects of table 75b, based on notions that the next three sentences mention. The TA0 result correlates with transforming 0 to $@_0$ (which is appropriate for fermions). The SA1-and-SA2 result $\pi_{@_0, @_{-1}}$ correlates with transforming 0 to $@_0$ (which is appropriate for fermions) and transforming one $@_0$ to $@_{-1}$ (which is also appropriate for fermions). The TA5-and-TA6 result correlates with applying double-entry bookkeeping and with transforming $\kappa_{0,0}$ to $\kappa_{0,-1}$ (for which the notation of [blank] is appropriate). From here, one presumably can mirror steps - that this essay shows elsewhere - that lead to representations for individual simple 1C fermions, individual simple 1N fermions, individual simple 1Q fermions, and individual simple 1R fermions. (See discussions related to table 45, table 46, and table 50.)

4.3. Predictions and correlations regarding properties of elementary particles

We explore masses and other properties of elementary particles.

Table 75: Indirect correlations between 0G solutions and simple fermions

(a) Bases

Direct basis (solutions)	Other basis	Subfamily	Fermions	Discussion related to ...
-	2W	1C	Charged leptons	Table 75b and table 75c
-	1C	1N	Neutrinos	Table 46
-	1C	1Q	Quarks	Table 50
-	1N	1R	Arcs	Table 50

(b) A PFS-centric representation for the ground state for W bosons

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

(c) A PFS-centric representation for the 1C subfamily (with $\pi_{@_0,@_{-1}}$ omitted regarding TA1-and-TA2)

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

Table 76: Rest energies for known non-zero-mass simple bosons

Φ	S	Symbol	Name	Experimental mc^2 (GeV)	Calculated		Difference (standard deviations)
					N	mc^2 (GeV)	
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

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

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

Table 76 shows, in the column for which the label includes the word experimental, rest energies for the known non-zero-mass simple bosons. (See reference [13].) 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 (93) and on assuming that nine correlates with the square of the mass of the Z boson. Equation (94) shows the size of one unit. The related mass is $\approx 30.396 \text{GeV}/c^2$. In table 76, 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.

$$(m_{H^0})^2 : (m_Z)^2 : (m_W)^2 :: 17 : 9 : 7 \tag{93}$$

$$\approx 9.239 \times 10^2 (\text{GeV}/c^2)^2 :: 1 \tag{94}$$

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 (93) shows, the possibly least accurately suggested mass is that of the W boson. Equation (93) correlates with a number that is within four standard deviations of the nominal mass of the W boson. (See table 76.)

Proposed modeling correlates the numbers in equation (93) 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 32e.)

The following correlations pertain regarding relative squares of masses. (See table 73 and table 32e.) 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. (See table 73.) 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. (See discussion related to equation (136). See also discussion - regarding the mass of the 2J bosons - related to equation (95).) 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 $S'' = 1$ 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). (Perhaps, see discussion related to equation (136).)

To the extent that m_{W} does not exactly comport with equation (93), proposed modeling 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 (196).) The contribution of minus two (compared to the Z boson) - that equation (93) implies - might correlate with each of 2G24 and nominal magnetic dipole moment.

4.3.2. The masses of the aye boson and jay bosons

We explore modeling for the mass of the jay (or, 2J) bosons.

For the jay bosons, correlation with the 0G∅ solution seems to be appropriate. The 0G∅ solution correlates with $j_{\lambda \in \Gamma} = 0$. (Compare with discussion related to table 73.) The result $j_{\lambda \in \Gamma} = 0$ might correlate with $S'' = 0$. (See discussion related to table 76.) The result $S'' = 0$ correlates with a relative square of mass of one. (See the column - in table 32e - labeled $D + 2\nu''$.) Paralleling results for the Z and W bosons, the square of the masses of the jay bosons would be proportional to plus one minus one, which is zero. (The term minus one correlates with the notion of subtracting one for elementary bosons that have spins of one.) Equation (95) extends equation (93).

$$(m_{\mathrm{H^o}})^2 : (m_{\mathrm{Z}})^2 : (m_{\mathrm{W}})^2 : (m_{\mathrm{2J}})^2 :: 17 : 9 : 7 : 0 \tag{95}$$

We explore modeling for the mass of the aye (or, 0I) boson.

We suggest that the aye boson correlates with the solution for which $\sigma'' = +1$ and $S'' = 1$. (See table 32e.) The result $D + 2\nu'' = 0$ pertains and correlates with a zero square of mass.

4.3.3. Possible masses of the tweak bosons

We explore possibilities regarding masses of T-family bosons.

We explore using patterns that have bases in G-family solutions and in aspects of table 32e.

Table 77 points to a possible mass for zero-charge 2T bosons. Table 77a summarizes information pertaining to some simple bosons. The $D + 2v''$ column shows information - from table 32e - that correlates with the relevant positive contribution to the sums that correlate with the squares of the masses of the simple bosons. The Ω'' and S'' columns show other information from table 32e. For other than the 0I boson, the $j_{\lambda \in \Gamma}$ shows the number of oscillator pairs relevant to solutions $\Sigma \mathrm{G}\Gamma$ for which $\Sigma = 0$. (See, for example, discussion related to table 76.) The next column shows the relevant negative contribution that correlates with spin. (See, for example, discussion related to table 76.) The last column sums the $D + 2v''$ integer and the spin-related integer. (See table 76 for a use of the symbol N.) Table 77b extrapolates from table 77a. The equation $S'' = 7$ provides the first possibility (beyond the limit $\lambda \leq 8$) to have G-family-like solutions for which $\Sigma = 0$. (See discussion related to equation (91).) The equation $S'' = 7$ would correlate with allowed values of λ of two, four, six, eight, 10, 12, and 14. For $S'' = 7$, $D + 2\nu'' = 50$.

The charges for the $\mathrm{T}^{\pm 1}$ and $\mathrm{T}^{\pm 2}$ bosons are between the charges for the Z^0 and $\mathrm{W}^{\pm 3}$ bosons. We assume that the relevant charge-related (or magnetic-moment-related) contributions to the total values of N are negative numbers that fall in the range of minus two to zero. Equations (96) and (97) pertain. (Here, T^0 denotes each of $\mathrm{T}^{0''}$ and $\mathrm{T}^{0'}$. Here, $\mathrm{T}^{\pm}$ denotes each of $\mathrm{T}^{\pm 2}$ and $\mathrm{T}^{\pm 1}$.) Based on data from reference [13] regarding the Higgs boson, the rest energies of the T-family bosons would comport with equations (98) and (99).

$$(m_{\mathrm{T^o}})^2/(m_{\mathrm{H^o}})^2 = 49/17 \tag{96}$$

$$47/17 \leq (m_{\mathrm{T^\pm}})^2/(m_{\mathrm{H^o}})^2 \leq 49/17 \tag{97}$$

$$(m_{\mathrm{T^o}})c^2 \approx 212.5\mathrm{GeV} \tag{98}$$

Table 77: Patterns regarding the squares of masses of some simple bosons

(a) Results for the 0I, 2J, 2W, and 0H bosons

Simple bosons	$D + 2v''$	Ω''	S''	$j_{\lambda \in \Gamma}$	Spin-related	N for zero-charge simple bosons
0I	0	1	1	(-1)	0	0
2J	1	0	0	0	-1	0
2W	10	-9	3	3	-1	9
0H	17	-16	4	4	0	17

(b) Extrapolation regarding 2T bosons

Simple bosons	$D + 2v''$	Ω''	S''	$j_{\lambda \in \Gamma}$	Spin-related	N for zero-charge simple bosons
2T	50	-49	7	7	-1	49

$$208\text{GeV} \lesssim (m_{\text{T}^\pm})c^2 \lesssim 213\text{GeV} \tag{99}$$

Proposed modeling suggests that equations (98) and (99) correlate with the lowest possible rest energies for tweaks. (Possibly, for example, the mass range correlates with, for example, $S'' = 7$, $S'' = 8$, $S'' = 11$, or $S'' = 12$.)

Detecting $2\text{T}^\pm$ particles might require an energy of at least twice the rest energy of a $2\text{T}^\pm$.

4.3.4. A prediction for the tauon mass

Equation (100) shows an experimental result for the tauon mass, m_τ. (See reference [14].)

$$m_{\tau, \text{ experimental}} \approx (1776.86 \pm 0.12) \text{ MeV}/c^2 \tag{100}$$

Equation (101) defines the symbol β'. Equation (102) defines β. Here, m denotes mass, ϵ denotes electron, q denotes charge, ε_0 denotes the vacuum permittivity, and G_N denotes the gravitational constant. Equation (103) possibly pertains. Equation (103) predicts a tauon mass, which equation (104) shows, with a standard deviation of less than one eighth of the standard deviation correlating with the experimental result. (For relevant data, see reference [14].) Equation (105) shows an approximate value of β that we calculate, using data that reference [14] shows, via equation (102).) Elsewhere, we correlate the numbers four and three in the left-hand side of equation (102) with a notion of channels. (See discussion related to equation (130) and discussion related to equation (134).)

$$\beta' = m_\tau / m_\epsilon \tag{101}$$

$$(4/3) \times \beta^{12} = ((q_\epsilon)^2/(4\pi\varepsilon_0))/(G_N(m_\epsilon)^2) \tag{102}$$

$$\beta' = \beta \tag{103}$$

$$m_{\tau, \text{ calculated}} \approx (1776.8400 \pm 0.0115) \text{ MeV}/c^2 \tag{104}$$

$$\beta \approx 3477.1891 \pm 0.0226 \tag{105}$$

To the extent that equation (103) 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 modeling does not, as yet, suggest a relationship - perhaps similar to equation (102) - regarding the ratio m_μ/m_ϵ. Here, μ denotes muon. (See discussion related to equations (119) and (120).)

4.3.5. The masses of quarks and charged leptons

Table 78 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 79 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

Table 78: 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 79: Approximate rest energies (in MeV) for quarks and charged leptons

		M' Charge	3 $-1 \cdot |q_\epsilon|$	2 $+(2/3) \cdot |q_\epsilon|$	1 $-(1/3) \cdot |q_\epsilon|$
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		$m_\tau c^2 \approx 1.777 \times 10^3$		

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 79 shows, regarding the rest energies of quarks and charged leptons, data that people report and numbers that we calculate via equation (108). Below, we discuss the table and the data before we discuss the equation and the calculations. Equation (108) results from fitting data. This essay does not show modeling that would generate equation (108).

Regarding the placement of quarks, some placements in table 79 differ from the respective placements in table 78. In table 79, the variable M' and the columns related to quarks reflect the concept that some aspects regarding mass correlate with charge. In table 79, 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 79 reflect information from reference [13].) For each particle other than the top quark, reference [13] provides one estimate. For the top quark, reference [13] provides three estimates. For each quark, table 79 shows a data range that runs from one standard deviation below the minimum nominal value that reference [13] shows to one standard deviation above the maximum nominal value that reference [13] 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 (108). Equation (106) 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 (107) produces a meaningful value of $m(M'', 3/2)$. (No elementary particle correlates with $M' = 3/2$. Aspects of equations (108), (112), and (113) 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 (108) comport with this role.)

$$m(3,1)m(3,2) = m(3,0)m(3,3) \tag{106}$$

$$(m(M'', 3/2))^2 = m(M'', 2)m(M'', 1) \tag{107}$$

Table 80: Ranges of $d'(M'')$ that fit the data ranges that table 79 shows for quark masses

Symbol	Minimum (approximate)	Nominal (table 79)	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

The following concepts pertain regarding developing and using equation (108). We use equation (102) to calculate β. Equation (108) calculates the same value of m_τ that equation (104) calculates.

Equation (108) 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 (109).) 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 (107).) Regarding charged leptons, $M' = 3$, the term $1 - \delta(M', 3)$ is zero, and the factor - in equation (108) - that includes the fine-structure constant is one. (See equation (112).)

$$m(M'', M') = m_\epsilon \times (\beta^{1/3})^{M'' + (j''_{M''})d''} \times (\alpha^{-1/4})^{(1-\delta(M',3))\cdot((3/2)\cdot(1+M'')+(j'_{M'})d'(M''))} \tag{108}$$

$$\alpha = ((q_\epsilon)^2/(4\pi\varepsilon_0))/(\hbar c) \tag{109}$$

$$j''_{M''} = 0, +1, -1, 0 \text{ for, respectively, } M'' = 0, 1, 2, 3 \tag{110}$$

$$d'' = (2 - (\log(m_\mu/m_\epsilon)/\log(\beta^{1/3}))) \approx 3.840679 \times 10^{-2} \tag{111}$$

$$1 - \delta(M', 3) \text{ equals } 0, \text{ for } M' = 3, \text{ and equals } 1, \text{ otherwise} \tag{112}$$

$$j'_{M'} = 0, -1, 0, +1 \text{ for, respectively, } M' = 3, 2, 3/2, 1 \tag{113}$$

$$d'(0) \sim 0.318 \tag{114}$$

$$d'(1) \sim -1.057 \tag{115}$$

$$d'(2) \sim -1.5091 \tag{116}$$

$$m(1, 3) \approx 8.59341 \text{MeV}/c^2 \tag{117}$$

In equation (108), the factor $3/2$ correlates with the average of $M' = 2$ and $M' = 1$ and correlates with equation (107). (Note the appearance of $M' = 3/2$ in equation (113). The concepts of $M' = 3/2$ and $m(M'', 3/2)$ are useful mathematically, though not necessarily directly relevant to physics.) Regarding equations (114), (115), and (116), we choose values that fit data. (The relative signs of the three $d'(\_)$ reflect the differences - regarding the positioning of quarks - between table 78 and table 79.) Regarding each charged lepton, our calculations fit data to more significant figures than the numbers in table 79 show. Regarding the tauon, our calculation correlates with a mass that may be more accurate, and more accurately specified, than the mass that references [13] and [14] show. (See equations (104) and (100).)

Table 80 shows ranges of $d'(M'')$ that fit the data ranges that table 79 shows for quark masses. (See equations (114), (115), and (116).)

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 81: 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	≈ 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	$-3/2$	$m_t c^2 \approx 1.695{\times}10^5$	$m_b c^2 \approx 4.322{\times}10^3$

Table 81 speculates regarding 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 experimental results that table 79 shows. To the extent that table 81 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 81 comports with nature, equation (118) pertains.

$$(m_s)^2 m_\mu = m_\epsilon m_\tau m_c \tag{118}$$

The charge q_ϵ correlates with β via equation (102). The charge q_ϵ appears in α, via equation (109). Based on equations (93) and (108) and based on modeling for the G-family, proposed modeling entangles concepts related to mass and concepts related to charge more deeply than does ongoing modeling.

Equations (119) and (120) explore the possibility for a relationship - perhaps similar to equation (102) - regarding the ratio m_μ/m_ϵ or the ratio m_τ/m_μ. Equation (121) shows the result that we compute based on data from reference [13]. Equation (122) shows the result that we compute based on data from reference [14]. 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 (102).) We do not explore possible significance for the notion that $1 + x \approx 10/9$.

$$(1+x)\beta^{1/3} = m_\tau/m_\mu \approx m(1,3)/m_\epsilon \tag{119}$$

$$(1+x)^{-2}\beta^{1/3} \approx m_\mu/m(1,3) \tag{120}$$

$$x \approx 0.110033 \tag{121}$$
$$x \approx 0.110031 \tag{122}$$

4.3.6. The relative strengths of electromagnetism and gravity

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

We explore modeling for interactions that involve a charged simple fermion, such as an electron.

We assume that we can work within aspects of proposed modeling that de-emphasize translational motion and multicomponent objects. We assume that conservation of angular momentum pertains.

We correlate the symbol 1F with that fermion. We explore interactions that model as if the number of incoming bosons equals the number of outgoing bosons. (Perhaps, compare with table 115. Note that, in table 115, a number n - such as in nf - denotes a number of particles and not a value of $2S$. For example, 3f denotes three elementary fermions.) Equation (123) shows an interaction in which the fermion absorbs a photon. The spin of the fermion flips. Angular momentum is conserved. Trying to replace, in equation (123), 2G with 4G does not work. The angular momentum associated with the fermion can change by no more than one unit. The interaction would not conserve angular momentum. Equation (124) can pertain. (Equation (124) does not portray an interaction - mediated by a 2J boson - between two fermions. One can consider that the 2J particle in equation (124) is a $2J_\pm$. See table 70. One might want to consider the notion that equation (124) pertains regarding modeling and - in the current state of the universe - does not necessarily pertain regarding easily directly observable physics.)

$$1F + 2G \rightarrow 1F + 0I \tag{123}$$

$$1F + 4G \rightarrow 1F + 2J \tag{124}$$

The notion that $1F + 4G \rightarrow 1F + 0I$ does not pertain might correlate with ongoing modeling 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 KMS Newtonian modeling.

For each of the three charged leptons, equation (125) 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 (126) shows notation regarding the masses of charged leptons. (See discussion related to table 79.) 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 (108), which pertains to the masses of quarks and charged leptons.) Equation (127) repeats equation (101). Equation (128) shows results that reflect data. (We used data that reference [14] shows.) Equation (129) provides a 4G4 analog to the 2G2 equation (125). The symbol G_N denotes the gravitational constant. The equation correlates with a magnitude of the force. Here, the interaction is attractive.

$$r^2 F = (q_\epsilon)^2/(4\pi\varepsilon_0) \tag{125}$$

$$m(M'', 3) = m_x, \text{ for the pairs } M'' = 0, x = \epsilon; \ M'' = 2, x = \mu; \text{ and } M'' = 3, x = \tau \tag{126}$$

$$\beta' = m_\tau/m_\epsilon \tag{127}$$

$$m(M'', 3) = y_{M''}(\beta')^{M''} m_\epsilon, \text{ with } y_0 = y_3 = 1 \text{ and } y_2 \approx 0.9009 \tag{128}$$

$$r^2 F = G_N(m(M'', 3))^2 \tag{129}$$

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 (130) pertains within experimental errors regarding relevant data. (Reference [13] provides the data.) Here, in essence, the equation $y_{18} = y_0 = 1$ pertains. Equation (130) echoes equation (102).

$$((q_\epsilon)^2/(4\pi\varepsilon_0))/4 = (G_N(m(18,3))^2)/3, \text{ with } m(18,3) = (\beta')^6 m_\epsilon \tag{130}$$

Proposed modeling interprets equation (130) as suggesting that the strength of 2G2 correlates with four so-called channels. (See discussion related to equation (134).) 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 (130) links the ratio of two simple particle masses to a ratio of the strengths of two G-family force components.

