Modeling that matches, augments, and unites data about physics properties, elementary particles, cosmology, and astrophysics

Thomas J. Buckholtz

Ronin Institute for Independent Scholarship, Montclair, New Jersey 07043, USA

Abstract

This essay shows and uses modeling that matches and predicts data. Our work addresses five facets of physics. One facet is properties of objects. The modeling catalogs properties. The modeling suggests a new property – isomer. An isomer is a near copy of a set of most elementary particles. A second facet is elementary particles. The modeling matches all known elementary particles. The modeling suggests new elementary particles. The properties and the particles seem to suffice to explain dark matter. The modeling describes a graviton. A third facet is cosmology. The modeling suggests bases for five eras in the evolution of the universe. Two eras would precede inflation. A fourth facet is astrophysics. The modeling matches data about dark matter and galaxies. The modeling seems to offer insight about galaxy formation. That the modeling seems to explain facet three and facet four data might confirm some of our work regarding facets one and two. A fifth facet is physics modeling. Our work augments and does not disturb centuries of useful physics. Our modeling has roots in discrete mathematics. Our modeling unites itself and widely-used physics modeling.

Keywords: Beyond the Standard Model, Dark matter, Galaxy evolution, Rate of expansion of the universe, Inflation, Quantum gravity

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Contents

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

1. Introduction

This essay suggests advances regarding two sets of physics challenges. One set features describing elementary particles that people have yet to find and describing dark matter. One set features explaining cosmology and astrophysics data that people have yet to explain and predicting cosmology and astrophysics data that people have yet to obtain.

We suggest that our explanations regarding cosmology and astrophysics data correlate with the possibility that our descriptions of new particles and dark matter comport with nature.

We blend two sets of work.

We use the two-word term ongoing modeling to describe models developed by people other than us. We divide the models into two categories. We correlate the word core and the word unverified with that division. The word core correlates with people having found that the models comport with nature. The word unverified correlates with other ongoing modeling.

We use the two-word term proposed modeling to describe our work. We divide the models into two categories. We correlate the word core and the word supplementary with that division. Core proposed modeling addresses properties of elementary particles and dark matter. Core proposed modeling also suggests explanations for cosmology and astrophysics data. Supplementary proposed modeling features suggested supplements to core ongoing modeling kinematics models.

This essay unites core ongoing modeling and core proposed modeling. Core ongoing modeling provides models for the motions of and changes to objects. Core proposed modeling suggests and interrelates properties of objects.

Proposed modeling augments core ongoing modeling. Proposed modeling does not disturb core ongoing modeling. Some ongoing modeling uses space-time coordinates. Core proposed modeling has bases

Some properties of objects

(A catalog that includes a parameter λ)

λ *	Symbol	Property
2	q	Charge
4	m	Mass
6	-	Three generations (for elementary fermions)
8	$\vec{j}$	Angular momentum
10	$\hbar$	Quantum of angular momentum exchange
12	$\vec{p}$	Momentum
14	c	Speed limit
16	$\vert q_e \vert$	Quantum of charge exchange

* λ – A parameter. λ=2 correlates with electromagnetism and with a spin-1 force carrier (the photon). λ=4 correlates gravitation and with a possible spin-2 force carrier (the graviton). While the cataloguing technique extends to λ=16, the series of possible forces and possible force carriers does not extend beyond λ=8.

Figure 1: A catalog of some properties of objects

Elementary particles

(Elementary-particle subfamilies)

In hadron-like		>0	Σ=2S *	=0		In hadron-like	G family
	0H	m	0	m	0I		
1Q	1C	$\vert q \vert$	1	$\vert q \vert$	1N	1R	
	2W	m	2	m	2J	2U	2G
			4	m			4G
			6	m			6G
			8	m			8G

* S – spin, as in $S(S+1)\hbar^2$

0H: Higgs boson. 1Q: quarks. 1C: charged leptons. 2W: weak-interaction (Z and W) bosons.
1N: neutrinos. 2U: gluons. 2G: photon.
0I: inflaton. 1R: zero-charge analogs to quarks. 2J: modeling analog to the Pauli exclusion force.
4G: graviton. 6G: interacts with (and strength differs by) fermion generation. 8G: interacts with spin.

Known	m - mass
Suggested	q - charge

Figure 2: Subfamilies of elementary particles

that do not use space-time coordinates. Core proposed modeling does not disturb core ongoing modeling that people might correlate with notions of space-time.

The following figures preview some results that this essay discusses.

Figure 1 shows a catalog of some properties of objects. The symbol λ denotes a parameter that proposed modeling uses. The symbol λ indexes items in the catalog.