- Equation (130) links the strength of 2G2 interactions to the strength of 4G4 interactions.

- Equation (131) correlates the fine-structure constant, α, with a function of the tauon mass and the electron mass. (Regarding the fine-structure constant, see equation (109).)

$$\alpha = ((q_\epsilon)^2/(4\pi\varepsilon_0\hbar c)) = (4/3) \times (m_\tau/m_\epsilon)^{12} G_N(m_\epsilon)^2/(\hbar c) \tag{131}$$

- Equation (132) characterizes a per channel ratio that pertains for interactions between two electrons.

$$(((q_\epsilon)^2/(4\pi\varepsilon_0))/4) / ((G_N(m_\epsilon)^2)/3) \approx 3.124 \times 10^{42} \tag{132}$$

- Equation (133) recasts equation (102) to feature, in effect, the magnitudes of three interactions, with each one of the interactions involving two similar particles. (For example, $G_N(m_\tau)^2$ correlates with a gravitational interaction between two tauons.)

$$(4/3)((G_N(m_\tau)^2)/(G_N(m_\epsilon)^2))^6 = ((q_\epsilon)^2/(4\pi\varepsilon_0))/(G_N(m_\epsilon)^2) \tag{133}$$

Table 82: Possibilities, based on concepts related to observations and proposed modeling pertaining to neutrinos

Two possibilities:
• If we assume that all three neutrinos are Dirac fermions, discussion related to equation (143) and table 84 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 (135) would pertain. The number of channels is one. The factor of three in equation (143) correlates with the number of Dirac neutrinos. (See discussion regarding table 84.) • 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 (143) and table 84 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 (134) would pertain. The factor of three in equation (143) correlates with a ratio of three 4G channels to one 8G channel.

4.3.7. Channels and interactions that involve G-family bosons

The notion of channels pertains to, at least, the relative strengths of the 2G2 component of 2G (or, electromagnetism) and the 4G4 component of 4G (or, gravity). (See discussion related to equation (130).) We extrapolate. For 6G6, the number of channels is two. For 8G8, the number of channels is one. For $\Sigma = 10$ and $\Gamma = [\![10]\!]$, $\Sigma G\Gamma$ would correlate with zero channels and no interactions.

Each of equation (134) and equation (135) provides a candidate formula for the number of channels that pertain for a G-family solution $\Sigma G\Gamma$ that correlates with a G-family elementary particle. (This discussion does not necessarily pertain regarding the jay bosons and the 0G∅ solution. This discussion does not necessarily pertain regarding other - for example, the Higgs boson and the weak interaction bosons - elementary bosons that correlate with 0GΓ solutions.)

$$5 - (\Sigma/2) \tag{134}$$

$$5 - (\lambda_{max}/2), \text{ with } \lambda_{max} = \max\{\lambda | \lambda \in \Gamma\} \tag{135}$$

Equation (134) would correlate with excitations of the various ΣG. (See, for example, table 48.) Possible G-family forces correlating with $\Sigma \geq 10$ would not be relevant to physics. (See table 23.) We would say that $\Sigma_{max} = 8$.

Equation (135) provides another possibility. Equation (135) correlates with notions of components $\Sigma G\Gamma$. Equation (135) might correlate with TA-side symmetries. (See table 62.) Either one of $\Sigma_{max} = 8$ or $\Sigma_{max} = 20$ might pertain to nature.

Proposed modeling uses equation (135) to compute numbers of channels.

We elaborate regarding the selection of equation (135) to compute numbers of channels.

Regarding 2G, some objects measure as having charge (which correlates with 2G2) and not having intrinsic magnetic fields (which would correlate with 2G24). Other objects measure as having intrinsic magnetic fields and not having net non-zero charge. We think that such notions point to the notion that channels correlate directly with 2GΓ and not directly with 2G.

Table 82 summarizes a thought experiment. The notion that some neutrinos are Dirac fermions and some neutrinos are Majorana fermions seems less than fully appealing. (See, for example, table 29e.)

This essay uses equation (135) to compute numbers of channels.

4.3.8. 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.

Equation (136) provides one definition of the fine-structure constant. (Compare with equation (109), which provides a more common definition.) In equation (136), $(q_\epsilon)^2/(4\pi\varepsilon_0 c)$ correlates with the strength of 2G2.

$$\alpha = ((q_\epsilon/\hbar)^2/(4\pi\varepsilon_0 c)) \cdot \hbar \tag{136}$$

Equation (136) 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 modeling considers that magnetic flux is always an integer multiple of $h/(2q_\epsilon)$. (We note the existence of an analog
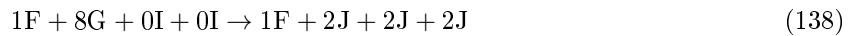
- to equation (136) - for which $\alpha = (\cdots) \cdot K_{\text{J}}$. Elsewhere, this essay links spin to aspects pertaining to the squares of masses of elementary bosons. See, for example, discussion related to equation (93) and discussion related to equation (95). Elsewhere, this essay mentions the notion that aspects pertaining to squares of masses of elementary bosons might link with nominal magnetic dipole moment. See, discussion related to equation (93). Possibly, the $\alpha = (\cdots) \cdot K_{\text{J}}$ analog to equation (136) has relevance to aspects pertaining to squares of masses of elementary bosons. This essay does not further discuss possible relevance of the $\alpha = (\cdots) \cdot K_{\text{J}}$ analog to equation (136).)

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

We use the symbol ΣB to denote an elementary boson having a spin of $\Sigma/2$. The expression 1F+2B→1F+0B can pertain for each of the following cases - 2B correlates with 2G, 2B correlates with 2W, and 2B correlates with 2U. This notion might correlate with ongoing modeling notions that correlate with relationships between the strengths of the electromagnetic, weak, and strong interactions.

4.3.9. Relative strengths of interactions re G-family bosons with spins of at least two

Equations (137) and (138) parallel equation (124). Compared to equation (124), equation (137) requires dissipation - from the incoming G-family boson - of one more unit - of magnitude $\hbar$ - of spin. Compared to equation (137), equation (138) requires dissipation - from the incoming G-family boson - of one more unit - of magnitude $\hbar$ - of spin.

$$1\text{F} + 6\text{G} + 0\text{I} \rightarrow 1\text{F} + 2\text{J} + 2\text{J} \tag{137}$$

$$1\text{F} + 8\text{G} + 0\text{I} + 0\text{I} \rightarrow 1\text{F} + 2\text{J} + 2\text{J} + 2\text{J} \tag{138}$$

Each of 4G4, 6G6, and 8G8 interacts with a different property of objects. In effect, 4G4 interacts with (at least some) elementary fermions, while neither of 6G6 and 8G8 interacts with elementary fermions. (See table 93.)

We explore the notion that a strength scaling relationship might pertain regarding G-family components ΣGΓ that share a value of Γ. For two such ΣGΓ, Σ_1GΓ and Σ_2GΓ, equation (139) pertains.

$$|\Sigma_2 - \Sigma_1|/4 \text{ is an integer} \tag{139}$$

We interpret equation (136) as suggesting that a factor of α might pertain regarding modeling the absorbing of a unit of spin. For a step from equation (124) to equation (138), two factors of α would pertain. The factor of α^2 correlates with the notion that some proposed modeling suggests $\alpha^2 m_\epsilon$ as equaling or being somewhat less than the ongoing modeling average neutrino mass. (See equation (143).)

We explore aspects that would be relevant for the case of $\Sigma_{max} = 20$ but not for the case of $\Sigma_{max} = 8$.

Each one of 10G, 12G, ..., and 20G would interact with anomalous properties and not with nominal properties. Examples of ongoing modeling nominal properties include charge (which correlates with a proposed modeling component, 2G2, of 2G), nominal magnetic dipole moment (which correlates with a proposed modeling component, 2G24, of 2G), and rest mass (which correlates with a proposed modeling component, 4G4, of 4G). An example of an ongoing modeling anomalous property is anomalous magnetic dipole moment. Detecting effects of ΣG for which $\Sigma \geq 10$ might be difficult. (See discussion related to equation (140).)

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 92c with the combination of table 92a and table 92b.) Equation (140) pertains. Also, each G-family physics-relevant ΣGΓ solution for which $\Sigma \geq 10$ correlates with one of the words dipole, quadrupole, or octupole.

$$\Sigma - \Sigma' \geq 4 \tag{140}$$

Equation (141) follows from equation (109).

$$\alpha^2 < 5.33 \times 10^{-5} \tag{141}$$

Effects correlating with each G-family physics-relevant ΣGΓ solution for which $\Sigma \geq 10$ might 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.

Table 83: Possible relevance - regarding some interaction strengths - of the fine-structure constant (with the symbol O denoting the two-word term ongoing modeling; with the symbol P denoting the two-word term proposed modeling; with KMS denoting KMS modeling; with PFS denoting PFS 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 - KMS	QED calculations of anomalous magnetic dipole moments	Terms involving j virtual photons (See discussion related to equation (193).)	α^j
P - PFS	Relationship between the masses of quarks and the masses of charged leptons	(See equation (108).)	$(\alpha^{-1/4})^*$
P - PFS	Possible relationship between the strength of 2G2 and the strength of 2G24	(See discussion related to equation (136).)	α
P - PFS	Lepton number and (ongoing modeling) perceived masses for neutrinos	Ratio of strengths: 4G2468x to 8G2468x, with x equal to a or b (See discussion related to equation (142). See table 84. See discussion related to equation (138).)	1 to α^2
P - PFS	Possible generalization for $\Sigma \geq 4$, $2 \in \Gamma$, and $j > 0$	Ratio of strengths: $\Sigma G\Gamma$ to $(\Sigma + 2j)G\Gamma$ (See discussion related to equation (138).)	1 to α^j
P - PFS	Possible (speculative) aspects regarding the mass of the W boson.	(See discussion related to table 76 and discussion related to equation (136).)	?

4.3.10. Roles of the fine-structure constant

Table 83 notes some possibilities for relevance of the fine-structure constant regarding ratios of strengths of interactions.

4.3.11. Numbers of fermion generations

Unverified ongoing modeling 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.

Table 58 points to proposed modeling aspects that correlate with exactly three generations for elementary fermions. For modeling for elementary fermions, the $SU(2)$ symmetry that correlates with the SA5-and-SA6 oscillator pair correlates with three generators. For example, regarding table 45, the three (SA-side) generators correlate with three fermion generations. The matching TA5-and-TA6 $SU(2)$ symmetry correlates with rebuttable somewhat conservation of fermion generation.

4.3.12. Ongoing modeling estimates for the sum of neutrino masses

Equation (142) provides ongoing modeling limits for the sum, across three generations, of neutrino masses. (See reference [13]. Reference [15] provides the lowest of the upper limits that reference [13] lists.) The integer j correlates with generation. Equation (142) comes from interpretations of astrophysics data.

$$0.06\text{eV}/c^2 \lesssim \sum_{j=1}^{3} m_j \lesssim 0.12\text{eV}/c^2 \tag{142}$$

Independent of results of observations and of assumptions about modeling, equation (143) pertains.

$$3\alpha^2 m_\epsilon \approx 0.0816\text{eV}/c^2 \tag{143}$$

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 (142). 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 (142). The factor of three might correlate with the range $1 \leq j \leq 3$ in equation (142).

Table 84: 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 modeling) that at least one generation of neutrino has non-zero mass

Table 85: Aspects relevant to modeling regarding magnitudes of neutrino oscillations

Aspect
• The relationship between 8G2468x and 4G2468x that correlates with equation (139) is relevant. Here, x can be either one of a and b.
• A relationship between equations (124) (which involves 4G) and (138) (which involves 8G) is relevant.
• A notion that the factor α pertains twice is relevant. (See equation (136).) Each factor of α correlates with the unit $\hbar$ of spin.
• For electrons, the ratio of the strength of 8G2468x to the strength of 4G2468x is α^2.
• For each of the three neutrinos - the strength of 8G2468x equals the strength of 8G2468x for electrons.

4.3.13. Models that might estimate an ongoing modeling sum of neutrino masses

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

One possibility has bases in the notion that one can extrapolate, based on equation (108), 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 modeling notion that neutrino oscillations correlate with interactions that we correlate with the 4G subfamily. Table 48a correlates 4G with rebuttable somewhat conservation of fermion generation. Neutrino oscillations might correlate with virtual interactions with 4G or with multiple close-by interactions with 4G. (People might, therefore, correlate neutrino oscillations with notions of CP violation. See discussion related to table 42.) However, such interactions might not account for observed magnitudes of neutrino oscillations. (Also, ongoing modeling 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 (78).) Some refraction might correlate with ongoing modeling notions of classical physics interactions with gravity. As far as we know, people have yet to detect (gravitational lensing of neutrinos or) gravitational refraction of neutrinos. (See discussion related to table 86.) Proposed modeling 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, here, neutrinos model as being Dirac fermions and not as being Majorana fermions. (For Majorana fermions, ι_{3LB} would be zero. Perhaps, see table 29e.)

Table 84 points to notions that might underlie modeling regarding neutrino oscillations.

Table 85 lists aspects that we posit to have relevance. Here, we posit that - regarding the strength of 8G2468x interactions with neutrinos - the mass of the muon and the mass of the tauon are not relevant. (Perhaps, the notion of rest energy minus freeable energy pertains. Perhaps, that notion correlates with the notion that, for ΣG2468x, each of $4 \in \Gamma$ and $6 \in \Gamma$ pertains.)

We discuss possible implications regarding ongoing modeling.

Ongoing modeling astrophysics modeling does not include modeling that proposed modeling correlates with 6G and 8G. We posit one or two conceptual mapping steps. First, in the context of proposed modeling, modeling for 8G octupole components of force maps to modeling for octupole components of 4G forces. Perhaps that step suffices. In this context, ongoing modeling paralleling aspects of proposed modeling 4G2468a and 4G2468b interprets 8G effects on neutrinos as correlating with non-zero neutrino

Table 86: Aspects that might correlate with the extent to which neutrinos have non-zero masses

Aspect
• 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.

mass. The following (or, second) step pertains to the extent that relevant ongoing modeling does not correlate adequately well with proposed modeling non-monopole components of 4G. In the context of proposed modeling, modeling for 4G octupole components of force maps to modeling involving 4G4. In this context, ongoing modeling based on only proposed modeling 4G4 would interpret 8G effects on neutrinos as correlating with non-zero neutrino mass.

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

We consider our interpretation of aspects of ongoing modeling. We consider gravitational interactions between two electrons. Equation (144) describes results based just on the component that correlates with proposed modeling 4G4 effects. Equation (145) assumes that ϵ' correlates with one standard deviation regarding the mass of an electron. (Reference [13] provides the data that we use for these calculations.) The lepton number for an electron equals the lepton number for a matter neutrino. Equation (146) correlates with results based just on the component that correlates with proposed modeling 8G effects. (One exponent of two correlates with the exponent of two pertaining, in essence, to equation (143). One exponent of two correlates with the notion that the interaction involves two simple fermions.) The result that equation (146) shows is less than the result that equation (145) shows. In this context of ongoing modeling, the proposed modeling interaction, between two electrons, based on lepton number is not incompatible with measurements of electron masses.

$$G_N(m_\epsilon(1+\epsilon'))^2/r^2 \approx G_N(m_\epsilon)^2(1+2\epsilon')/r^2 \tag{144}$$

$$|\epsilon'| \approx 1.2 \times 10^{-8} \tag{145}$$

$$(\alpha^2)^2 \approx 2.8 \times 10^{-9} \tag{146}$$

Proposed modeling suggests that, for KMS 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.

We summarize proposed modeling suggestions about ongoing modeling 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.

4.3.14. Neutrino masses

Discussion related to table 84 suggests that proposed modeling 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 86 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 84 and to equation (143) suggests modeling that would be compatible with data and with elementary particle Standard Model ongoing modeling aspects that suggest that all neutrinos have zero rest masses.

We discuss aspects related to neutrino oscillations.

Ongoing modeling hypothesizes that gravity catalyzes neutrino oscillations. This hypothesis might correlate with a process of elimination. Ongoing modeling suggests that each known simple particle does not catalyze neutrino oscillations. Ongoing modeling suggests that photons do not catalyze neutrino oscillations. Ongoing modeling suggests that the strong interaction does not catalyze neutrino oscillations. The only ongoing modeling catalyst for neutrino oscillations might be gravity.

Proposed modeling suggests that 4G correlates with rebuttable somewhat conservation of fermion generation. Proposed modeling suggests that interactions mediated by 4G bosons might be insufficient to catalyze known amounts of neutrino oscillations. Proposed modeling suggests that 8G bosons catalyze observed neutrino oscillations. (See discussion related to table 84.)

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 [16] and [17].)

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

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

Table 62 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.

4.3.16. A possible lack of neutrino asymmetry

Reference [18] 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 modeling 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 modeling 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 modeling suggests that, via ongoing modeling virtual interactions, relevant neutrinos interact via 8G interactions with an ι_{3LB} that is negative essentially 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.)

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 modeling might provide, relative to ongoing modeling, new details or better-defined explanations.

Table 87 lists some topics for which proposed modeling seems to provide insight that augments insight that ongoing modeling suggests.

We discuss immediately below some, but not all, of the items that table 87 lists.

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

Table 87: Aspects of nature - that ongoing modeling discusses or suggests - for which proposed modeling seems to provide insight that augments insight that ongoing modeling 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 phenomena just before the inflationary epoch.
• Details regarding 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.

Ongoing modeling 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 modeling suggests an explanation that has bases in components of 4G forces. The explanation does not necessarily depend on ongoing modeling notions of dark energy negative pressure or on ongoing modeling models that have bases in general relativity. The proposed modeling explanation might be generally compatible with ongoing modeling models. The proposed modeling explanation points to some subtleties that ongoing modeling might miss.

Ongoing modeling 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 modeling suggests explanations for each of these ratios. (See discussion regarding table 95 and see, for example, table 106.) The explanations have bases in proposed modeling specifications for dark matter and in effects correlating with PFS modeling, with components of 4G forces, and with components of 2G forces. (See, for example, discussion related to tables 92, 93, 94, and 95.)

Ongoing modeling suggests that the early universe includes an inflationary epoch. Ongoing modeling proposes a role, during that epoch, for a so-called inflaton particle. Proposed modeling suggests that jay (or, 2J) bosons played key roles just before the inflationary epoch. One such role correlates with producing aye (or, 0I) bosons. Proposed modeling suggests that the aye simple particle correlates with the notion of an inflaton. Proposed modeling suggests that octupole components of 4G forces provided for rapid expansion.

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

Ongoing modeling provides hypotheses regarding possibilities for substantial objects that might be significantly smaller than galaxies and contain mostly dark matter. Proposed modeling 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 modeling 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 (147) and (148) show. The symbol $1Q \otimes 2U$ 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.

$$1Q \otimes 2U \tag{147}$$

$$1R \otimes 2U \tag{148}$$

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.

We correlate work above with the two-element term PR1ISP modeling.

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 explore the notion that some five-plus to one ratios reflect something fundamental in nature. We correlate some results from this exploration with PR6ISP modeling. (See table 21b.)

The symbol element PR denotes the one-element term physics-relevant. The symbol element ISP correlates with the four-word term isomers of simple particles. The notion of isomer correlates with one so-called SM6_ symmetry. (See table 21b.) Discussion related to table 98 and table 99 posits aspects that might correlate with differences between relevant isomers. (This proposed modeling notion of isomers does not necessarily correlate with ongoing modeling notions of isomers. This proposed modeling notion of isomers does not necessarily parallel the nuclear physics notion - same numbers of protons and neutrons, but different energy states - of isomer. This proposed modeling notion of isomers does not necessarily correlate with the chemistry notion - same numbers of various atoms, but different spatial arrangements - of molecular isomers.)

PFS modeling correlates interactions with charge with the 2G2 component of the 2G force. We posit that nature includes six isomers of charge. PFS 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 simple particles. One isomer of charge, nominal magnetic dipole moment, and related simple particles measures as ordinary matter. (The previous sentence also pertains regarding PR1ISP modeling.) We label that isomer as isomer zero. We posit that each of the other five isomers of charge, nominal magnetic dipole moment, and related simple particles measures as dark matter. (PR1ISP modeling does not include these five isomers.) We label those isomers as isomer one, isomer two, ..., and isomer five. We posit that each of the six isomers correlates with its own 2U particles (or, gluons). We posit that one isomer of 4G4 interacts with each one of the one ordinary matter isomer and five dark matter isomers.

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 isomer-zero 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.

Table 88 provides perspective regarding PR6ISP 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 [19].) People suggest that dark matter might include components that include quarks or that might experience Yukawa-like potentials. (See, for example, references [20] and [21].) People suggest that nature might include dark matter photons. (See, for example, reference [22].)

Regarding each one of the six PR6ISP isomers, we suggest that each combination - that table 79 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 98.) For example, for so-called isomer one, the generation three charged lepton may have the same mass as the ordinary matter electron. (See table 79.) The ordinary matter electron has a generation number of one.

Tables 21b and 27d discuss the symbol ι_I. Discussion just above pertains regarding PRι_IISP, with ι_I being one or six. Within any one PRι_IISP, equation (149) pertains for each simple particle, for each component of G-family force, for each U-family particle, and for each hadron-like particle. For example, for PR6ISP modeling, for the electron, the number of isomers is six and the span of each isomer is one.

Table 88: Perspective regarding PR6ISP modeling

PR6ISP 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. (PR36ISP modeling offers a different explanation for the one known ratio of one to one. See discussion regarding equation (149) and discussion regarding equation (172).)
• Correlates with an $SU(2) \times U(1)$ symmetry to which table 20 alludes. (See, for example, table 58c.)
• Echoes the notion that PFS modeling intertwines 2G-related aspects and 4G-related aspects in ways that ongoing modeling does not. (See, for example, equation (108).)
• Echoes the exponent of six that equation (130) discusses.
• Echoes the six ranges that equation (152) and table 98 feature.
• Correlates with information that table 58 shows.
• Seems to correlate with aspects of unverified ongoing modeling.

For PR6ISP modeling, for the 4G4 component of 4G, the number of isomers is one and the span of each isomer is six.

$$\text{(number of isomers)} \times \text{(span of one isomer)} = \iota_I \tag{149}$$

PR6ISP modeling suggests that 2G248 has a span of six isomers of simple particles.

PR6ISP modeling assumes that the span of six for 2G248 embraces the same six isomers as does the span of six for 4G4.

We explore the notion that nature might include 36 isomers. (See table 21b.)

PR36ISP 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 simple particles. We use the two-element term doubly-dark matter to correlate with the 30 isomers of simple particles that do not interact with the ordinary matter isomer 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 simple particles interact with the ordinary matter isomer via 2G248.

From the perspective of each one of the 36 isomers of simple particles, the following statements pertain. The isomer correlates with its own isomers of 2G2, 2G24, 4G246, 4G2468a, and 4G2468b. The isomer interacts via 2G248 with five other isomers. The isomer interacts via 4G4 with five other isomers. 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 PR6ISP modeling, PR36ISP modeling correlates with an additional six-generator symmetry. (See table 21b.)

We preview features of each of PR1ISP, PR6ISP, and PR36ISP modeling.

Table 89 discusses cumulative features of various types of modeling. Generally, each row augments the rows above that row. Regarding ongoing modeling, the symbol NR denotes the concept that the notion of isomers is not relevant. We think that PR6ISP 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, PR36ISP offers an alternative (to PR6ISP) explanation of dark energy density. (See discussion related to equation (172).) Otherwise, regarding bases for aspects that table 89 lists, PR36ISP is similar to PR6ISP. Discussion related to equation (172) suggests that PR6ISP modeling might suffice to explain known phenomena and that it might not be necessary to consider PR36ISP modeling. From a standpoint of observations, distinguishing between the case of PR6ISP and the case of PR36ISP might prove difficult.

Table 90 shows relationships regarding PR1ISP, PR6ISP, PR36ISP, and G-family forces.

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

We consider PR6ISP modeling.

We discuss spans for components of G-family root forces.

We start from the span of six that we posit for 4G4. (See discussion regarding equation (149).) We consider TA-side symmetries for G-family solutions. (See table 62.) We aim to develop numbers that belong in the table 62 column that has the label span (for $\iota_I \geq 6$). The number of generators of each

Table 89: Cumulative features of various types of modeling

(a) Featured modeling

Modeling	ι_I	New descriptions and new explanations	New subtleties
Ongoing modeling	NR	• (Baseline)	-
PR1ISP	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
PR6ISP	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
PR36ISP	36	-	• Ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter

Table 90: Relationships regarding PR1ISP, PR6ISP, PR36ISP, and G-family forces

Aspects
• Absent the notion that some components of G-family forces have spans of more than one, PR6ISP would correlate with six non-interacting sub-universes. • In PR6ISP models, each sub-universe consists of an isomer of PR1ISP. The six isomers of PR1ISP might differ by as little as differing matches between generation of charged lepton and mass of charged lepton. (See discussion related to table 98.) • In PR6ISP models, the main interactions between PR1ISP-like isomers correlate with the monopole component (or, 4G4) of gravity (or, 4G). Some other interactions between PR1ISP-like isomers correlate with a dipole (or, 4G48) component of gravity (or, 4G). Some other interactions between PR1ISP-like isomers correlate with dipole and quadrupole components of electromagnetism (or, 2G). • Absent the notion that some components of G-family forces have spans of more than one, PR36ISP would correlate with 36 non-interacting sub-sub-universes. • In PR36ISP models, each sub-sub-universe would consist of an isomer of PR1ISP. • In PR36ISP models, six sub-universes pertain. Each sub-universe consists of a somewhat isomer of PR6ISP. Within each somewhat isomer of PR6ISP, the six PR1ISP-like isomers do not interact with each other via electromagnetism (or, 2G). • In PR36ISP models, the main interactions between somewhat-PR6ISP-like isomers correlate with dipole and quadrupole components of electromagnetism (or, 2G). No interactions between somewhat-PR6ISP-like isomers correlate with gravity (or, 4G). Within each somewhat-PR6ISP-like isomer, the main interactions between PR1ISP-like isomers correlate with the monopole component (or, 4G4) of gravity (or, 4G). Within each somewhat-PR6ISP-like isomer, some other interactions between PR1ISP-like isomers correlate with a dipole (or, 4G48) component of gravity (or, 4G). (Per the previous item in this table, within each somewhat-PR6ISP-like isomer, no interactions between PR1ISP-like isomers correlate with electromagnetism.) • In PR6ISP models and PR36ISP models, within each PR1ISP-like isomer, interactions correlating with gravity (or, 4G) occur and interactions correlating with electromagnetism (or, 2G) occur.

Table 91: Aspects correlating with our positing that the span for each elementary particle - other than the G-family elementary particles - is one

Aspect
• No family - other than the G-family - of elementary particles correlates with the notion of components. Possibly, for those families, no analog to equation (150) pertains.   • The spans for charged elementary particles are one. There may be no relevant symmetries that would suggest that spans for other elementary particles should be anything but one.   • The G-family of elementary particles is the only family for which $n_{TA0} = 0$ and $n_{TA0} = -1$.   • There are no apparently relevant differences in symmetries between 1C and 1N. Each isomer correlates with its own 1N. Similar notions - of spans of one for some particles implying that other particles have spans of one pertain. Regarding such notions, the following ordered pairings pertain - 1Q and 1R, W and Z, 2W and 2T, 2W and 2J, and 0H and 0I.   • We posit a span of one for 2U. (Possibly, 2W and 2U is another ordered pairing. Possibly, in some sense, a span of one for 1Q implies a span of one for 2U.)   • We posit that a span of one pertains for 0P. (2U and 0P would be another ordered pairing.)

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 (46).) We generalize. We assert that, for each G-family solution for which a TA-side symmetry of $SU(j)$ pertains, equation (150) 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.

$$g_7/g_j \qquad (150)$$

Table 91 discusses aspects correlating with our positing that the span for each elementary particle - other than the G-family elementary particles - is one.

The span for 1Q⊗2U is one, based on the non-zero charges of 1Q particles. We assume that the span for 1R⊗2U is one.

Equation (151) shows notation for denoting the span, s, for a simple particle or for a component of a root force.

$$\Sigma(s)\Phi \quad \text{or} \quad \Sigma(s)\Phi\Gamma \qquad (151)$$

Table 92 shows the span for each component of G-family forces. The table pertains for each of PR6ISP modeling and PR36ISP modeling. Rows in table 92a list all $\Sigma\gamma$ components. Table 92a lists 2(6)G248 and does not list 2(1)G248. Rows in table 92b list $\Sigma \le 8$ G-family force components that do not correlate with $\Sigma\gamma$. Table 92c lists some solutions that might - but do not necessarily - correlate with G-family force components. (See discussion related to equation (135).) For $\Sigma_{max} = 8$, table 92c is not physics-relevant. For $\Sigma_{max} = 20$, table 92c pertains regarding G-family forces.

We consider all three of PR1ISP modeling, PR6ISP modeling, and PR36ISP modeling.

Table 93 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 modeling view, elementary particle Standard Model aspects from aspects that the elementary particle Standard Model does not embrace. The symbol 1Q⊗2U correlates with known and possible hadrons. The symbol 1R⊗2U correlates with possible hadron-like particles. Regarding the PR36ISP 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 PR36ISP 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 93a does not include G-family components that do not correlate with $\Sigma\gamma$ solutions. Regarding the PR6ISP case, the span for 2G68 is two. (See table 93b.) Regarding the PR36ISP case, the span for 2G68 is two and the notion of ‖2G pertains. Regarding the PR6ISP 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 93 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 rebuttable somewhat conservation of fermion generation pertains for 1f+1b→1f+1b interaction vertices. (Regarding the notation 1f+1b→1f+1b, see

Table 92: 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

discussion regarding table 115.) The symbol †† denotes that rebuttable always conservation of fermion generation pertains for 1f+1b→1f+1b interaction vertices. The word No denotes that interactions do not occur. Proposed modeling suggests the possibility that neither the 0H boson nor the 0I boson interacts directly with multicomponent objects. Proposed modeling 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 59 and discussion related to table 62.) Tables 93c and 93d summarize some concepts relevant to tables 93a and 93b.

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

Table 94 summarizes aspects regarding information - centric to isomers - that proposed modeling fields carry. (Table 94 illustrates concepts that table 63 discusses.) In ongoing modeling, 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 59.) Table 94 discusses additional information (compared to information that ongoing modeling fields carry) that proposed modeling 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 $\gamma 2$ solutions. The 2(2)G68 solution does not correlate with interactions with individual simple fermions. Table 84 correlates $\lambda = 8$ with leptons and baryons. Each of table 66b and discussion related to table 25 correlates $\lambda = 8$ with rotation or spin. Table 58 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 PR6ISP pertains to nature) or doubly dark matter objects (for the case in which PR36ISP 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 PR6ISP pertains to nature) or by some doubly dark matter objects (for the case in which PR36ISP pertains to nature) interacts with ordinary matter via 2(2)G68.

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

We discuss ratios that PR6ISP modeling or PR36ISP modeling might predict or explain.

Table 95 lists some approximate ratios of dark matter effects to ordinary matter effects that PR6ISP modeling might explain. We designed PR6ISP 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 (and other, except for G-family) elementary particles and the plus correlates with (ordinary matter isomer) hadron-like particles that do not interact with 2γ force components. Galaxy clusters seem to be sufficiently large to comport with similar ratios. (However, galaxy clusters that are remnants of collisions of galaxy clusters might be exceptions. See discussion related to table 104.) Discussion just above regarding 2(2)G68 correlates with the approximately one to one ratio. (See, also, discussion related to equation (162).) 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 106.) 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 106.) Regarding the last row in table 95, see AX in table 106a and B0, B3, and BY in table 106b and note that only one of table 106a and table 106b pertains to nature.

5.2.4. Some properties of isomers of quarks and charged leptons

We consider PR6ISP modeling and PR36ISP modeling.

Table 96 lists aspects that seem to correlate with each other regarding the one isomer that correlates with ordinary matter and the five isomers that correlate with dark matter. (See discussion - in table 20c - regarding SM6a. See discussion related to equation (108). See discussion related to table 98.)

We explore modeling that correlates each of the six relevant isomers with a range of M''. In equation (152), the integer n numbers the isomers. Here, the ordinary matter isomer correlates with $n = 0$.

Table 93: 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; with the symbol † denoting that rebuttable somewhat conservation of fermion generation pertains; and with the symbol †† denoting that rebuttable always 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	PR1ISP span	PR6ISP span	PR36ISP span	1b interact w/ 1f	1b interact w/ MCO
0H	0I	1	1	1	Yes††	No
-	0P	1	1	1	No	Yes
1C	-	1	1	1	-	-
1N	-	1	1	1	-	-
1Q	1R	1	1	1	-	-
2U	-	1	1	1	Yes††	No
2W	2T	1	1	1	Yes†	No
-	2J	1	1	1	Yes†	Yes
1Q⊗2U	1R⊗2U	1	1	1	-	-
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)	Yes†	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	PR1ISP span	PR6ISP span	PR36ISP span	1b interact w/ 1f	1b interact w/ MCO
-	2G68	1	2(:2G)	2 (‖2G)	No	Yes

(c) Notes regarding the case PR6ISP

Note
• For one of $4G\Gamma_4$ with a span of two and $2G\Gamma_2$ 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 ($4G\Gamma_4$ and $2G\Gamma_2$), different pairings might pertain. (Note the notation :4G and :2G.)

(d) Notes regarding the case PR36ISP

Note
• For each $\Sigma\Phi$ with $\Phi \neq G$ and with a PR6ISP span of six or two, we assume that ‖2G pertains.
• For each $4G\Gamma$ with a PR6ISP span of six or two, we assume that ‖4G pertains.

Table 94: Aspects regarding information - centric to isomers - that proposed modeling fields carry

Aspect
● Compared to ongoing modeling models regarding fields, proposed modeling adds - to the set of information that an excitation carries - information about the isomer or isomers correlating with the excitation.
● For PR1ISP 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 modeling) information.
● For PR6ISP 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 93.)
● For PR36ISP 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 93.)
● For each of PR1ISP modeling, PR6ISP modeling, and PR36ISP modeling, the excitation does not necessarily carry information about the simple particles or force components that participated in creating the excitation.
● For each of PR1ISP modeling, PR6ISP modeling, and PR36ISP 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.

Table 95: 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 modeling also suggests an explanation - correlating with PR36ISP 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 96: Aspects that seem to correlate with each other regarding the one isomer that correlates with ordinary matter and the five isomers that correlate with dark matter

Aspect
● The exponent of six in equation (130) correlates with the notion of six isomers, one of which correlates with ordinary matter and five of which correlate with dark matter.
● The number, six, of isomers correlates with the number, six, of generators of the SM6a $SU(2) \times U(1)$ symmetry.
● The SM6a symmetry breaks - across the six isomers - based on aspects that correlate with relationships between - for charged leptons - mass and generation.

Table 97: 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

Table 98: Relationships between quark generation and lepton aspects

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

$$\text{isomer } n \;\leftrightarrow\; 3n \le M'' \le 3n + 3, \text{ for } 0 \le n \le 5 \tag{152}$$

Table 97 shows interpretations regarding modeling for the six isomers. (Compare with table 79.) Here, for $n \ge 1$, 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 79 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 (108) might help estimate ongoing modeling 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 98 shows, for each value of n, relationships between quark generation and lepton aspects. Table 98 extends table 97 and includes quarks. For each n, the order for quarks is generation one, generation two, and then generation three.