Figure 2 summarizes some information about elementary particles. The figure alludes to all known elementary particles. The figure alludes to elementary particles that proposed modeling suggests and that people have yet to find. Each row correlates with one value of Σ. The symbol Σ equals $2S$. The symbol S denotes spin and correlates with the ongoing modeling expression $S(S+1)\hbar^2$. Correlations between Σ and λ exist.

Figure 3 suggests rest energies for some elementary fermions. Proposed modeling calculates the suggested rest energies.

Figure 4 shows a catalog of eras regarding the evolution of the universe. Proposed modeling suggests aspects regarding each of five eras. Figure 5 discusses the notion of isomers.

Figure 5 depicts information about - and discusses a proposed modeling explanation for - the ratio of dark matter density of the universe to ordinary matter density of the universe.

Figure 6 lists some seemingly prevalent observed ratios of dark matter to ordinary matter. Proposed modeling suggests explanations for each ratio.

Figure 7 suggests that ongoing modeling provides a framework for cataloging, comparing, and uniting

Suggested rest energies for some elementary fermions

(Calculated approximate rest energies)

Subfamily	Elementary particle	Approximate rest energy		Note
1C	Tauon	1776.8400±0.0115	MeV	The standard deviation reflects the standard deviation correlating with measurements of G_N .
1Q	Up (quark)	2.335	MeV	
1Q	Down (quark)	4.479	MeV	
1Q	Charm (quark)	1.178×10^3	MeV	
1Q	Strange (quark)	1.006×10^2	MeV	
1Q	Top (quark)	1.695×10^5	MeV	
1Q	Bottom (quark)	4.232×10^3	MeV	
1R	Arc – generation one	8.593	MeV	
1R	Arc – generation two	8.593	MeV	
1R	Arc – generation three	1.0566×10^2	MeV	This rest energy equals the muon rest energy.
1N	Neutrinos – each of the three generations	3.4475×10^{-2}	eV	Effects of 6G correlate with measurements that people interpret as implying that masses differ by generation.

Figure 3: Suggested rest energies for some elementary fermions

Eras regarding the rate of separation of large clumps

(Eras regarding "the rate of expansion of the universe")

RSDF *	Force **	Rate of separation	Era name	Duration	Note
?		?	TBD	?	Speculative
r^{-6}	Attractive	Is negative	TBD	Fraction of a second	
r^{-5}	Repulsive	Is positive	TBD	Fraction of a second	Isomers form
r^{-5}	Repulsive	Increases	Inflation	Fraction of a second	
r^{-4}	Attractive	Decreases	TBD	Billions of years	
r^{-3}	Repulsive	Increases	TBD	Recent billions of years	
(r^{-2})	(Attractive)				Speculative

* RSDF –Radial Spatial Dependence of Force (assuming the use of modeling that has bases in Newtonian kinematics) that dominates between two large clumps

** Force – 4G (or, gravity). The notion of components, each with its own RSDF, parallels the 2G (or, electromagnetism) notions – regarding stationary, non-rotating objects – of r^{-2} for an electrostatic monopole force and r^{-3} for a magnetic dipole force.

Observed

Suggested

Figure 4: Eras regarding the evolution of the universe

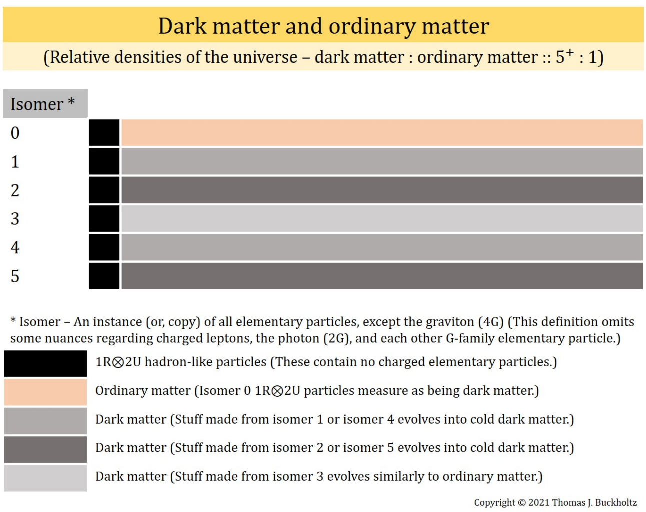

Figure 5: Dark matter and ordinary matter

Ratios of dark matter to ordinary matter

(Seemingly prevalent approximate ratios)

Dark matter	Ordinary matter	Phenomenon
5^+	1	Density of the universe
5^+	1	Some galaxy clusters
1	1	Some absorption of CMB *
0^+	1	Some galaxies
4	1	Some galaxies
1	0^+	Dark matter galaxies

* CMB – Cosmic microwave background radiation

Figure 6: Seemingly prevalent approximate ratios of dark matter to ordinary matter

A framework for comparing and uniting physics models

(Proposed modeling seems to unite itself and various advances regarding ongoing modeling.)