Table 98 has roots in models that correlate with the relative strengths of 2G2 and 4G4. We posit that aspects regarding mass correlate with the column with label M''. We posit that, 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. This essay de-emphasizes the possibility that the masses of dark matter quarks correlate with changes of signs regarding the various $d'(\_)$. (See equations (114), (115), and (116).) We assume that, for each of the six ranges that equation (152) specifies, the masses of the relevant quarks match the masses that table 79 would show if the masses in table 79 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 $|q_\epsilon|/3$.

Work above might be appropriate for proposed modeling to be compatible with observations regarding the Bullet Cluster. (See discussion related to table 104.)

Table 99 summarizes two possible cases.

Table 99: Two possible cases regarding the evolution of the five dark matter isomers and the one ordinary matter isomer

Case	Aspect
Case S	Isomer three evolves similarly to isomer zero. Isomer four evolves similarly to isomer one. Isomer five evolves similarly to isomer two. Isomers one, two, four, and five do not evolve similarly to isomer zero.
Case D	Each of the six isomers evolves differently from the other five isomers.

We correlate the two-word term case S with work above.

We do not know of data that correlates with the actual fractions of dark matter that pass through the collision with just gravitational interactions having significance. (See table 104.) Case S can comport with fractions that are less than or that somewhat exceed four-fifths (or, percentages that are less than or that somewhat exceed 80 percent).

Observations of more than 80-plus percent might correlate with geometric aspects such as the sizes and trajectories of the two galaxy clusters.

We explore the possibility that observations correlate with percentages that are too big for the combination of geometric aspects and case S to explain.

For percentages that are significantly above 80-plus percent, modeling might need to correlate with a significant difference in evolution between isomer three and isomer zero.

Proposed modeling allows for aspects that might comport with a significant difference in evolution between isomer three and isomer zero.

We correlate the two-word term case D with work below. (See table 99.)

One possibility correlates with at least one of the dominant charge or dominant handedness or dominant sign of 3LB for charged leptons. This possibility might correlate with a difference between even n and odd n. (See table 98.) Aspects of this possibility might correlate with relationships between the 3CH-centric $\pi_{@_0, @_{-1}}$ that correlates with oscillators SA1-and-SA2 and the 3LB-centric $\pi_{@_0, @_{-1}}$ that correlates with oscillators SA7-and-SA8. (See table 45.) For example, the following sentences might pertain. For even n, $@_0$, $@_{-1}$, $@_0$, and $@_{-1}$ pertain respectively for SA1, SA2, SA7, and SA8. For odd n, $@_0$, $@_{-1}$, $@_{-1}$, and $@_0$ pertain respectively for SA1, SA2, SA7, and SA8.

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 case S. (See discussion related to table 98 and see table 99.)

We compare isomer one and isomer zero. (See discussion related to table 98.) 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 density and temperature suffice to catalyze tweak-based interactions that do not conserve fermion generation. Regarding generation one quarks, more transitions to higher generations of leptons occur for isomer one than for isomer zero. (For isomer one, the higher generations of leptons are less massive than the generation one lepton. Also, the isomer one generation one charged lepton is more massive than the isomer zero generation one charged lepton.) Regarding generation two and generation three quarks, fewer transitions - per unit time - to lower generations of leptons 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.

Table 100: Ordinary matter, four cool dark matter isomers, and the one other dark matter isomer (with results correlating with case S, as per table 99)

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 101: Ordinary matter and five cool dark matter isomers (with results possibly correlating with case D, as per table 99)

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

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 modeling uses of the three-word term cold dark matter.)

Table (100) pertains regarding case S. (See table 99.)

We anticipate that notions that table 100 summarizes might explain aspects of the Bullet Cluster and aspects regarding galaxy dark matter halos. (Regarding the Bullet Cluster, see discussion related to table 104. Regarding dark matter halos, see, for example, discussion related to table 106.)

Table (101) might pertain regarding case D. (See table 99.) The form of cool dark matter correlating with isomer three might differ considerably from the forms of cool dark matter correlating with isomers one and four and with isomers two and five.

To the extent that notions that table 100 summarizes do not explain aspects of the Bullet Cluster and aspects regarding galaxy dark matter halos, notions that table 101 summarizes might explain aspects of the Bullet Cluster and aspects regarding galaxy dark matter halos.

Work elsewhere in this essay assumes that case S pertains and that one can de-emphasize case D. (See, for example, discussion related to table 104 and discussion related to table 106.) We think that, an ability for case S to comport with observations - for at least other than the Bullet Cluster and possibly for the Bullet Cluster - might suffice for proposed modeling to de-emphasize case D.

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 93a.) This description correlates with PR6ISP modeling.

PR6ISP 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. Each of the six isomers correlates with its own isomer of 1R⊗2U hadron-like particles. The 1R⊗2U hadron-like particles correlating with each - including the ordinary matter isomer - of the six isomers measure as being dark matter. Otherwise, from the perspective of observations that people make, one isomer (of non-G-family elementary particles) measures as being ordinary matter and the other five isomers (of non-G-family elementary particles) 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. (See table 100.)

5.3.2. Densities of the universe

Ongoing modeling 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 (153) pertains regarding the total density of the universe, Ω.

$$\Omega = \Omega_\nu + \Omega_c + \Omega_b + \Omega_\gamma + \Omega_\Lambda \tag{153}$$

In ongoing modeling, the symbol Ω_c correlates with all dark matter. To the extent that proposed modeling PR6ISP modeling or PR36ISP 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 modeling correlates with the term dark matter.

Proposed modeling suggests equation (154). The symbol $\Omega_{1R2U,0}$ denotes the density of the universe that correlates with 1R⊗2U that correlates with the ordinary matter isomer (or, isomer zero). The symbol $\Omega_{b,>0}$ denotes the baryonic density of the universe that correlates with the five dark matter isomers (or, isomers one through five). The symbol $\Omega_{\gamma,>0}$ denotes the photon density of the universe that correlates with the five dark matter isomers (or, isomers one through five). The symbol $\Omega_{\nu,>0}$ denotes the neutrino density of the universe that correlates with the five dark matter isomers (or, isomers one through five).

$$\Omega_c = \Omega_{1R2U,0} + \Omega_{b,>0} + \Omega_{\gamma,>0} + \Omega_{\nu,>0} \tag{154}$$

We interpret data regarding recent states of (ordinary matter) CMB (or, cosmic microwave background radiation) as correlating with equation (155). The symbol $\Omega_{1R2U,0}$ correlates with the plus in the ratio five-plus to one. The relationships $\Omega_b \gg \Omega_\gamma$ and $\Omega_b \gg \Omega_\nu$ pertain regarding data. (Reference [13] provides data regarding $\Omega_b \gg \Omega_\gamma$ and $\Omega_b \gg \Omega_\nu$.) Each of isomers one, two, ..., and six has its own 1R⊗2U, Equation (156) pertains.

$$\Omega_{b,>0} \approx \Omega_{b,>0} + \Omega_{\gamma,>0} + \Omega_{\nu,>0} \approx 5(\Omega_b + \Omega_\gamma + \Omega_\nu) \approx 5\Omega_b \tag{155}$$

$$\Omega_{1R2U,0} \approx (\Omega_c - 5\Omega_b)/6 \tag{156}$$

Equation (160) estimates $\Omega_{1R2U,0}$ for the current state of the universe. (Reference [13] provides the data that equations (157), (158), and (159) show.)

$$\Omega_b \approx 0.0484 \pm 0.001 \tag{157}$$

$$\Omega_c \approx 0.258 \pm 0.011 \tag{158}$$

$$\Omega_\gamma \approx 0.0000538 \pm 0.0000150 \tag{159}$$

$$\Omega_{1R2U,0} \approx 0.0027 \tag{160}$$

Reasons exist for not taking results - that equation (160) shows - to be exact. For example, we note the size of the standard deviation in equation (158).

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 89 and includes equation (150).) A ratio of five-plus to one seems to pertain for billions of years. (See discussion related to equation (155) and discussion related to equation (161).) We use that ratio to posit the six-isomer basis for PR6ISP modeling.

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

We discuss modeling 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⊗2U hadron-like particles. (See, for example, discussion regarding equations (206) and (207).) For each of the six isomers, the relative densities of the universe of 1R⊗2U hadron-like particles and ordinary matter 1Q⊗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 (206) and (207).) Regarding PR6ISP modeling and PR36ISP modeling, proposed modeling does not necessarily include interactions that would convert ordinary matter 1Q⊗2U to dark matter 1Q⊗2U or interactions that would convert dark matter 1Q⊗2U to ordinary matter 1Q⊗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 [23] 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 (161) pertains. (Perhaps, see equations (157) and (159).) That time range starts somewhat after 380,000 years after the Big Bang and continues through now.

$$\Omega_\gamma \ll \Omega_b \text{ and } \Omega_\nu \ll \Omega_b \tag{161}$$

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 [24].) 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 [25].)

Proposed modeling suggests the following explanation. Solution 2(2)G68 has a span of two. 2(2)G68 interactions are 2(2)GΓ interactions. Equation (162) pertains. Solution 2(2)G68 does not correlate with interactions with individual simple fermions. (The TA-side symmetry is $SU(5)$. See table 62 and table 93b.) 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 PR6ISP modeling. The doubly dark matter case correlates with PR36ISP modeling.

$$2G68 \notin 2\gamma, \ 2G68 \notin \gamma2 \tag{162}$$

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 modeling 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 [26].)

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

Table 102: Eras and components of 4G forces, regarding expansion of the universe

Era	A/R	RSDF	Components of 4γ	Other components of 4G	Span (PR6ISP or PR36ISP)
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

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 102 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. Acceleration pertains for the most recent some billions of years. (Regarding observations that correlate with the eras that correlate with deceleration and recent acceleration, see references [27], [28], [29], and [30].) 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 119 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 102, 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 65. Proposed modeling suggests that, for the purposes of this discussion, neither 4(1)G268 nor 4(2)G26 correlates with significant effects.) Proposed modeling suggests (but does not necessarily require) that, for the components of 4γ that table 102 lists, the two-word term net repulsive correlates with a notion of essentially always repulsive (though perhaps sometimes not significantly repulsive). Proposed modeling suggests (but does not necessarily require) that, for the components of 4γ that table 102 lists, the two-word term net attractive correlates with a notion of essentially always attractive (though perhaps sometimes not significantly attractive).

Proposed modeling suggests that the ongoing modeling 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 - including the creation of isomers - before through just after inflation

Ongoing modeling suggests that an inflationary epoch might have occurred. Ongoing modeling suggests that the epoch started around 10^{-36} seconds after the Big Bang. (This essay de-emphasizes discussing aspects that might correlate with a time that people correlate with the two-word term Big Bang.) Ongoing modeling 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 modeling 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 modeling. (Reference [31] summarizes aspects related to inflation, points to references regarding ongoing modeling, and discusses some ongoing modeling work.)

Table 103: Some possible reactions involving pairs of jay bosons

Incoming particles	Effective refraction (n_{SA0})	Outgoing particles
$2J_\pm + 2J_\pm$	0^-	4G+0I, 2G+0I, 0I+0I
$2J_\pm + 2J_\mp$	0^-	2G+0I, 0I+0I
$2J_0 + 2J_0$	0^-	4G+0I, 2G+0I, 0I+0I
$2J_\pm + 2J_\pm$	$(-1)^+$	4G+0I
$2J_\pm + 2J_\mp$	$(-1)^+$	0I+0I
$2J_0 + 2J_0$	$(-1)^+$	4G+0I, 0I+0I

Reference [32] 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.

We anticipate discussing phenomena that might correlate with times during and just after the inflationary epoch.

We speculate about phenomena that might have occurred before the inflationary epoch.

Table 103 shows some possible reactions involving pairs of jay bosons. The leftmost column describes the pair of incoming jay bosons. The middle column describes two possibilities regarding modeling. (See discussion related to table 68.) For one possibility, an effective n_{SA0} correlates with 0^-. For the other possibility, an effective n_{SA0} correlates with $(-1)^+$. The rightmost column shows possibilities for pairs of outgoing particles. (Table 103 correlates with the case n=2 in table 115.) For $n_{SA0} \lessgtr 0$, each of the three jay bosons might exhibit aspects of longitudinal polarization. Each of the $2J_+$ and $2J_-$ would exhibit two states. The $2J_0$ would exhibit three states. For $n_{SA0} \gtrless -1$, each of the three jay bosons would not exhibit aspects of longitudinal polarization. Each of the $2J_+$ and $2J_-$ would exhibit one state. The $2J_0$ would exhibit two states. We discuss, as an example, the case of incoming $2J_\pm + 2J_\mp$. For $n_{SA0} \gtrless -1$, the incoming particles correlate with units of spin that have opposite circular polarizations. In effect, the circular polarizations sum to zero circular polarization. The outgoing pair 0I+0I is appropriate. For $n_{SA0} \lessgtr 0$, one of the incoming particles might have a unit of circular polarization and the other incoming particle might not have circular polarization. Producing 2G+0I is possible.

We explore the notion that, just before the inflationary epoch, the main component of the universe might have consisted of jay bosons. (One might speculatively correlate the notion of a universe composed essentially only of jay bosons with seemingly unique aspects of modeling regarding the 0G∅ solution.)

Proposed modeling correlates (absence effects that would correlate with notions of refraction) the expression $n_{SA0} = -1$ with jay bosons. Ongoing modeling seems to suggest that nature creates photons (or, 2G) primarily after the inflationary epoch. Regarding time just before inflation, we assume that the lower half of table 103 pertains and that the upper half of table 103 does not pertain.

We assume that the particle density is sufficiently large that modeling can correlate the production of 4G with the 4G2468x components of 4G. (Regarding the symbol 4G2468x, see table 82.)

Equation (163) describes a possible interaction. The span for each of $2J_-$, 4G2468x and 0I is one. For PR6ISP models, the one six-fold (or, $SU(2) \times U(1)$) relevant symmetry could correlate with equal creation of six isomers for each of $2J_-$, 4G2468x, and 0I. (See tables 21 and 58.) For PR36ISP models, the two six-fold (or, $SU(2) \times U(1)$) relevant symmetries might correlate with equal creation of 36 isomers for each of $2J_-$, 4G2468x, and 0I.

$$2(1)J_- + 2(1)J_- \rightarrow 4(1)G2468x + 0(1)I \tag{163}$$

We turn our attention to the inflationary epoch.

Proposed modeling 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 modeling notions of a boson with zero spin. (See reference [31].) Ongoing modeling uses the word inflaton to name that boson. Proposed modeling suggests the possibility that the octupole components of 4γ provided the repulsive aspect of gravity. (See, for example, table 119.) Those components interact with individual simple particles and are repulsive. Equation (164) shows such an interaction. Here, x and y might be either of a and b.

$$0(1)I + 4(1)G2468x \rightarrow 0(1)I + 4(1)G2468y \tag{164}$$

Equation (165) shows a phenomenon, which might pertain to the extent that aye and jay bosons co-existed in a dense environment.

$$2(1)\mathrm{J}_0 + 2(1)\mathrm{J}_0 + 0(1)\mathrm{I} \to 2(1)\mathrm{J}_0 + 2(1)\mathrm{J}_0 + 8(1)\mathrm{G}2468\mathrm{x} \qquad (165)$$
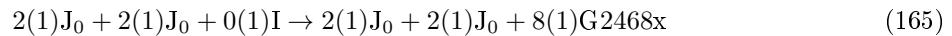
The end of the inflationary epoch might correlate with a change, regarding effects of 4G, from octupole repulsion being dominant to quadrupole attraction being dominant. (This essay does not speculate regarding the extent to which jay bosons continued to have significant effects - except, for example, effects that ongoing modeling correlates with the Pauli exclusion principle - after the inflationary epoch. Possibly, the density of stuff - other than jay bosons - decreased enough that - in a sense of ongoing modeling - essentially no non-virtual jay bosons existed.) 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.

We turn our attention to just after the inflationary epoch.

References [32] and [31] suggest that inflaton particles dominated (what proposed modeling might 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 modeling 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 (166).) Each of proposed modeling and ongoing modeling includes interactions by which 2G components produce matter-and-antimatter pairs of simple fermions. Interactions between elementary particles would produce simple bosons that are not ayes or jays. (This essay does not speculate regarding the extent to which aye bosons continued to have significant effects much after the inflationary epoch. Possibly, the density of stuff - other than aye bosons - decreased enough that - in a sense of ongoing modeling - essentially no non-virtual aye bosons existed.) From there, the above-mentioned cascade could occur. Proposed modeling suggests the possibility that attraction based on the quadrupole component of 4γ contributed to clumping.

$$0\mathrm{I} + 0\mathrm{I} \to 2\mathrm{G} + 2\mathrm{G} \qquad (166)$$

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.

We discuss isomers and spans.

Our work considers three $\mathrm{PR}\iota_I \mathrm{ISP}$ cases - ι_I is one, ι_I is six, and ι_I is 36. Table 93 suggests that the span for each of the 2J bosons, 0I boson, quadrupole component of 4γ, and the two octupole components of 4γ is one.

We explore the case for which ι_I is six.

As soon as 4G excites - for example, via the interaction that equation (163) symbolizes - isomers can couple to each other. We consider an excitement of 4G that - for discussion purposes - we correlate with equation (163). The excitement can interact with any one of the six isomers of 2J. The excitement can interact with any one of the six isomers of 0I. Such (in effect, monopole and also - via 4(2)G48 - dipole) coupling has impact, even though - from a standpoint of kinematics or dynamics - octupole components play dominant roles.

Similar notions pertain regarding 2G. Most notably, some components - such as 2(2)68 and 2(6)248 - correlate with interactions between isomers.

We explore the case for which ι_I is 36.

Concepts similar to concepts pertaining for the case for which ι_I is six pertain. However, for any one isomer of a span-one elementary particle (such as a 2J boson), the span of six correlating with 4(6)G4 is, in effect, orthogonal to the span of six correlating with 2(6)248.
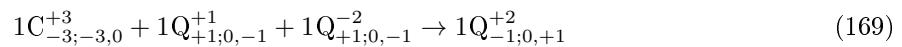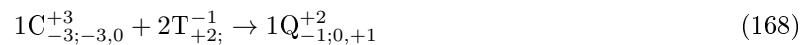
5.3.8. Baryon asymmetry

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 modeling consider that early in the universe baryon symmetry pertained. Unverified ongoing modeling 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 [18].)

Proposed modeling suggests scenarios that might have led to baryon asymmetry.

In one scenario, the interactions that equations (167) and (168) show pertain. This scenario converts three antimatter fermions into one matter fermion. Equation (169) shows an overall result. (Regarding equation (167) 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 (168) 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 (167) and (168) show dominated compared to similar reactions that involve antiparticles to the particles that equations (167) and (168) show. Domination might correlate with an occurrence of more $2\mathrm{T}^{-1}_{+2;}$ lasing than $2\mathrm{T}^{+1}_{-2;}$ lasing.

$$1\mathrm{Q}^{+1}_{+1;0,-1} + 1\mathrm{Q}^{-2}_{+1;0,-1} \rightarrow 2\mathrm{T}^{-1}_{+2;} \tag{167}$$

$$1\mathrm{C}^{+3}_{-3;-3,0} + 2\mathrm{T}^{-1}_{+2;} \rightarrow 1\mathrm{Q}^{+2}_{-1;0,+1} \tag{168}$$

$$1\mathrm{C}^{+3}_{-3;-3,0} + 1\mathrm{Q}^{+1}_{+1;0,-1} + 1\mathrm{Q}^{-2}_{+1;0,-1} \rightarrow 1\mathrm{Q}^{+2}_{-1;0,+1} \tag{169}$$

A threshold energy might be in or above the range of 208 GeV to 213 GeV. (See equation (99).) A corresponding temperature is about 2×10^{15} degrees Kelvin. As far as we know, this result - regarding temperature or (equivalently) regarding time after the Big Bang - is not inconsistent with core ongoing modeling.

We note two possible causes for an occurrence of more $2\mathrm{T}^{-1}_{+2;}$ lasing than $2\mathrm{T}^{+1}_{-2;}$ lasing. Possibly, the imbalance occurred, in effect, statistically at the time that baryon asymmetry first appeared. Possibly, earlier, an imbalance regarding production of left circularly polarized 8G2468 and right circularly polarized 8G2468 occurred - perhaps statistically. (Note equation (165).) To the extent that effects correlating with such residual 8G2468 remained long enough, some differences in energy distributions between some types of matter fermions and the corresponding types of antimatter fermions might have occurred. Those differences might have driven the asymmetry in tweak lasing.

We explore a concept that involves isomers.

Table 98 suggests possibilities for taking a multiple-isomer view of baryon asymmetry. We consider PR6ISP modeling. In this view, the lepton range $9 \leq M'' \leq 12$ and quark range $9 \leq M'' \leq 11$ might provide for an antimatter-centric 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 PR36ISP modeling. This essay does not further explore details regarding or implications of this concept.

5.3.9. Filaments and baryon acoustic oscillations

Proposed modeling is compatible with the ongoing modeling notion that ordinary matter baryon acoustic oscillations contributed to the formation of filaments.

Regarding models for which ι_I (as in PRι_IISP) exceeds one, each of the five dark matter isomers has its own baryon-like particles and its own 2(1)G physics. Proposed modeling suggests, for models for which ι_I exceeds one, that dark matter baryon-like acoustic oscillations occurred in the early universe. Proposed modeling suggests that dark matter baryon-like acoustic oscillations contributed (along with ordinary matter baryon acoustic oscillations) to the formation of filaments.

5.3.10. Amounts of clumping for large clumps of ordinary matter gas and of dark matter

Reference [33] discusses observations that point to the notion that clumping of matter - ordinary matter gas and dark matter - might be less than ongoing modeling models suggest. The article alludes to a dozen observational studies and points to three papers - reference [34], reference [35], and communication 124a. For example, the last one of the three references studies distortions regarding images of galaxies.

The work studies amounts of clumping of - for example - dark matter along the path that the observed light took. Clumps would be - to use wording from reference [33] - too thin. (Reference [33] suggests a result of too thin by about ten percent. This essay does not explore the topic of quantifying such thinness.) A distribution of galaxies would be - to use wording from reference [36] - too smooth. The reference suggests a notion of ten percent more evenly spread than ongoing modeling predicts.

Proposed modeling suggests that such effects might correlate with the notion that $4(2)G48$ repels more stuff than would $4(1)G48$. (See table 102.) Early formation of clumps correlates with $4(1)G246$ attraction. Early clumps correlate with single isomers. Effects of $4(2)G48$ repulsion would dilute matter around early clumps more than would effects that ongoing modeling might correlate with, in effect, $4(1)G48$ repulsion. Effects of dilution might carry into the times for which $4(6)G4$ attraction dominates and leads to the clumps to which observations pertain.

5.3.11. 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 [37] and [38] report ratios of five-plus to one. The observations have bases in gravitational lensing. Reference [39] reports, for so-called massive galaxy clusters, a ratio of roughly 5.7 to one. (Perhaps, note reference [40].) The observations have bases in X-ray emissions.

Proposed modeling is not incompatible with these galaxy cluster centric ratios. Either one of PR6ISP modeling and PR36ISP modeling can pertain.

Reference [41] 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. This essay de-emphasizes discussing the extent to which proposed modeling comports with this formula. Proposed modeling might suggest a correlation, based on proposed similarities between most dark matter and ordinary matter.

5.3.12. Galaxy clusters - an explanation for aspects of the Bullet Cluster

We consider either PR6ISP modeling or PR36ISP 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 modeling 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 modeling 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.

We assume that four dark matter isomers correlate with proposed modeling notions of cool dark matter and that one dark matter isomer exhibits behavior similar to behavior that ordinary matter exhibits. (See discussion related to table 98 and see table 100.)

Proposed modeling suggests that, for each of the two galaxy clusters, essentially all the stuff correlating with isomers one, two, four, and five would pass through the collision with just gravitational interactions having significance. For isomer three, incoming $1R \otimes 2U$ would pass through. For isomer zero, incoming

Table 104: Aspects regarding a collision between two galaxy clusters (with the assumption that each of the two galaxy clusters has not undergone earlier collisions; and with the assumption that case S pertains, as per table 100)

Aspect
• 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 somewhat less than 20 percent of dark matter interacts with dark matter and slows down. (For each galaxy cluster, this dark matter correlates with the IGM correlating with isomer three.)   • At least 80 percent of dark matter passes through with just gravitational interactions having significance.   • Essentially all of the incoming 1R⊗2U passes through the collision with just gravitational interactions having significance.

1R⊗2U (which measures as dark matter) would pass through. Thus, at least 80 percent of the incoming dark matter would pass through the collision with just gravitational interactions having significance.

Table 104 lists aspects regarding a collision between two galaxy clusters. Here, we assume that each of the two galaxy clusters has not undergone earlier collisions. Here, we assume that case S pertains. (See table 100.)

We suggest that these proposed modeling notions might 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 galaxy clusters and the fractions of IGM that, in effect, detach from outgoing galaxy clusters.

We discuss possible aspects regarding an outgoing galaxy cluster.

Suppose that, before a collision, ordinary matter IGM comprised much of the ordinary matter in the galaxy cluster. Suppose that, because of the collision, the galaxy cluster has a significant net loss of ordinary matter IGM. After the collision, the galaxy cluster could have a (perhaps somewhat arbitrarily) large ratio of amount of dark matter to amount of ordinary matter.

To the extent that IGM detaches from galaxy clusters after the galaxy 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 isomer three.

5.3.13. Galaxies - formation

We discuss galaxy formation scenarios.

We assume that nature comports with at least one of PR6ISP modeling and PR36ISP modeling. (Neither ongoing modeling nor PR1ISP modeling includes the notion of more than one dark matter isomer. Regarding each of ongoing modeling and PR1ISP modeling, 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 collisions between galaxies.

We anticipate that such galaxy formation and evolution scenarios will explain galaxy centric data that table 95 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.

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 124b and communication 124c discuss data that pertains regarding a time range from about one billion years

Table 105: A scenario for the formation and evolution of a galaxy for which the original clump contains essentially just one isomer

Steps
• 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.

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 100 shows and our discussion regarding the Bullet Cluster. Regarding the Bullet Cluster, see discussion related to table 104.)

We organize this discussion based on the isomer or isomers that originally clump based, respectively, on 4G246 attraction or on 4G246 attraction 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 105 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 PR6ISP 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.

5.3.14. 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 100.) 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 106a and the rightmost column in table 106b.) However, we consider the possibility that people might not know of data or current modeling that would adequately point to the one of case A and case B that pertains. We discuss both cases.

Table 106 pertains. (See table 95.) The following sentences illustrate the notion that some statements in table 106 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 de-emphasize some aspects regarding 1R⊗2U hadron-like particles.

Table 106 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 106 features pertain somewhat broadly. We think that galaxies that have core clumps that feature more than one isomer are more likely to appear as elliptical galaxies (and not as 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.

Table 106: 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$\approx$4:1, with most DM in a halo. Might be a spiral galaxy.
A3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the four other DM isomers over time. Some OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
AX	1, 2, 4, or 5	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other isomers over time. OM stars can form over time. Can get to DMA:OMA$\approx$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$\approx$4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BP	The DM isomer that 4G48 connects to the OM isomer	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the other DM isomers over time. OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
B3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA$\approx$4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BY	Any one of the other three DM isomers	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA$\approx$4:1, with three or four DM isomers in a halo. Might appear to be an elliptical galaxy.

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 95 comports with these results. We suggest that visible early galaxies correlate with generalization of label-A0 or with generalization of label-B0. (See table 106.) Label-A3 or label-B3 evolves similarly to label-A0 or label-B0, but is not adequately visible early on.

- Reference [42] provides data about early stage galaxies. (See, for example, figure 7 in reference [42]. 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 [43] suggests that redshifts of at least seven pertain to times ending about 770 million years after the Big Bang.

- Reference [44] 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 modeling suggests that the above galaxy evolution scenario comports with this data.

We discuss observations correlating with later times. Table 95 comports with these results.

- Reference [45] discusses some MED09 spiral - or, disk - galaxies. A redshift of approximately $z = 1.57$ pertains. (See reference [46].) The redshift correlates with a time of 4.12 billion years after the Big Bang. (We used reference [43] to calculate the time.) Reference [45] 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 106 shows might 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 106.)

    – To the extent that such an MED09 galaxy models as being nearly untouched, proposed modeling 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 modeling 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 [47] 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 [43] 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 [48].) 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 might pertain. (See table 106.)

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 95 seems to comport with these results. (See table 106.)

- Reference [49] 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 [50] discusses 19 dwarf galaxies that lack having much dark matter, from their centers to beyond radii for which ongoing modeling 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 modeling seems to be able to explain either ratio. Proposed modeling might not necessarily explain ratios that would lie between the two reported ratios.

  - Reference [51] 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 [52] 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 [45] 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 106 shows can pertain.

- The galaxy NGC1052-DF4 might correlate with a ratio of much less than one to one. (See reference [53].) 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 [54].) 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 [55].) People speculate regarding a so-called quenching mechanism. Proposed modeling suggests that phenomena similar to phenomena that might pertain regarding Markarian 1216 might pertain regarding XMM-2599.

People report other data. Table 95 and table 106 seem not to be incompatible with these results. We are uncertain as to the extents to which proposed modeling provides insight that ongoing modeling 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 [56].) 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 [57].) 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 [58].) Observations feature sub-millimeter wavelength light. We might assume that proposed modeling galaxy formation scenarios comport with such galaxies. We are not certain about the extent to which proposed modeling 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 modeling 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 models. (For a discussion of some possible inconsistencies, see reference [59].)

- We are uncertain as to the extent to which proposed modeling might provide insight regarding the existence of two types - born and tidal - of ultra-diffuse galaxies. (See reference [60].)

Observations that we discuss above indicate that some galaxies do not exhibit dark matter halos. Proposed modeling that we discuss above comports with the notion that some galaxies do not exhibit dark matter halos.

5.3.15. Aspects regarding some components of galaxies

We discuss effects, within galaxies, that might correlate with dark matter.

Reference [61] reports, based on a study of 11 galaxy clusters, more instances of more gravitational lensing - likely correlating with clumps of dark matter that correlate with individual galaxies - than ongoing modeling simulations predict. (Perhaps, see reference [62].) Reference [62] suggests that the number of instances - 13 - compares with an expected number of about one. We suggest the possibility that the clumps might be dark matter galaxies. (See, for example, table 106.) Perhaps some of the dark matter galaxies are dwarf dark matter galaxies. We suggest the possibility that galaxies with significant amounts of ordinary matter gravitationally captured (or at least attracted) such dark matter clumps.

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 [63] suggests that 65 percent of the ultra-diffuse galaxies are more massive than people might expect based on ongoing modeling relationships, for so-called normal galaxies, between stellar mass and halo mass. We are uncertain as to the extent to which proposed modeling might explain this result. For example, proposed modeling might suggest that phenomena related to isomers might play a role. (See, for example, table 106.) 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 106 is not incompatible with the notion that visible stars do not include much dark matter.

Discussion related to table 106 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 [64] and [65].)

We suggest that proposed modeling 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 [66].) Proposed modeling 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 modeling 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.

5.3.16. 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 [67].) 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 [68].) Proposed modeling 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 [68] and [69].) 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 modeling notions of the existence of dark matter stars that would be similar to ordinary matter stars.

5.3.17. High-mass neutron stars

We discuss proposed modeling 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 [70].) 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 [71] and [72].)

Some ongoing modeling models suggest a maximum neutron star mass of about $1.5M_{\odot}$. (See reference [72].)

Observations correlate with most known neutron star pairs having masses in the range that equation (170) shows and one neutron star pair having a mass of about 3.4 solar masses. (See references [73] and [74].) 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.

$$2.5M_\odot \lesssim M \lesssim 2.9M_\odot \tag{170}$$

People speculate - based on, at least, the GW190425 result - about needs for new modeling regarding neutron stars. (See references [73] and [72].)

Detection GW190814 suggests that people have inferred the existence of an object for which equation (171) pertains. (See reference [75].) People speculate that the object might have been a high-mass neutron star or might have been a low-mass black hole.

$$M \approx 2.6M_\odot \tag{171}$$

We discuss possible bases for high-mass neutron stars.

The PR6ISP span of 4G4 is six.

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.

5.3.18. Dark energy density

We explore possible explanations for non-zero dark energy density.

Equation (172) 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 [13] provides the four items of data.) We know of no inferences that would not comport with a somewhat steady increase, regarding the inferred ratio correlating with equation (172), from approximately zero, with time since somewhat after the Big Bang. (Communication 124d implies a ratio of approximately zero correlating with 380 thousand years after the Big Bang. Also, inferences that reference [76] discusses might suggest that dark energy density increases with time.)

$$\Omega_\Lambda/(\Omega_c + \Omega_b + \Omega_\gamma) \approx 2.3 \tag{172}$$

Some aspects of ongoing modeling correlate inferred dark energy densities of the universe with phenomena correlating with terms such as vacuum energy, vacuum fluctuations, or quintessence. Proposed modeling is not necessarily incompatible with notions such as vacuum energy. However, double-entry aspects of proposed modeling point to possibilities for modeling that does not embrace notions such as vacuum energy.

Aspects related to aye (or, 0I) bosons and jay (or, 2J) bosons might lead to phenomena similar to effects that ongoing modeling correlates with vacuum energy, vacuum fluctuations, or quintessence. (See discussion related to equations (123) and (124). Note that, for much of the history of the universe, large-scale effects of 0I and 2J bosons might be small compared to other phenomena.) Ongoing modeling correlates some of those - that is, vacuum energy, vacuum fluctuations, or quintessence - effects with data about dark energy densities. To the extent that phenomena correlating with aye and jay bosons suffice to explain dark energy densities, there might not be a need to consider PR36ISP modeling. Assuming that such phenomena might not adequately explain non-zero dark energy density, we discuss possibilities for other proposed modeling aspects that might explain non-zero dark energy density.

For PR6ISP modeling, proposed modeling includes the notion of 2(6)G248, whereas ongoing modeling correlates with the notion of 2(1)G248. We suggest that the difference, in proposed modeling, between 2(6)G248 and 2(1)G248 might correlate with nature's indirectly producing effects, regarding CMB, that people correlate, via ongoing modeling, with some non-zero dark energy density. The difference correlates with interactions between ordinary matter and dark matter.

For PR36ISP modeling, differences between 2(>1)GΓ and 2(1)GΓ correlate with interactions between ordinary matter plus dark matter and doubly dark matter. Dark energy density might correlate with a notion of dark energy stuff. Dark energy stuff would correlate with 30 doubly dark matter isomers. Modeling suggests an upper bound of approximately five regarding, in effect, a possible future value for the ratio that correlates with equation (172).

6. Discussion: core ongoing modeling and core proposed modeling

This unit discusses possibilities for adding aspects of core proposed modeling to core ongoing modeling.

6.1. The elementary particle Standard Model

We explore synergies between proposed modeling and the elementary particle Standard Model.

Equation (173) shows internal symmetries that correlate with the ongoing modeling elementary particle Standard Model. Proposed modeling might correlate with these symmetries. (Regarding $SU(3)$, see discussion regarding table 54. Regarding $SU(2)$, see discussion regarding table 42. Regarding $U(1)$, see discussion regarding table 36 and discussion regarding table 42.)

$$SU(3) \times SU(2) \times U(1) \tag{173}$$

People might try to add to the Standard Model some of the symmetries that proposed modeling suggests. Examples include conservation of charge and rebuttable somewhat conservation of fermion generation.

People might try to add to the Standard Model some of the simple particles and root forces that proposed modeling suggests. Examples include the jay bosons and 8G.

People might try to add to the Standard Model the 1R⊗2U hadron-like particles that proposed modeling suggests.

Proposed modeling might provide a basis for extending the Standard Model to include concepts related to mass and concepts related 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 modeling suggests regarding refraction. (See discussion related to equation (79).)

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 might have 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 PR6ISP modeling, approximately one-sixth of such one-isomer black holes features ordinary matter and approximately five-sixths of such one-isomer black holes features dark matter.

- Proposed modeling is not necessarily incompatible with an ongoing modeling notion of possible large-scale flatness for the universe.