U_A	λ	Aspect (with fermion denoting elementary fermion; and with boson denoting elementary boson)	Baseline (O.M. & P.M.)	Classical advance (O.M. & P.M.)	Quantum advance (O.M.)	Quantum advance (P.M.)
UTA	0	Entanglement			(concept)	(parameter)
UTA	2	Color charges			3	3
UTA	4	Total energy	Conserved		Discrete states	Discrete states
UTA	6	Freeable total energy		$(1/2)k_BT$	Discrete spectra	Discrete spectra
USA	0	Nonzero/zero (boson mass or fermion charge)			(concept)	(parameter)
USA	2	Charge		Conserved		
USA	4	Passive gravitational energy			? Graviton (GR)	Isomers of ΣΦ (Φ≠G)
USA	6	Freeable passive gravitational energy; fermion generations			? Graviton (SM)	Graviton (4G); 3 gens
USA	8	Angular momentum	Conserved		Discrete states	Discrete states
USA	10	Freeable angular momentum			$\hbar$	$\hbar$
USA	12	Momentum	Conserved			
USA	14	Freeable momentum; boost symmetry		; c		
USA	16	Freeable charge; magnitudes of fermion nonzero charge			$\lvert q_e\rvert$	$\lvert q_e\rvert$; 3 magnitudes

(O.M.) – Ongoing modeling seems to be OK.

(O.M.) – Ongoing modeling seems not to be OK.

(P.M.) – Proposed modeling might be OK.

GR (General relativity) – no isomers

SM (Standard Model) – elementary bosons ($m^2 \propto \Sigma(\pm \text{integer})$) and elementary leptons ($\log(m/m_e) \propto \Sigma(\beta^j \alpha^k \times (\approx \text{integer}))$) differ regarding mass

Isomers of ΣΦ (Φ≠G) – 6 isomers of the subfamilies ΣΦ for which Φ≠G

4G (Proposed modeling ENT models and GFC aspects); 3 fermion generations

Figure 7: A framework for cataloging, comparing, and uniting aspects of proposed modeling and aspects of ongoing modeling

aspects of proposed modeling and aspects of ongoing modeling. Figure 7 uses and extends notions that figure 1 shows.

2. Methods

This unit addresses the following opportunities. Motivate and develop methods that proposed modeling uses. Use the methods. Develop and show results from using the methods. Discuss the methods and results.

2.1. Modeling regarding objects and their properties

We develop bases for modeling objects and their properties. We show a means for cataloging some properties of objects.

2.1.1. Bases for modeling objects and properties

Ongoing modeling models photons via two harmonic oscillators. For modeling a photon, one chooses two spatial axes. Each axis is perpendicular to the direction in which the photon moves. The two axes are perpendicular to each other. Ongoing modeling might label the two axes with, respectively, the symbols x and y. Each harmonic oscillator models a number of excitations that people correlate with the photon mode that people correlate with the relevant axis. Equations (1), (2), and (3) show a number - n - of excitations, the raising operator, and the lowering operator. Equation (4) shows the ongoing modeling range for the integer n.

$$|n> \tag{1}$$

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

$$a^{-}|n>= n^{1/2}|n-1> \tag{3}$$

$$n \geq 0 \tag{4}$$

Ongoing modeling correlates with three spatial dimensions. Proposed modeling suggests adding, regarding photons, a third harmonic oscillator. The oscillator correlates with the direction of motion. Modeling might label the axis correlating with the direction of motion with the symbol z. Ongoing modeling states that photons have zero mass. Ongoing modeling states that longitudinal polarization does not pertain for photons. Proposed modeling suggests extending each of equations (1), (2), and (3) to pertain for the domain that equation (5) shows. Regarding the oscillator that correlates with z, equation (6) shows that this extension is compatible with zero longitudinal polarization. Longitudinal polarization does not excite.

$$n \geq -1 \tag{5}$$

$$a^{+}|-1>= (1+(-1))^{1/2}|0>= 0|0> \tag{6}$$

Proposed modeling uses the construct $@_k$ to denote a value k that does not change. For example, equation (7) pertains.

$$@_0 = 0 \tag{7}$$

Equation (8) pertains regarding our suggested extension - of ongoing modeling for photons - to include three spatial harmonic oscillators. The notation $\{\cdots\}$ denotes a set. The expression $KSAj$ parses as follows. The symbol K correlates with the notion of kinematics modeling. (Elsewhere, we discuss notions of other modeling. See, for example, table 1.) The symbol S correlates with the word spatial. (Elsewhere, we discuss notions of T and temporal. See, for example, discussion related to equation (12).) The symbol A correlates with the word aspects. For example, one can read SA as denoting the two-word phrase spatial aspects. The symbol j varies over the range of applicable oscillators. Equation (9) pertains for mode x. Equation (10) pertains for mode y.

$$\{KSAj\} = \{KSAz, KSAx, KSAy\} \tag{8}$$

$$n_{KSAz} = -1,\ n_{KSAx} = n,\ n_{KSAy} = @_0 \tag{9}$$

$$n_{KSAz} = -1,\ n_{KSAx} = @_0,\ n_{KSAy} = n \tag{10}$$

For each of the two modes, equation (11) pertains. The symbol $\equiv$ correlates with the notion of definition. The leftmost equality defines the symbol A_{KSA}.

$$A_{KSA} \equiv \sum_{\{KSAj\}} (n_{KSAj} + (1/2)) = n_{KSAz} + n_{KSAx} + n_{KSAy} + (3/2) = n + (1/2) \tag{11}$$

Ongoing modeling correlates with one temporal dimension. Proposed modeling suggests including an oscillator that correlates with the temporal dimension. Proposed modeling suggests that, for each of the two modes, equations (12), (13), and (14) pertain. Here, the symbol T correlates with word temporal. The symbol t correlates with the one temporal coordinate.

$$\{KTAj\} = \{KTAt\} \tag{12}$$

$$n_{KTAt} = n \tag{13}$$

$$A_{KTA} \equiv \sum_{\{KTAj\}} (n_{KTAj} + (1/2)) = n_{KTAt} + (1/2) = n + (1/2) \tag{14}$$

Equation (15) pertains for each photon mode.

$$A_{KTA} - A_{KSA} = 0 \tag{15}$$

We use the two-element term double-entry bookkeeping to describe the equality that equation (16) shows. Adding a unit to one of A_{KTA} and A_{KSA} requires adding a unit to the other quantity.

$$A_{KA} \equiv A_{KTA} - A_{KSA} = 0 \tag{16}$$

Ongoing modeling includes two-mode photon models for which one mode correlates with left circular polarization and the other mode correlates with right circular polarization. Circular polarization models are invariant with respect to choices of transverse axes. Compared to linear polarization models, circular polarization models are more invariant with respect to choice of observer. For models correlating with a photon in a vacuum, all observers would agree on the number of excitations for left circular polarization and on the number of excitations for right circular polarization.

We convert kinematics notions above to pertain for circular polarization modes. From a perspective of equations underlying models, we use the substitutions that equation (17) shows. An expression of the form $a \leftarrow b$ denotes the six-element phrase b takes the place of a. The oscillator $KSA0$ correlates with longitudinal polarization. We adopt the convention that an oscillator KSA(odd number) correlates with left circular polarization. Oscillator $KSA1$ correlates with left circular polarization. Oscillator $KSA2$ correlates with right circular polarization.

$$KSAz \leftarrow KSA0,\ KSAx \leftarrow KSA1,\ KSAy \leftarrow KSA2 \tag{17}$$

We use the abbreviation KIN (for the word kinematics) and the two-word term kinematics modeling to characterize work and discussion leading to equation (17). Ongoing modeling KIN modeling features aspects regarding motions of and changes to objects. KIN modeling does not necessarily fully address the question of characterizing the objects.

We anticipate developing modeling that outputs representations that correlate with elementary particles. We use the abbreviation ENT (for the word entity) and the two-word term entity modeling to contrast with - respectively - KIN and the two-word term kinematics modeling. Development of proposed modeling ENT modeling stems, in part, from KIN modeling for the photon.