Table 107 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 modeling 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 - at least - 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 [77].)

People suggest possible incompatibilities between observations and ongoing modeling models. (See, for example, reference [78], reference [79], reference [80], reference [36], and communication 124e. However, some people note possible objections to some notions of incompatibility. See, for example, references [81] and [82].) People suggest phenomenological remedies regarding the modeling. (See, for example, reference [83].)

Proposed modeling 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 PR1ISP modeling, including 4G aspects of PR1ISP modeling.

We consider the case of PR6ISP modeling.

Table 107: 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
• Aspects regarding before the inflationary epoch. (See discussion related to equation (163).)
• Aspects regarding during the inflationary epoch. (See discussion related to equation (164).)
• Production of 1R⊗2U hadron-like particles. (Possibly, the vanishing of seas composed of gluons and quarks or arcs.)
• Transition in dominance, regarding various masses of objects or 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 102.)
• Earliest visible galaxies of various types that table 106 suggests.
• Achievement, by some galaxies, of approximately four to one ratios of dark matter density to ordinary matter density. (See table 106.)
• Transition in dominance, regarding various masses of objects or sizes of objects, from attraction based on 4(1)G246 to repulsion based on 4(2)G48. (See discussion related to table 102.)
• Transition in dominance, regarding various masses of objects or sizes of objects, from repulsion based on 4(2)G48 to attraction based on 4(6)G4. (See discussion related to table 102.)

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 4G has a span of one isomer. The 4G48 repulsive component of 4G 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 PR36ISP modeling.

Six isomers of 4(6)G4 pertain. General relativity might pertain somewhat for each of the six PR6ISP-like isomers. The concept of geodesic motion would not pertain across PR6ISP-like isomers.

6.4. Quantum electrodynamics regarding positronium

Reference [11] reports a discrepancy between the observed energy correlating with one type of fine-structure transition in positronium and a prediction based on core ongoing modeling. (See discussion regarding equation (84).)

Proposed modeling suggests the discrepancy correlates with a limit to the applicability of current core ongoing modeling. Table 70 suggests aspects that might correlate with that limitation. Features of the suggestion include the following notions. Core proposed modeling offers the opportunity to correlate the core ongoing modeling notion of a Pauli exclusion force with effects of jay bosons. Effects of jay bosons correlate with an interaction - between an electron and a positron bound together in positronium - for which ongoing modeling does not have an analog.

6.5. 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

Table 108: Possible rest energies for 1R⊗2U hadron-like particles

Possible rest energies (in GeV) for 1R⊗2U
~ 0.06
~ 0.9
~ 4
Other.

Table 109: Instances in which core proposed modeling PFS models might seem to depend on - or at least might seem to reflect - aspects of core ongoing modeling KMS models

Instance
• Core proposed modeling PFS PDE models use an equation that features terms that seem to reflect aspects related to core ongoing modeling models for root forces. One example features suggesting that solutions to the equation correlate with simple elementary particles. (See, for example, table 33.)
• Core proposed modeling PFS models use symmetries that core ongoing modeling correlates with conservation of energy, conservation of momentum, and conservation of angular momentum. One example features the extent to which ΣGΓ components correlate with ΣG interactions with elementary particles. (See, for example, discussions related to tables 62 and 93.)
• Core proposed modeling PFS models use aspects related to the core ongoing modeling notion of index of refraction. One example features modeling regarding some aspects of neutrino oscillations. (See discussion related to table 68.) One example features some aspects related to gluons and the strong interaction. (See discussion related to table 68.)
• Core proposed modeling PFS models use aspects related to the core ongoing modeling notions of the Pauli exclusion principle and a Pauli exclusion force. One example features aspects related to the 2J bosons. (See table 70a.)

[13] 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.

Equation (174) might estimate the current relevant ratio of density of 1R⊗2U hadron-like particles to density of ordinary matter. (Regarding the symbol $\Omega_{1R2U,0}$ and the ratio $\Omega_{1R2U,0}/\Omega_b \sim 0.055$, see discussion related to equation (154).) The symbol $m_{\_}$ denotes the rest mass of a typical hadron-like particle. The leftmost use of the ratio $m_{1R\otimes2U}/m_{1Q\otimes2U}$ correlates with rest energy (or rest mass) per particle. The rightmost use of the ratio $m_{1R\otimes2U}/m_{1Q\otimes2U}$ occurs as the input to a calculation of an exponential and correlates with a hypothesis regarding the relative numbers of particles that nature created.

$$0.055 \sim \Omega_{1R2U,0}/\Omega_b \sim (m_{1R\otimes2U}/m_{1Q\otimes2U})\exp(-m_{1R\otimes2U}/m_{1Q\otimes2U}) \tag{174}$$

Two mathematical solutions exist. The respective solutions, expressed in terms of $m_{\_}c^2$ and in units of GeV are ~ 0.06 and ~ 4.

Table 108 summarizes some possible rest energies for 1R⊗2U hadron-like particles.

6.6. Relationships between core proposed modeling and core ongoing modeling

We develop - elsewhere - some aspects of core proposed modeling in a manner that does not necessarily correlate with core ongoing modeling. However, the core proposed modeling list of suggested elementary particles might not necessarily be independent of core ongoing modeling, which tends to feature laws of motion.

Table 109 notes instances in which core proposed modeling PFS models might seem to depend on - or at least might seem to reflect - aspects of core ongoing modeling KMS models.

7. Discussion: unverified ongoing modeling and core proposed modeling

This unit discusses possibilities that core proposed modeling provides insight regarding unverified aspects of ongoing modeling.

7.1. Supersymmetry

Table 23 might suggest possibilities for some notion of symmetry based on equation (175). Here, the symbol $\leftrightarrow$ correlates with notions of exchanging roles. For some relevant nonnegative values of Σ, table 23 might suggest possibilities for a relevant notion of symmetry based on equation (176).

$$m \dot{>} 0 \ \leftrightarrow \ m \dot{=} 0 \tag{175}$$

$$\Sigma \ \leftrightarrow \ \Sigma + 1 \tag{176}$$

Tables 23 and 92 seem, in themselves, to be incompatible with supersymmetry. People might explore the notion of layering supersymmetry over results that tables 23 and 92 show. However, given aspects of proposed modeling, supersymmetry might not be necessary to explain known phenomena.

7.2. String theory

We discuss the notion that aspects of proposed modeling might help people explore the relevance of string theory to elementary particle physics.

We suggest perspective about string theory and about proposed modeling. (Reference [84] provides perspective about string theory.) Regarding simple particles and root forces, proposed modeling correlates with the three-word term modeling regarding what. Proposed modeling outputs a list of what elementary particles nature embraces or might embrace. We contrast notions of modeling regarding what with notions correlating with the three-word term modeling regarding how. Proposed modeling might not yet suggest modeling regarding how nature selects or forms elementary particles. Attempts to apply string theory to elementary particle physics might correlate with trying to develop modeling regarding how and trying to use the modeling regarding how to produce modeling regarding what.

We suggest that would-be applications of string theory to elementary particle physics, correlate with KMS modeling. Regarding physics modeling, proposed modeling adds, compared to ongoing modeling, the notion of PFS 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 PFS aspects along with KMS aspects.

People might want to explore possible correlations between string theory notions of so-called frothiness of space-time and aspects of PFS modeling.

PFS modeling includes notions of volume-like solutions that correlate with fields for elementary particles and notions of point-like solutions that correlate with particles for elementary particles. (See equations (60) and (61).) Here, in effect, transitions between volume-like and point-like can involve changes regarding a number, D, of dimensions. The numbers D correlate with, at least, aspects of PFS modeling. Perhaps, people can interpret seeming transitions - regarding modeling - between volume-like and point-like as correlating with (at least, mathematical) notions of frothiness.

7.3. Theory of everything

We speculate that proposed modeling points toward possibilities for a superset of a so-called theory of everything.

People discuss the notion of modeling that would describe much of fundamental physics. Within this context, people use the three-word term theory of everything to allude to modeling that would unify quantum mechanics and general relativity. People use the one-element term ToE to abbreviate the three-word phrase theory of everything.

We suggest that such a use of the term ToE might correlate with overlooking key aspects of nature. In the context of proposed modeling and ongoing modeling, that use of the term ToE might correlate with a notion of a unified modeling of motion and might overlook the topic of objects that move.

Table 110 notes aspects of a possible superset of a so-called ToE.

The superset correlates, at the least, with the notion of modeling regarding what. The superset does not necessarily correlate with modeling regarding how nature, in effect, selects or creates properties of objects, selects or creates elementary particles, or selects or creates relevant aspects regarding motion.

Table 110: Aspects of a possible superset of a so-called ToE (or, theory of everything)

Aspect
• Modeling that lists properties of elementary particles and of other objects.
• Modeling that lists elementary particles.
• Modeling that embraces or integrates modeling regarding motion.
• Modeling that unifies the aspects above.

People characterize some ongoing modeling candidates for a ToE by (mathematical) 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 110.

We suggest that the properties portion of our work might correlate with the group $SU(17)$.

Table 111 illustrates the notion that table 58 correlates with the group $SU(17)$ and with six applications of equation (47). This essay does not speculate regarding possibilities for detecting phenomena that would correlate with PR216ISP but not with PR36ISP.

Table 112 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. (Discussions regarding table 72 and table 75 might provide an alternative description relevant to some facets of the last three aspects that table 112 lists.)

Notions above may suffice to embrace much modeling of motion - including classical physics models and quantum physics models - that comports with six isomers of all elementary particles except G-family elementary particles, conservation of energy, conservation of momentum, and conservation of angular momentum. (Regarding six isomers of simple particles, see table 111a. The notion of six isomers of simple particles 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 an aspect of core proposed modeling PFS modeling and with independence from classical models (including general relativity) regarding motion. Classical modeling regarding motion correlates with ongoing modeling KMS modeling.

Beyond notions above, we are uncertain as to the extent to which people might want to add group theoretic concepts related to specific modeling regarding 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.

7.4. The strong CP problem

We discuss insight, that proposed modeling might provide, regarding the strong CP problem.

Ongoing modeling 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. Unverified ongoing modeling suggests that such violation might correlate with the existence of axions.

Table 113 lists aspects correlating with insight that proposed modeling might provide regarding the extent to which nature includes strong CP violation. Table 113a lists aspects that people might interpret as ruling out strong interaction contributions to CP violation. Table 113b lists aspects that, if relevant, people might interpret as suggesting that the strong interaction contributes to CP violation.

7.5. Possible lacks of some unverified ongoing modeling elementary particles

We discuss notions that proposed modeling correlates with nature possibly not including some elementary particles that some unverified ongoing modeling models suggest might exist.

7.5.1. A possible lack of magnetic monopoles

Table 92 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 (177) expresses.

$$\text{The 2G2 solution correlates with electromagnetic (not magnetic) monopole moments.} \qquad (177)$$

Table 111: 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 energy 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	Component of an $SU(2) \times U(1)$ symmetry	Component of an $SU(2) \times U(1)$ symmetry
3	-	3	$SU(3)$ strong interaction symmetry	-

(b) Notes regarding table 111a

Note
• For the first row (in table 111a), the value of 17 for $j_1 + j_2$ equals the 17 in the expression $SU(17)$.
• For each row (in table 111a) after the first row, $j_1 + j_2$ equals j_1 for the immediately preceding row. (Note equation (47).)
• For the first five rows (in table 111a), the $U(1)$ item correlates both with an ability to sum the property (that the $SU(j_2)$ item shows) across values for components of a multicomponent object and, thereby, with an exact (not rebuttable somewhat) conservation law.
• For the first four rows (in table 111a) for which $j_2 = 2$, the SA-side count column in table 58a interprets the three generators of $SU(2)$.
• Regarding the row (in table 111a) for which $j_2 = 4$, table 58a shows another step. That step correlates with another (that is, beyond the one correlating with the sixth row in table 111a) $SU(2) \times U(1)$ symmetry. The $SU(2) \times U(1)$ symmetry that the other step that table 58a shows correlates with phenomena regarding (at least) charged leptons and aspects of dark matter.
• PRι_IISP modeling might - for each of $\iota_I = 1$, $\iota_I = 6$, and $\iota_I = 36$ - correlate with use of $\log_6(\iota_I)$ uses of the $SU(2) \times U(1)$ symmetries.
• To the extent that PR36ISP is not relevant to physics, an overall $SU(15)$ symmetry might suffice.
• The span for 6G468 is six. (See table 62.) To the extent that PR36ISP is relevant to physics, an overall $SU(19)$ symmetry and the notion of PR216ISP might pertain.
• The span for 8G26 is six. (See table 62.) To the extent that PR216ISP is relevant to physics, an overall $SU(21)$ symmetry and the notion of PR1296ISP might pertain.

Table 112: 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

Aspect
• The notion that table 111 correlates with a group, $SU(17)$.
• A link from table 111 to table 58.
• A link from XA in table 58 to representations for almost all elementary bosons. (Perhaps, note tables 20c, 25, and 48. G-family mathematics might point to all elementary bosons other than the gluons and the pie boson. See, for example, discussion related to tables 62 and 73 and discussion related to equations (98) and (99).)
• 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 elementary boson. (See table 55.)
• A link from PDE modeling to modeling for all elementary fermions.

Table 113: Aspects correlating with insight that proposed modeling 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

Aspect
• Unverified ongoing modeling 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 modeling 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 (189).)
• Unverified ongoing modeling seems to suggest that if at least one quark had zero mass, strong CP violation would not exist. Proposed modeling 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 modeling, to rule out strong CP violation.
• Each of core ongoing modeling and core proposed modeling 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 table 42.) With respect to conservation of fermion generation (or aspects correlating with the oscillator pair TA5-and-TA6), a proposed modeling representation for gluons has similarities to a proposed modeling representation for the 2W subfamily. (Compare table 54 and table 42.) 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. Also, the notion that an individual quark or arc correlates - at any one time - with only one color charge might suggest - from a standpoint of modeling - that nature does not exhibit CP violation catalyzed by gluons. A notion - regarding 2U - of always (and not necessarily rebuttable always and not necessarily rebuttable somewhat) conservation of fermion generation might pertain.
• Unverified ongoing modeling seems to suggest that, if nature includes magnetic monopoles, strong CP violation can occur. Proposed modeling suggests possible insight regarding the possible existence of magnetic monopoles. (See discussion related to equation (177).) The insight seems to suggest that nature does not include magnetic monopoles.

(b) An aspect that, if relevant, people might interpret as suggesting that the strong interaction contributes to CP violation

Aspect
• Detection of currently hypothetical so-called axion elementary particles might point to non-conservation - that might correlate with the strong interaction - of CP symmetry.

Table 114: Comparative features of supplementary proposed modeling dynamics modeling and ongoing modeling dynamics modeling

Compared to ongoing modeling models regarding motion, use of proposed modeling models might be ...
• As successful or more successful regarding describing allowed states.   • As successful 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.

7.5.2. A possible lack of axion elementary particles

Each of the following statements might point to insight regarding attempting to detect axions. Proposed modeling 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 (199).) Proposed modeling 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 (166) shows an interaction that people might interpret as correlating with producing a magnetic field.)

8. Discussion: supplementary proposed modeling and core ongoing modeling

This unit explores the possibility that supplementary proposed modeling points to useful models for motion.

Discussion above in this essay features proposed modeling suggestions regarding elementary particles and dark matter particles, plus ongoing modeling models regarding motion. We generally assume that the PEPM particle set and ongoing modeling models for motion are adequately compatible with each other. We generally assume that the PEPM particle set and ongoing modeling models for motion are adequate for modeling relevant aspects of nature.

Discussion herein speculates about proposed modeling that would have bases in core proposed modeling models and would pertain directly to motion.

8.1. Modeling that proposed modeling suggests regarding dynamics

Table 30 alludes to possible proposed modeling 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 CQFM to denote results from developing, from PFS modeling, a possibly useful somewhat analog to ongoing modeling QFT (or, quantum field theory). The acronym CQFM correlates with the four-word term complementary quantum field modeling. Ongoing modeling QFT modeling correlates with the notion of KMS modeling. CQFM would feature KMS modeling. (See table 17.)

We do not necessarily expect that proposed modeling models for motion duplicate ongoing modeling models for motion. Ongoing modeling models tend to be linear in energy. Ongoing modeling quantum models for motion tend to be linear in $\hbar$. Proposed modeling models for motion tend to be quadratic in energy. Proposed modeling 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 CQFM might include models that feature potentials or that CQFM might point to models that feature potentials.

We do not necessarily expect that proposed modeling aspects that seem to have parallels to ongoing modeling QFT (or, quantum field theory) need to comply with special relativity. (Regarding ongoing modeling, reference [85] discusses a definition of QFT that does not necessarily imply a correlation with special relativity.)

Table 114 compares aspects of supplementary proposed modeling dynamics modeling and aspects of ongoing modeling dynamics modeling.

8.1.1. CQFM interaction vertices that involve simple particles and root forces

We explore notions that underlie possible CQFM models regarding interaction vertices. (See the second row in table 30. Perhaps, see aspects, that mention $\nu_{SA} < 0$, of table 31.)

This work generalizes from work above that, nominally, pertains for simple particles. Equations (53) and (54) pertain regarding all simple particles and all root forces. We posit that results - regarding some

Table 115: 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	$-3/2$	A matter fermion and a boson produce two matter fermions and one antimatter fermion.
(3f+0b↔3f+0b)	$-3/2$	-
0f+nb↔0f+nb, for n≥2	$-n$	A Higgs boson creates two photons.

roles for ν_{SA}, ν_{TA}, and ν'' - from that work extend to all simple particles and all root forces. (See, for example, table 32b.)

Table 115 lists types of interaction vertices that proposed modeling 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. Note, for example, that 1b can correlate with $0I^0$, which is the aye boson.) 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 $\nu\_$. 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.

CQFM posits that the notion of 3f does not necessarily violate ongoing modeling notions of fermion statistics. CQFM features aspects that appear to aggregate QFT interactions. (For one example, CQFM does not necessarily require notions of virtual particles. For this example, CQFM appears to aggregate multiple QFT Feynman diagrams. For another example, CQFM points toward modeling that replaces bosons with potentials.) Leaving aside the notion of aggregation of interactions, 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 core ongoing modeling QFT and supplementary proposed modeling CQFM.