We show aspects that correlate with ENT modeling for the photon. Equations (18), (19), (20), (21), (22) and (23) pertain. Symbols of the form $ETAj$ denote oscillators that correlate with the two-word term temporal aspects. However, space-time coordinates do not underlie ENT modeling. Symbols of the form $ESAj$ denote oscillators that correlate with the two-word term spatial aspects. $ESA1$ correlates with left circular polarization. $ESA2$ correlates with right circular polarization. The two-word term longitudinal polarization correlates with $ESA0$. Equation (23) correlates with double-entry bookkeeping.

$$\{ETAj\} = \{ETA0\} \tag{18}$$

$$n_{ETA0} = n \tag{19}$$

$$\{ESAj\} = \{ESA0, ESA1, ESA2\} \tag{20}$$

$$n_{ESA0} = -1,\ n_{ESA1} = n,\ n_{ESA2} = @_0 \tag{21}$$

$$n_{ESA0} = -1,\ n_{ESA1} = @_0,\ n_{ESA2} = n \tag{22}$$

$$A_{EA} \equiv A_{ETA} - A_{ESA} = 0 \tag{23}$$

ENT modeling for the photon has similarities to KIN modeling for photons. (Compare equation (17) and discussion related to equation (23).) We anticipate ENT modeling for the Higgs boson. Longitudinal polarization pertains. Circular polarization does not pertain. The Higgs boson correlates with $\{ESAj\} = \{ESA0\}$. Each of the photon and the set of weak interaction bosons correlates with $\{ESAj\} = \{ESA0, ESA1, ESA2\}$.

Equation (24) defines the symbol Σ. Here, S is the spin - in the sense of the ongoing physics KIN modeling expression $S(S+1)\hbar^2$ for the square of total spin. Σ is a nonnegative integer.

$$\Sigma \equiv 2S \tag{24}$$

For some elementary particles, the number of ENT modeling spatial oscillators does not equal three. For the elementary particles discussed just above, equation (25) pertains. The symbol $|$ denotes the two-word phrase such that. (Elsewhere, we show that equation (25) does not pertain for ENT modeling for some elementary particles. See discussion - that follows equation (48) - regarding elementary fermions.)

$$\Sigma = 2S = \max(j | n_{ESAj} = 0) \tag{25}$$

We anticipate that - in ENT modeling and for integer $j \geq 1$ - the oscillator $ESA(2j-1)$ correlates with left circular polarization that correlates with $\Sigma = 2j$. The oscillator $ESA(2j)$ correlates with right circular polarization that correlates with $\Sigma = 2j$. For example, $ESA3$ and $ESA4$ correlate with $\Sigma = 4$, $S = 2$, and the would-be graviton.

For ENT modeling and other non-KIN modeling, double-entry bookkeeping continues to pertain.

For ENT modeling and other non-KIN modeling, we continue to use the words temporal and spatial, even though the modeling does not necessarily directly correlate with space-time coordinates. For some ENT modeling, no continuous variables pertain. Some ENT modeling features essentially only integers. The integers are numbers of oscillators and the values of various n_{abAj}. (This essay de-emphasizes discussing the extent to which people might consider that a mathematical space that correlates with a combination of ENT modeling and notions of an energy-momentum space might correlate with a tangent space to a mathematical space correlating with KIN modeling.)

Equations (26) and (27) pertain throughout proposed modeling. For equation (26), the symbol a can be any one of K, E, G, and U. (See table 1.) The symbol b can be any one of T (for temporal) and S (for spatial). Equation (27) correlates with double-entry bookkeeping.

$$A_{abA} \equiv \sum_{\{abAj\}} (n_{abAj} + (1/2)) \tag{26}$$

$$A_{aA} \equiv A_{aTA} - A_{aSA} = 0 \tag{27}$$

Table 1 discusses types of modeling. Some of the types of modeling correlate with equations (26) and (27).

Before discussing ENT modeling for elementary particles that are not the photon, we note aspects of ENT modeling that pertain for more than just the photon.

Equation (23) correlates with an invariance with respect to a choice between KIN modeling that is quadratic in energy and KIN modeling that is linear in energy. Regarding a photon, the expression $0 = E^2 - (pc)^2$ is quadratic in energy. The symbol E denotes energy. The symbol p denotes the magnitude of momentum. The symbol c denotes the speed of light. One can consider that an ENT raising operator correlates with adding one unit of each of the two relevant items - E^2 and $(pc)^2$ - that have the dimensions of the square of energy. For an object with mass m and modeling based on the equation $E^2 = (mc^2)^2 + (pc)^2$ from special relativity, one can consider that an ENT raising operator correlates with adding one unit of each of the three relevant items - E^2, $(mc^2)^2$, and p^2c^2. The Klein-Gordon equation provides an example of KIN modeling - for other than just photons - that can be quadratic in energy. Regarding a photon, the expression $0 = E - pc$ is linear in energy. One can consider that an ENT raising operator correlates with adding one unit of each of the two relevant items - E and pc - that have the dimensions of energy. Each of the Dirac equation and the Schrodinger equation provides an example of KIN modeling - for other than just photons - that is linear in energy.

Either one of A_{ETA} and A_{ESA} would correlate with the ongoing modeling notion of a photon ground state energy that correlates with the expression $0 + (1/2)$ and with the number one-half. (See, for example, equation (14).) People interpret ongoing modeling KIN models as correlating with notions of nonzero quantum energy of the vacuum. Proposed modeling suggests - via equations such as equation (16) - modeling that might obviate needs to consider nonzero quantum energy of the vacuum. Proposed modeling suggests a notion for which this essay uses the two-word term freeable energy. (See, for example, the use in table 12b of the four-word term freeable passive gravitational energy.) For a proposed modeling model and a choice of object, the ground state of the object models as having zero freeable energy. (The

Table 1: Types of modeling

Modeling	a	Notes
KIN	K	KIN denotes the word kinematics. Modeling features motions of and changes to objects. Modeling might not yet suggest elementary particles that people have yet to find. Modeling has roots in the principle of stationary action and in Lagrangian mathematics. KIN modeling underlies much ongoing modeling. Proposed modeling suggests re-interpretations of and extensions to ongoing modeling KIN modeling.
ENT	E	ENT denotes the word entity. Modeling matches all known elementary particles and suggests specific elementary particles - and properties of those particles - that people have yet to find. The set of elementary particles might suffice to explain much data that ongoing modeling seems not to explain. Modeling has roots in some aspects of KIN modeling, in symmetries that correlate with physics conservation laws, and in Hamiltonian mathematics. ENT modeling is a subset of proposed modeling.
GFC	G	GFC denotes the two-element phrase G-family components. Modeling suggests correlations between long-range forces and properties of objects. (Each of the notion of the G-family of elementary particles and the notion of long-range forces correlates with the photon, the would-be graviton, and possibly other elementary particles.) Modeling has roots in ENT modeling and in symmetries that correlate with physics conservation laws. GFC modeling is a subset of proposed modeling. GFC modeling echoes aspects of ongoing modeling.
UNI	U	UNI denotes the word united. Modeling produces a catalog of properties of objects and of relationships between properties. (Here, the notion of object includes both elementary particles and objects that include more than one elementary particle.) Modeling unites aspects of KIN modeling, ENT modeling, and GFC modeling. UNI modeling unites aspects of ongoing modeling and aspects of proposed modeling.
Double-entry bookkeeping		Double-entry bookkeeping pertains for the following. Some proposed modeling re-interpretations of or extensions to ongoing modeling KIN modeling. Proposed modeling ENT modeling. Proposed modeling GFC modeling. Some aspects of proposed modeling UNI modeling.
Quantum excitations		The notion of quantum excitations pertains for some KIN modeling and for ENT modeling. The notion of quantum excitations does not necessarily directly pertain for GFC modeling.

Table 2: An ENT representation for photon ground states

$ETA4$	$ETA3$	$ETA2$	$ETA1$	$ETA0$	$ESA0$	$ESA1$	$ESA2$	$ESA3$	$ESA4$	$\Sigma\Phi$
				0	-1	0	0			2G

Table 3: A basis for ENT representations for G-family ground states (with LCP denoting left circular polarization; and with RCP denoting right circular polarization)

$ETA\cdots$	$ETA0$	$ESA0$	$ESA1$	$ESA2$	$ESA3$	$ESA4$	$ESA\cdots$
$\cdots$	0	-1	$\Sigma=2$:LCP	$\Sigma=2$:RCP	$\Sigma=4$:LCP	$\Sigma=4$:RCP	$\cdots$

following example features the topic of choice of model. A model for transitions between energy levels in an atom does not necessarily need to consider the rest energies of the relevant electrons and atomic nucleus as correlating with freeable energy. Such a model can feature a ground state that correlates with the ground state of the atom.)

We discuss ENT modeling for elementary particles that are not the photon.

This essay uses the notation Φ to correlate with so-called families of elementary particles. This essay uses the notation $\Sigma\Phi$ to name so-called subfamilies of elementary particles. The two-element term G family includes the photon and the would-be graviton. Here, Φ=G.

Regarding ENT modeling, this essay tends to emphasize ground states and de-emphasize excited states. Such work in this essay tends to feature harmonic oscillator states that correlate with the numbers 0 and -1. Such work tends not necessarily to state explicitly distinctions between $@_k$ and k.

Table 2 shows an ENT representation for photon ground states.