Proposed modeling can accommodate, for the weak interaction, modeling that does not require the notion of virtual particles. Equation (178) shows an ongoing modeling 1f+1b↔1f+1b vertex. A muon transforms into a matter neutrino and a W boson. Equation (179) shows an ongoing modeling 1f+1b↔1f+1b vertex. The W boson transforms into an electron and an antimatter neutrino. Core proposed modeling can accommodate that modeling. Supplementary proposed modeling can accommodate that modeling and can accommodate the 1f+1b↔3f+0b vertex that equation (180) shows. Equation (180) does not show a virtual particle such as a W boson. Modeling based on equation (180) can be useful. However, modeling based just on equation (180) would not necessarily support research that estimates properties of the W boson and would not necessarily estimate the strength of the interaction that equation (180) shows.

$$\mu^{-3} + 0I^0 \to \nu^0 + W^{-3} \tag{178}$$

$$W^{-3} \to e^{-3} + \bar{\nu}^0 \tag{179}$$

$$\mu^{-3} + 0I^0 \to \nu^0 + e^{-3} + \bar{\nu}^0 \tag{180}$$

8.1.2. Supplementary proposed modeling dynamics models re multicomponent objects

We discuss the possibility that CQFM extends to include interactions involving objects that are not elementary particles.

For proposed modeling models of interactions that involve simple particles and root forces in free environments, the KMS PDE notion of the mathematical limit expression $(\eta_{SA})^2 \to 0$ pertains. (See discussion related to equation (13).) Here, $(\eta_{TA})^2 \to 0$ pertains. We say that the vertex models as being

Table 116: 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	

point-like with respect to KMS 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 modeling models 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 (181) 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.

$$|\eta_{SA}| \tag{181}$$

We discuss some aspects of proposed modeling models. (These remarks tend to correlate with the last row in table 30. However, some of these remarks pertain regarding the existence of elementary particles and regarding the first row in table 116. See discussion regarding table 55 and the pie simple boson.)

Table 116 notes aspects of PDE mathematics that can pertain for dynamics modeling and $\nu_{SA} \geq 0$. In table 116, 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 8.) 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). The term correlates with a contribution that is proportional to $+r^{-2}$. The potential decreases as r increases.) However, when equations (31), (182), and (183) pertain, one can swap the Ω_{SA}/r^2 term and the Ω_{TA}/t^2 term in equation (31). The swap leads, in effect, to a new Ω_{SA}/r^2 that has a sign that is opposite to the sign correlating with the old Ω_{SA}/r^2. The new Ω_{SA}/r^2 would correlate with attraction. For some aspects of modeling, equations (184) and (185) pertain.

$$(t/\eta_{TA})^2 = (r/\eta_{SA})^2 \tag{182}$$

$$\xi'_{TA} = \xi'_{SA} \tag{183}$$

$$t^2/(2(\eta_{TA})^2) + r^2/(2(\eta_{SA})^2) = tr/(|\eta_{TA}| \cdot |\eta_{SA}|) \tag{184}$$

$$v_c = |\eta_{SA}|/|\eta_{TA}| \tag{185}$$

We anticipate exploring notions correlating with the third and fourth rows in table 30.

8.1.3. Dynamics models for hadron-like particles

We discuss various topics regarding 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 49 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.

We discuss modeling for dynamics in hadrons that contain no more than three quarks.

Ongoing modeling 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 modeling 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 60. 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 dynamics symmetries for internal aspects of the same combined object.) Proposed modeling 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 modeling dynamics modeling correlates with the notion that neither one of quarks and gluons behaves like free simple particles. Proposed modeling suggests that a hadron-like particle must include at least two (non-virtual) unfree fermions. (The notion of virtual correlates with ongoing modeling. Core proposed modeling 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 [86] and [87] suggest opportunities to improve understanding regarding modeling that might explain the masses of hadrons such as protons. Proposed modeling 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 and hadron-like particles that contain more than three quarks.

Reference [88] discusses an observation of tetraquarks that feature four charm quarks, of which two are matter quarks and two are antimatter quarks. The article suggests that people might benefit by considering that such tetraquarks might feature two components. Each component would feature a matter charm quark and an antimatter charm quark. Proposed modeling suggests that the pie boson might correlate with the binding to each other of the two components.

Reference [89] 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 modeling correlates with the pie boson might play roles in such dynamics.

8.1.4. Dynamics models for nuclear physics

We discuss possibilities for developing proposed modeling models for atomic nuclei.

Ongoing modeling bases some aspects of modeling on notions of a Pauli exclusion force and on notions of a Yukawa potential. Ongoing modeling 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 [90] expresses concerns regarding modeling some aspects of nuclear physics based on the notion of virtual pions.

Core proposed modeling PFS modeling and core ongoing modeling KMS modeling can pertain. Here, KMS modeling includes a Pauli exclusion force and a notion of virtual pions.

Supplementary proposed modeling KMS 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 55.) The attraction might correlate with a PDE-centric expression proportional to the term that equation (186) shows. (See discussions related to equations (181) and (184).)

$$-\exp(-tr/(|\eta_{TA}| \cdot |\eta_{SA}|)) \to -\exp(-r/(|\eta_{SA}|)) \tag{186}$$

Proposed modeling suggests that jay (or, 2J) bosons correlate with repulsion between some pairs of hadrons that people know to occur in atomic nuclei. Each hadron in known atomic nuclei correlates with a 3LB number of minus one. Proposed modeling suggests that the $2J_-$ boson correlates with the relevant repulsion. (See table 70.)

We are uncertain as to the extent to which such models for atomic nuclei would improve on ongoing modeling techniques.

8.1.5. Dynamics models for atomic physics

We discuss possibilities for developing proposed modeling models for atomic physics.

Regarding some atomic physics, people might want to explore using modeling that correlates with equations (187) and (188). Equation (187) 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. KMS 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).

$$(\xi'_{SA}/2)(\eta_{SA})^{-2} \to 0^+ \tag{187}$$

$$(\xi'_{SA}/2)(\eta_{SA})^2 \text{ is a positive constant} \tag{188}$$

8.1.6. Dynamics models for quantum transitions

We discuss the possibility that aspects of proposed modeling pertain to temporal aspects of quantum transitions.

People may have observed quantum transitions that take non-zero time. (See reference [91].)

Proposed modeling 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 (186). (See discussions regarding equations (184) and (186).)

8.2. Possible applications of proposed modeling KMS modeling

We explore possible applications of supplementary proposed modeling KMS 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 (189) shows an upper bound on the electric dipole moment for the neutron. (See reference [13]. Here, the one-letter symbol m denotes meters.)

$$0.30 \times 10^{-27} |q_\epsilon| \, m \tag{189}$$

For each hadron for which dynamics modeling based on supplementary proposed modeling 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 8, regarding PDE-based modeling that correlates with some aspects of the strong, electromagnetic, and weak interactions.)

Proposed modeling 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 [89], of reference [92].)

We think that this discussion comports with comparisons that table 114 suggests.

8.2.2. Anomalous magnetic dipole moments

We explore two possibilities regarding supplementary proposed modeling approaches to estimating charged lepton anomalous magnetic dipole moments.

Equations (190), (191), and (192) show ongoing modeling KMS interpretations of results of experiments regarding anomalous magnetic dipole moments. (See reference [13].) 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 (109).)

$$a_\epsilon - (\alpha/(2\pi)) \approx -1.76 \times 10^{-6} \tag{190}$$

$$a_\mu - (\alpha/(2\pi)) \approx +4.51 \times 10^{-6} \tag{191}$$

$$-0.052 < a_\tau < +0.013 \tag{192}$$

Ongoing modeling 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 modeling 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 (193) shows a result correlating with a first-order Standard Model (or, ongoing modeling) calculation. (See reference [93].)

$$a_{\tau,\text{SM}} \approx +1.177 \times 10^{-3} \tag{193}$$

We explore a possible proposed modeling approach that tries to parallel the ongoing modeling approach.

Proposed modeling 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 modeling 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 62. Perhaps, note table 93.) 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 modeling suggests that contributions to a scale as $\alpha^{(\Sigma-2)/2}$. (Compare with discussion regarding equation (143).)

Solution 4G26 might correlate with the $\alpha/(2\pi)$ term that ongoing modeling 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 (190), equation (191), and discussion regarding table 118. 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 modeling 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 (194) pertains. Here, t_{cl} is the construct that the first column of table 117 identifies.

$$a_{\text{cl}} - (\alpha/(2\pi)) \approx a_{6\text{G}24,1} + a_{6\text{G}24,t} t_{\text{cl}} \tag{194}$$

Table 117 shows approximate possible values for $a_{6\text{G}24,1}$ and $a_{6\text{G}24,t}$, based on fitting data that equations (190) and (191) 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 118 provides, based on table 117 and equation (194), some possible suggestions for $a_\tau - (\alpha/(2\pi))$. The comparison is with respect to a Standard Model first order calculation. (See equation (193).) Per

Table 117: Possible approximations regarding the 6G24,1 and 6G24,t contributions to $a_{\mathrm{cl}} - (\alpha/(2\pi))$ for charged leptons

Assumption regarding t_{cl}	$a_{6\mathrm{G}24,1}$	$a_{6\mathrm{G}24,\mathrm{t}}$
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}
$(\mathrm{generation})^2$	-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 118: 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}	!
$(\mathrm{generation})^2$	$+15.0 \times 10^{-6}$	$+1.176 \times 10^{-3}$	-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}	!

the notion that the interaction strength does not necessarily correlate linearly or quadratically with an ongoing modeling 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 (108).)

Each one of the results that table 118 shows comports with experimental results. Except for the row regarding m and the row regarding m^2, each row in table 118 might comport with the calculation based on the Standard Model. The $(\mathrm{generation})^2$-centric result that table 118 shows might comport best, of the results that the table suggests, with the calculation based on the Standard Model. The $(\mathrm{generation})^2$-centric result differs from the result that equation (193) 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 117 shows, it might seem unlikely that $a_{6\mathrm{G}24,1}$ correlates with 8G26. However, it is possible that the strength of interactions correlating with 4G26 differs from the ongoing modeling result that correlates with $\alpha/(2\pi)$ and that $a_{6\mathrm{G}24,1}$ 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 (195) pertains. We assume that, in effect, equation (196) 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 (195), $4 \notin \Gamma$. For the left side of equation (196), $4 \in \Gamma$. Regarding table 118, 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 $a_{6\mathrm{G}24}$. The term is linear in a lepton's:".)

$$a_{4\mathrm{G}26} + a_{8\mathrm{G}26} = (\alpha/(2\pi)) + a_{6\mathrm{G}24,1} \tag{195}$$

$$a_{6\mathrm{G}24} = a_{6\mathrm{G}24,\mathrm{t}} \tag{196}$$

Table 119: Possible correlations, regarding PR1ISP modeling, with general relativity

Aspect regarding proposed modeling	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

Discussion related to equations (195) and (196) suggests the possibility that proposed modeling can pertain via modeling that features just two terms . 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 118, the column labeled fit. 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 114 suggests.

We also note that, regarding choices - that table 118 shows - regarding t_{cl} and ignoring the choices of m and m^2, each of the three quadratic choices - $(M'')^2$, (generation)^2, and $(\log(m/m_\epsilon))^2$ - might be more appropriate than any of the three linear choices - M'', generation, and $\log(m/m_\epsilon)$. This essay de-emphasizes looking for deeper meaning regarding the role of aspects - such as this one regarding table 118 or similar ones regarding equation (133) - that pertain to squares of properties.

8.3. Possibilities to complement ongoing modeling classical physics

We explore possibilities that supplementary proposed modeling might offer useful complements to core ongoing modeling classical physics modeling.

8.3.1. Possibilities for using Newtonian modeling in place of general relativity

Table 119 lists aspects related to 4GΓ solutions. In the context of PR1ISP 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 62.)

People might explore the feasibility of developing supplementary proposed modeling KMS modeling based on correlations that table 119 suggests. People might explore the extent to which such supplementary proposed modeling KMS modeling can be useful regarding PR1ISP modeling and regarding PR6ISP 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 models based on such broader contexts. People look for evidence that such 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 (177).)

Our work suggests possibilities for another example. (See table 66.) 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

Table 120: 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.
● Determine the extent to which our work regarding dark matter isomers and the Bullet Cluster comports with observations regarding collisions between galaxy clusters.
● 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 models.
● Predict and try to verify other phenomena that might correlate with proposed modeling.

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 a changing velocity. Here, the notion of moving with a changing velocity might correlate with linear motion and acceleration and might correlate with angular velocity.

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 120 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 modeling - falsifiability becomes feasible.

Table 121: Possible roles for the aye particle and for the 0I solution and for the jay particles and 2J solutions

(a) Possible roles in nature for the aye particle and for the jay particles

Possible roles
• The 0I and 2J particles play roles before the inflationary epoch. (See discussion related to equation (163),)
• The 0I and 2J particles play roles during the inflationary epoch. (See discussion related to equation (164).)
• The 0I particle functions as the inflaton and plays a role after inflation. (See discussion related to equation (166).)
• The 0I and 2J particles help explain some interactions. (Note interactions to which table 70 alludes directly or indirectly.)
• The 2J particles help explain the ongoing modeling notion of the Pauli exclusion principle, some ongoing modeling aspects related to the ongoing modeling notion of the Pauli exclusion principle, and an observation - regarding positronium - that might point to a limitation regarding current ongoing modeling. (See table 70a.)
• The 0I and 2J particles help explain phenomena that ongoing modeling correlates with terms such as vacuum energy, vacuum fluctuations, or quintessence.
• The 0I and 2J particles explain phenomena that ongoing modeling correlates with density of dark energy. (See discussion related to equation (172).)
• The 0I particle might correlate with situation-specific interaction rates. (See discussion related to equation (197).)

(b) Possible roles in modeling for the 0I solution and for the jay solutions

Possible roles
• The 0I and 2J solutions help explain scaling by factors of α correlating with adding vertices or with increasing G-family spin. (See discussion related to equation (137).)
• The 0I and 2J solutions simplify some aspects of modeling (and, regarding such, do not necessarily correlate with nature).

9.1.2. Possibilities for detecting or inferring aye and jay bosons

Table 121 lists possible roles for the aye particle and for the 0I solution and for the jay particles and 2J solutions. Each item in table 121a might point to possibilities for detecting or inferring at least one of aye bosons and jay bosons. For example, the item regarding positronium might correlate - regarding jay bosons - with such a detection or inference.

We discuss some items - that table 121a shows - for which we can offer information to which table 121a does not point.

Some aspects of ongoing modeling 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 [94].) 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 modeling suggests the possibility that the X particle is an aye boson or a jay boson.

Ongoing modeling proposes concepts such as interactions with a so-called quantum vacuum. Proposed modeling 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 and 2J bosons might correlate with effects similar to effects that ongoing modeling correlates with the notion of interactions with a quantum vacuum.

Equation (197) 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 (198) 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.

$$0H^0 \rightarrow ... \tag{197}$$

$$0I^0 + 0H^0 \rightarrow ... \tag{198}$$

We discuss aspects that table 121b 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 (137) and discussion related to equation (143).) Possibly, modeling based on the 0I solution and the 2J solutions correlates - in ways that this essay does not discuss - with aspects regarding spins, interactions, and KMS models. (See discussion related to equation (136).)

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 neutron stars.

People might want to consider possibilities for inferring the presence of dark matter content in neutron stars. (See discussion related to equations (170) and (171).)

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 [95].) 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 (199) shows. Reference [96] discusses two attempts to detect dark matter bosons that would correlate with interactions between neutrons in ordinary matter atomic nuclei and electrons in ordinary matter atoms that include the atomic nuclei. (Reference [96] cites reference [97] as exemplifying experiments regarding isotopes of ytterbium and reference [98] as exemplifying experiments regarding isotopes of calcium.) Proposed modeling suggests that at least one of equation (199) and $2(2)\text{G}68 \neq 2(1)\text{G}68$ might explain the types of effects that both attempts report.

$$2(6)\text{G}248 \neq 2(1)\text{G}248 \tag{199}$$

Proposed modeling suggests new possibilities for directly detecting dark matter or doubly dark matter. To the extent that PR6ISP pertains to nature and PR36ISP does not pertain to nature, the following discussion pertains to detecting dark matter. To the extent that PR36ISP pertains to nature, the following discussion pertains to detecting doubly dark matter. The basis for one possibility is the difference between $2(6)\text{G}248$ and $2(1)\text{G}248$. 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. (We are uncertain as to the extent that people might want to try to use, in the context of $2(6)\text{G}248$, detectors based on magnons. See reference [99]. The reference discusses possibilities for detecting light dark matter and not necessarily the types of dark matter that proposed modeling suggests. However, the proposed detection would be via magnetic fields.) Independent of that possible means for detection, people might try to infer $2(6)\text{G}248$ phenomena correlating with dark matter magnetic fields (or - for the PR36ISP case - $2(6)\text{G}248$ phenomena correlating with doubly dark matter magnetic fields). A basis for another possibility is the difference between $2(2)\text{G}68$ and $2(1)\text{G}68$. Proposed modeling suggests that $2\text{G}68$ correlates with, at least, some atomic transitions.

We discuss three possibilities for making and detecting dark matter.

Equations (200), (201), and (202) show interactions that would 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 427 GeV. (Here, we assume results that equations (98) and (99) show.) For an experiment, the number of conversions might be small. The following notions might correlate with such smallness. The range of the $2\text{T}^{\pm}$ boson might be small compared to the size of a neutron. (See discussion related to equation (88).) Effects that ongoing modeling 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.

$$2(Q^{-1} \to R^0 + T^{-1}) \tag{200}$$

$$Q^{+2} + T^{-1} \to Q^{+1} \tag{201}$$

$$Q^{+1} + T^{-1} \to R^0 \tag{202}$$

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 interactions.