We assume that table 3 pertains for G-family ground states.

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

In ongoing modeling KIN modeling, an excitation of a photon 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.

In proposed modeling ENT modeling, excitations of a photon carry similar information. We anticipate that GFC modeling points to encoded information to which ongoing modeling KIN modeling does not point. The additional encoded information correlates with the isomer or isomers that participated in the creation of the photon. (See table 8 and table 9c.)

We consider the left circular polarization mode of 2G.

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 (28) provides notation that we use for such combinations. The symbol ΣG denotes a subfamily of the G-family. The symbol Γ denotes a set of even positive integers. We use the symbol λ to denote an element of Γ. Each value of λ correlates with the oscillator pair $GSA(\lambda-1)$-and-$GSA\lambda$. For the above example of subtracting spin-1 from spin-2, the notation $\Gamma=24$ pertains and equation (29) pertains.

$$\Sigma\mathrm{G}\Gamma \tag{28}$$

$$\Sigma=|-2+4|=2 \tag{29}$$

Table 4 echoes table 3. Table 3 pertains for ENT modeling. Table 4 pertains for GFC modeling.

Table 5 points to possibly relevant solutions for which the limit $\lambda\leq 8$ pertains. (The word solution correlates with harmonic oscillator mathematics and double-entry bookkeeping. Here, a solution solves - or, satisfies - the equation $A_{GA}\equiv A_{GTA}-A_{GSA}=0$. We anticipate that some solutions have relevance

Table 4: A basis for GFC representations for G-family components (with LCP denoting left circular polarization; and with RCP denoting right circular polarization)

$GTA\cdots$	$GTA0$	$GSA0$	$GSA1$	$GSA2$	$GSA3$	$GSA4$	$GSA\cdots$
$\cdots$	0	-1	$\lambda=2$:LCP	$\lambda=2$:RCP	$\lambda=4$:LCP	$\lambda=4$:RCP	$\cdots$

Table 5: G-family solutions that may be relevant and for which $\lambda \leq 8$

Other	GFC monopole	GFC dipole	GFC quadrupole	GFC octupole
0G$\emptyset$	2G2	ΣG24	ΣG246	ΣG2468
	4G4	ΣG26	ΣG248	
	6G6	ΣG28	ΣG268	
	8G8	ΣG46	ΣG468	
		ΣG48		
		ΣG68		

Table 6: $\Sigma\gamma$ solutions for which both $\Sigma \leq 8$ and, for each $\lambda \in \Gamma$, $\lambda \leq 8$

Σ	GFC monopole	GFC dipole	GFC quadrupole	GFC octupole
2	2G2	2G24	2G248	
4	4G4	4G48	4G246	4G2468a, 4G2468b
6	6G6		6G468	
8	8G8			8G2468a, 8G2468b

to models regarding G-family physics. We use the word component - as in component of a ΣG field or of force - regarding physics applications of solutions that are relevant to G-family physics. We anticipate that some solutions have relevance regarding modeling that correlates with aspects of physics other than G-family aspects.) The labels GFC monopole through GFC octupole correlate with GFC modeling. The label GFC monopole correlates with the existence of one mathematical solution for each item in the column labeled GFC monopole. The label GFC dipole correlates with the existence of two mathematical solutions for each item in the column labeled GFC 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 GFC quadrupole correlates with the existence of four mathematical solutions for each item in the column labeled GFC quadrupole. G-family physics does not include phenomena that might correlate with the symbol 0G. For each of two GFC quadrupole items, the one 0GΓ mathematical solution is not relevant to G-family physics. For example, the solution 0G246, which correlates with $|-2-4+6|$, is not relevant to G-family physics. The label GFC octupole correlates with the existence of eight mathematical solutions for the one item in the column labeled GFC 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.

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 (30).) Here, the notation $\{a|b\}$ correlates with the ten-element phrase the set of all a such that conditions b pertain. The symbol $\in$ correlates with the four-word phrase is a member of (or, the four-word phrase is an element of). 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 (31).) The symbol $\notin$ correlates with the five-word phrase is not a member of.

$$\Sigma\gamma = \{\Sigma\mathrm{G}\Gamma | \Sigma \in \Gamma\} \tag{30}$$

$$\gamma\lambda = \{\Sigma\mathrm{G}\Gamma | \lambda \in \Gamma, \Sigma \notin \Gamma\} \tag{31}$$

Table 6 lists G-family solutions ΣGΓ for which both $\Sigma \leq 8$ and, for each $\lambda \in \Gamma$, $\lambda \leq 8$. The expressions $|-2+4-6+8|$ and $|-2-4-6+8|$ show that two solutions comport with the notion of 4G2468. We use the letters a and b to distinguish the two solutions. We use each of the letters x and y to refer to either one of the solutions or to both solutions. The expressions $|+2+4-6+8|$ and $|-2-4+6+8|$ show that two solutions comport with the notion of 8G2468.