Equations (203), (204), and (205) show interactions that would convert a proton into a dark matter $1R \otimes 2U$ 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 640 GeV. (Here, we assume results that equations (98) and (99) show.)

$$2(Q^{+2} \to R^0 + T^{+2}) \tag{203}$$

$$Q^{-1} \to R^0 + T^{-1} \tag{204}$$

$$2(T^{+2}) + T^{-1} \to W^{+3} + I^0 \tag{205}$$

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 (206) and (207) show interactions that would convert a positron and an electron into the fermion components for a $1R \otimes 2U$ hadron-like particle that would have some similarity to a neutral pion. A threshold energy could be about 81 GeV. Detecting the $1R \otimes 2U$ 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 be possible and prove difficult.

$$C^{+3} \to R^0 + W^{+3} \tag{206}$$

$$C^{-3} + W^{+3} \to R^0 \tag{207}$$

9.2. Possible opportunities regarding 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 (12).) 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 the 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 numbers of dimensions - that correlates with equation (15). We note bases for some possible opportunities. Possibly, people can find additional significance regarding the array of numbers for which table 9 shows a portion. Possibly, people can find significance regarding a set of similar arrays for which j varies.

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 68.) People might further explore using ALG modeling based on non-isotropic harmonic oscillator mathematics to do PFS modeling or to do KMS 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 modeling equations that, for example, sum momenta. (Discussion above points to symmetries that correlate with summable quantities related, for example, to charge, to lepton number minus baryon number, and to momenta. See, for example, table 58a.)

People might try to correlate modeling involving many objects with modeling regarding entropy. (See discussion related to equation (215).)

9.3. Possible opportunities to develop deeper insight

We discuss modeling that people might use as bases for developing new aspects of physics modeling.

9.3.1. Numbers of dimensions

Proposed modeling 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 (53) and (54).)

Proposed modeling includes modeling that features other than three spatial dimensions. (See, for example, the SA-side aspects of representations that table 48 shows or the column labeled with the one-element symbol D in table 32b.) Ongoing modeling includes modeling that features other than three spatial dimensions.

Some proposed modeling 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 30.) As far as we know, ongoing modeling does not include parallels to such aspects of proposed modeling. Ongoing modeling aspects that correlate with three spatial dimensions and one temporal dimension tend to correlate with proposed modeling aspects for which $\nu_{SA} \geq 0$ pertains. (See table 30.)

Equations (53) and (54) might provide a characterization that can be useful, for much physics modeling, regarding the notions of three spatial dimensions and one temporal dimension.

9.3.2. Arrow of time

Equation (184) and discussion related to equation (37) suggest a notion of a $\Psi(t,r)$ that correlates with the TA0-and-SA0 oscillator pair. (See equation (6).) We suggest that equation (208) might pertain. (Perhaps, see also discussion related to equation (184) and discussion related to equation (186).) 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.

$$\Psi(t,r) \propto \exp(-tr/(\eta_{TA}\eta_{SA})) \tag{208}$$

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 modeling notion that aspects of modeling of conservation of energy correlate with an $SU(5)$ symmetry (and not necessarily with an ongoing modeling notion of $S1G$ symmetry) might provide insight regarding the topic of arrow of time. Proposed modeling tends to correlate $SU(\_)$ symmetries with origins (with respect to coordinates) and with radial coordinates.

Table 122: Possible correlations between some types of models and three notions of mass (with HO3-4 denoting that oscillator pairs of the form XA3-and-XA4 pertain)

Models	Theme (regarding models)	m	HO3-4
Core ongoing modeling KMS	Motions of objects	m_{in}	-
Core proposed modeling PFS	Interactions of objects with environments	m_{pg}	Yes
Core proposed modeling UMS	Additive properties of objects	m_{ag}	Yes
Supplementary proposed modeling KMS	Motions of objects	m_{in}	Yes

9.3.3. Inertial mass and gravitational mass

We discuss the possibility that proposed modeling provides insight regarding the possible equivalence of inertial mass and passive gravitational mass.

We assume that ongoing modeling Newtonian mechanics pertains. Equation (209) describes the acceleration $\overrightarrow{a}$ of an object of inertial mass m_{in} because of a force $\overrightarrow{F}$. Equation (210) describes the force that an object of passive gravitational mass m_{pg} experiences because of an object - of active gravitational mass m_{ag} - that is located a distance $\overrightarrow{r}$ from the object correlating with m_{pg}. (To some extent, regarding $\overrightarrow{r}$, we assume that we can model all objects as being point-like.) The three-word term passive gravitational mass refers to a mass that correlates with reactions of an object to externally generated gravitational fields. The three-word term active gravitational mass refers to a mass that correlates with the gravitational field that correlates with an object (or, that the object generates). Also, $r = |\overrightarrow{r}|$. The notion that modeling based on equation (211) seems to pertain for objects has been a topic of discussion for centuries.

$$\overrightarrow{F} = m_{in}\overrightarrow{a} \tag{209}$$

$$\overrightarrow{F} = (G_N m_{pg} m_{ag}/r^2) \cdot (-\overrightarrow{r}/r) \tag{210}$$

$$m_{in} = m_{pg} \tag{211}$$

For purposes of this discussion, we posit that one can assume that freeable energy equals zero. (See, for example, tables 58 and 111.)

Table 122 shows possible correlations between some types of models and three notions of mass. For some rows in table 122, oscillator pairs of the form XA3-and-XA4 pertain.

Aspects related to table 122 might suggest insight regarding possible equivalences - at least for purposes of modeling - among the three notions of mass.

9.3.4. Notions that might link physics constants and modeling

Table 123 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 66 and table 84.) In table 123, an item in parentheses shows a non-zero magnitude that pertains for modeling that correlates with the notion of free environment. Except for regarding speed, the number is a minimal non-zero magnitude. (For charge, for unfree environments, $|q_\epsilon|/3$ pertains. For 3LB, for unfree environments, the number one 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 (78) and (79).) 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 60.) Such a correlation might be useful with solutions that allow $\lambda = [\![16]\!] \in \Gamma$.

Some items in table 123 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 $\hbar$ and might correlate with μ_0, the vacuum magnetic permeability. Mass might correlate with G_N, the gravitational constant.

Proposed modeling might suggest opportunities to further explore relationships between charge and mass and relationships between strengths of components of G-family forces. For example, table 83 points to possible relationships between charge and mass.

Table 123: 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 objects in free environments; and with ((_)) denoting a different type of non-zero physics constant)

Σ	Scalar	Vector	2-tensor	3-tensor
0				
2	Charge ($|q_\epsilon|$)	Magnetic flux (K_J)	Precessing flux	
4	Mass	Rotating mass	Moments of inertia	Rotating moments
6	Freeable energy			
8	3LB (3)	Spin ($\hbar/2$)		?
...				
16	Speed ((c))			

Proposed modeling 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 123, for which $\Sigma = 8$ pertains.)

Proposed modeling 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 (212) and (213) pertain. The symbol m denotes mass. Boson simple particle masses tend to feature relationships regarding squares of masses. Equation (212) points to results that feature squares of masses. For each simple boson other than the pie and tweak bosons, 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 quarks and arcs in hadron-like particles. Equation (213) 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 (214) follows from equation (213) and produces results pertaining to squares of simple fermion masses other than neutrino masses and arc masses.

$$\int\limits_{0}^{m/(m_Z/3)} 2r^1 dr \tag{212}$$

$$\int\limits_{1}^{m/m_\epsilon} r^{-1} dr \tag{213}$$

$$\int\limits_{1}^{m/m_\epsilon} 2r^{-1} dr \tag{214}$$

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 modeling models become more complex than ongoing modeling models 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 modeling expression for entropy that equation (215) 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.

$$j \log(j) \tag{215}$$

10. Concluding remarks

This unit discusses possible opportunities based on proposed modeling.

Proposed modeling might provide impetus for people to tackle broad agendas that our work suggests. Proposed modeling might provide means to fulfill aspects of such agendas. Proposed modeling might fulfill aspects of such agendas.

Opportunities might exist to develop more sophisticated modeling than the modeling that we present. Such a new level of work might provide more insight than we provide.

Proposed modeling might suggest applied mathematics techniques that have uses other than uses that we make.

Proposed modeling 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.

Acknowledgments

Table 124 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 124: Communications that this essay cites but that do not necessarily qualify for inclusion in the bibliography

(a)

Communication	Note
Asgari, M.; Lin, C.-A.; Joachimi, B. & others. KiDS-1000 Cosmology: Cosmic shear constraints and comparison between two point statistics. Link(2020): https://arxiv.org/abs/2007.15633	We did not find a publication beyond the stage of a preprint possibly submitted to Astronomy & Astrophysics.

(b)

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.

(c)

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."

(d)

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.

(e)

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] Frank Wilczek. Could Einstein Get Published Today? *The Wall Street Journal*, CCLXXVI(74):C4, September 2020. Link(2020): https://www.wsj.com/articles/could-einstein-get-published-today-11600974323. 1

[3] Eric Weisstein. Delta Function. Wolfram MathWorld web page. Link(2020): http://mathworld.wolfram.com/DeltaFunction.html. 2.2

[4] Kevin Harnett. Mathematicians Explore Mirror Link Between Two Geometric Worlds. *Quanta Magazine*, April 2018. Link(2020): https://www.quantamagazine.org/mathematicians-explore-mirror-link-between-two-geometric-worlds-20180409/. 2.4

[5] 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

[6] Julian Heeck. Unbroken B–L symmetry. *Phys. Lett. B*, 739:256–262, December 2014. 3.2.7

[7] Francesco Renga. Experimental searches for muon decays beyond the Standard Model. *Rev. Phys.*, 4:100029, November 2019. 3.2.7

[8] Sarah Charley. W bosons remain left-handed. *Symmetry*, July 2015. Link(2020): https://www.symmetrymagazine.org/article/july-2015/w-bosons-remain-left-handed. 3.2.7

[9] 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. 3.2.7

[10] Viviana Niro and Pedro Machado. Sterile Neutrino Down but Not Completely Out. *Physics*, 13, August 2020. Link(2020): https://physics.aps.org/articles/pdf/10.1103/Physics.13.123. 4.2.4

[11] L. Gurung, T. J. Babij, S. D. Hogan, and D. B. Cassidy. Precision Microwave Spectroscopy of the Positronium $n = 2$ Fine Structure. *Phys. Rev. Lett.*, 125:073002, August 2020. 4.2.7, 6.4

[12] Matteo Rini. A Fine Positronium Puzzle. *Physics*, 13, August 2020. Link(2020): https://physics.aps.org/articles/v13/s99. 4.2.7

[13] 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, 4.3.5, 4.3.5, 4.3.5, 4.3.6, 4.3.12, 4.3.13, 5.3.2, 5.3.2, 5.3.18, 6.5, 8.2.1, 8.2.2

[14] 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. 4.3.4, 4.3.4, 4.3.5, 4.3.5, 4.3.6

[15] 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. 4.3.12

[16] 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. 4.3.14

[17] 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. 4.3.14

[18] Johanna L. Miller. Closing in on neutrino CP violation. *Phys. Today*, 2020(1):0423a, April 2020. 4.3.16, 5.3.8

[19] 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

[20] Edward Witten. Cosmic separation of phases. *Phys. Rev. D*, 30(2):272–285, July 1984. 5.2.1

[21] M. H. Chan. Observational evidence for dark matter interacting through a Yukawa potential. *Astrophys. J. Letters*, 769(1):L2, May 2013. 5.2.1

[22] 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

[23] 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

[24] 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

[25] 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

[26] Paolo Panci. 21-cm line Anomaly: A brief Status. In *33rd Rencontres de Physique de La Vallee d'Aoste*, July 2019. 5.3.5

[27] N. G. Busca, T. Delubac, J. Rich, et al. Baryon acoustic oscillations in the Ly*a* forest of BOSS quasars. *A&A*, 552(A96), April 2013. 5.3.6

[28] 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

[29] 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

[30] 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

[31] 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, 5.3.7

[32] 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

[33] Charlie Wood. A New Cosmic Tension: The Universe Might Be Too Thin. *Quanta Magazine*, September 2020. Link(2020): https://www.quantamagazine.org/a-new-cosmic-tension-the-universe-might-be-too-thin-20200908/. 5.3.10

[34] Khaled Said, Matthew Colless, Christina Magoulas, et al. Joint analysis of 6dFGS and SDSS peculiar velocities for the growth rate of cosmic structure and tests of gravity. *Mon. Not. R. Astron. Soc.*, 497(1):1275–1293, July 2020. 5.3.10

[35] Supranta S. Boruah, Michael J. Hudson, and Guilhem Lavaux. Cosmic flows in the nearby Universe: new peculiar velocities from SNe and cosmological constraints. *Mon. Not. R. Astron. Soc.*, August 2020. 5.3.10

[36] Christopher Wanjek. Dark Matter Appears to be a Smooth Operator. *Mercury*, 49(3):10–11, October 2020. 5.3.10, 6.3

[37] 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. 5.3.11

[38] 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. 5.3.11

[39] Lawrence Rudnick. The Stormy Life of Galaxy Clusters: astro version. January 2019. Link(2020): https://ned.ipac.caltech.edu/level5/March19/Rudnick/frames.html. 5.3.11

[40] Lawrence Rudnick. The stormy life of galaxy clusters. *Phys. Today*, 72(1):46–52, January 2019. 5.3.11

[41] 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. 5.3.11

[42] 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. 5.3.14

[43] Nick Gnedin. Cosmological Calculator for the Flat Universe, 2015. Link(2020): http://home.fnal.gov/~gnedin/cc/. 5.3.14

[44] 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. 5.3.14

[45] 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. 5.3.14

[46] 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. 5.3.14

[47] 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. 5.3.14

[48] 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-per-cent-dark-matter-with-almost-no-stars/. 5.3.14

[49] 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. 5.3.14

[50] 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. 5.3.14

[51] Pieter van Dokkum, Shany Danieli, Yotam Cohen, et al. A galaxy lacking dark matter. *Nature*, 555(7698):629–632, March 2018. 5.3.14

[52] 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. 5.3.14

[53] 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. 5.3.14

[54] 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. 5.3.14

[55] 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. 5.3.14

[56] 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. 5.3.14

[57] 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. 5.3.14

[58] 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. 5.3.14

[59] Heather Hill. Massive galaxies from the early universe found hiding in plain sight. *Phys. Today*, September 2019. 5.3.14

[60] 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. 5.3.14

[61] Massimo Meneghetti, Guido Davoli, Pietro Bergamini, et al. An excess of small-scale gravitational lenses observed in galaxy clusters. *Science*, 369(6509):1347–1351, September 2020. 5.3.15

[62] Maria Temming. Dark matter clumps in galaxy clusters bend light surprisingly well. *Sci. News*, September 2020. Link(2020): https://www.sciencenews.org/article/dark-matter-clumps-galaxy-clusters-bend-light-surprisingly-well. 5.3.15

[63] 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. 5.3.15

[64] M. Volonteri. Evolution of Supermassive Black Holes. In *ESO Astrophysics Symposia*, pages 174–182. Springer Berlin Heidelberg, 2007. 5.3.15

[65] 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. 5.3.15

[66] 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. 5.3.15

[67] 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. 5.3.16

[68] David Ehrenstein. Mapping Dark Matter in the Milky Way. *Phys. Magazine*, 12(51), May 2019. Link(2020): https://physics.aps.org/articles/v12/51. 5.3.16

[69] Lina Necib, Mariangela Lisanti, and Vasily Belokurov. Inferred Evidence for Dark Matter Kinematic Substructure with SDSS–Gaia. *ApJ*, 874(1):3, March 2019. 5.3.16

[70] 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. 5.3.17

[71] 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. 5.3.17

[72] Heather Hill. Strange matter interacts strongly with nucleons. *Phys. Today*, 2020(1):0327a, March 2020. 5.3.17, 5.3.17

[73] 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/. 5.3.17, 5.3.17

[74] 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. 5.3.17

[75] 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. 5.3.17

[76] G. Risaliti and E. Lusso. Cosmological constraints from the Hubble diagram of quasars at high redshifts. *Nature Astronomy*, 3(3):272–277, January 2019. 5.3.18

[77] 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

[78] 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

[79] Johanna L. Miller. Gravitational-lensing measurements push Hubble-constant discrepancy past 5σ. *Phys. Today*, 2020(1):0210a, February 2020. 6.3

[80] 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

[81] 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

[82] 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

[83] 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

[84] 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

[85] 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

[86] 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

[87] 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

[88] Maria Temming. This is the first known particle with four of the same kind of quark. *Sci. News*, 198(2), August 2020. Link(2020): https://www.sciencenews.org/article/new-particle-cern-tetraquark-first-four-same-kind-quark. 8.1.3

[89] 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

[90] Philip W. Anderson. Brainwashed by Feynman? *Phys. Today*, 53(2):11–12, February 2000. 8.1.4

[91] 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

[92] 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

[93] G. A. Gonzalez-Sprinberg and J. Vidal. Tau magnetic moment. *J. Phys. Conf. Ser.*, 912(1):012001, 2017. 8.2.2

[94] Teppei Kitahara, Takemichi Okui, Gilad Perez, et al. New Physics Implications of Recent Search for KL→π0νν̄ at KOTO. *Phys. Rev. Lett.*, 124(7), February 2020. 9.1.2

[95] 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

[96] Katherine Wright. Hints of Dark Bosons. *Physics*, September 2020. Link(2020): https://physics.aps.org/articles/v13/s115. 9.1.3

[97] Ian Counts, Joonseok Hur, Diana P. L. Aude Craik, et al. Evidence for Nonlinear Isotope Shift in Yb+ Search for New Boson. *Phys. Rev. Lett.*, 125(12), September 2020. 9.1.3

[98] Cyrille Solaro, Steffen Meyer, Karin Fisher, et al. Improved Isotope-Shift-Based Bounds on Bosons beyond the Standard Model through Measurements of the D23/2-D25/2 Interval in Ca+. *Phys. Rev. Lett.*, 125(12), September 2020. 9.1.3

[99] Tanner Trickle, Zhengkang Zhang, and Kathryn M. Zurek. Detecting Light Dark Matter with Magnons. *Physical Review Letters*, 124(20), May 2020. 9.1.3