Work leading to table 5 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 KIN Newtonian modeling, with force laws. RSDF abbreviates the five-word term radial spatial dependence of force. The notion of RSDF pertains regarding KIN modeling. (The notion of RSDF does not directly pertain regarding GFC modeling.) Ongoing modeling correlates the word monopole with a potential energy that varies as r^{-1} and with the RSDF of r^{-2}. Here, r denotes an ongoing modeling KIN radial coordinate and the distance from the center of the one relevant object. Here, we de-emphasize angular aspects of forces. A series that starts with monopole continues. For example, ongoing modeling correlates the word dipole with a potential energy that varies as r^{-2} and with the RSDF of r^{-3}. (Perhaps, see table 7.)

Table 7: KIN modeling interpretations correlating with $\Sigma\gamma$ force components for which $\Sigma \leq 4$ and, for each $\lambda \in \Gamma$, $\lambda \leq 8$

(a) Interactions

Components	Property of an object (assuming that modeling pertains for zero translational motion)
2G2	Charge.
2G24	Magnetic dipole moment.
2G248	Magnetic dipole moment for which the direction of the axis (correlating with the dipole moment) changes over time. (Adjustment regarding 2G24. KIN spatial dipole. KIN RSDF r^{-3}.)
4G4	Mass.
4G48	Adjustment regarding 4G, to the extent that the object rotates. KIN spatial dipole. KIN RSDF r^{-3}.
4G246	Adjustment regarding 4G, to the extent that the object has a quadrupole moment of mass. KIN spatial quadruple. KIN RSDF r^{-4}.
4G2468a, 4G2468b	Adjustments regarding 4G, to the extents that quadrupole moments of mass rotate. KIN spatial octupole. KIN RSDF r^{-5}.

(b) An interpretation of $8 \in \Gamma$ and a preview of an interpretation of $[\![16]\!] \in \Gamma$ (with the notion that, for $\lambda \geq 10$, this essay uses $[\![\lambda]\!]$ to denote elements of Γ)

Aspect	Interpretation
$8 \in \Gamma$	Rotation
$[\![16]\!] \in \Gamma$	Ringing (or, pulsation)

Table 7 notes some aspects related to table 6. Table 7a discusses measurable properties for an object the measures as not moving.

We discuss aspects of table 7. Elsewhere, we further discuss the adjustments - regarding 4G - to which table 7a alludes. (See table 23.) Regarding non-4G G-family solutions for which $8 \in \Gamma$, $[\![16]\!] \notin \Gamma$, and at least one of two, four, and six is a member of Γ, one can consider that the presence of $\lambda = 8$ correlates with a KIN factor of $(ct)^{-1}$ and not with a KIN factor of r^{-1}. (For $\lambda \geq 10$, this essay uses $[\![\lambda]\!]$ to denote elements of Γ.) Here, t denotes an ongoing modeling KIN temporal coordinate and c denotes the speed of light. (Perhaps, consider the notion that - at least regarding propagation in a vacuum - $r^{-1} = (ct)^{-1}$.) Regarding non-4G G-family solutions for which $8 \in \Gamma$, $[\![16]\!] \notin \Gamma$, and at least one of two, four, and six is a member of Γ, the GFC (or ENT) notion of quadrupole correlates with the KIN notion of $r^{-3}t^{-1}$ and with the KIN notion of spatial dipole. Regarding KIN modeling, 2G248 correlates with an adjustment - that varies with time - to 2G24 and magnetic dipole moment. (See the 2G248 row in table 7a. Perhaps, consider the following example. For the planet earth, the axis of rotation does not match the axis for the magnetic dipole moment.) Similarly, the GFC notion of $[\![16]\!] \in \Gamma$ might correlate - for non-4G G-family solutions that are relevant to G-family physics - with a KIN factor of $(ct)^{-1}$ and not with a KIN factor of r^{-1}. (Note table 7b.) Such a correlation with a KIN factor of $(ct)^{-1}$ would pertain only to the extent that six is a member of Γ. Discussion related to table 10 suggests that there might not be any G-family physics relevant non-4G G-family solutions for which $[\![16]\!] \in \Gamma$.

Table 8 defines the two-word term simple particles and notes some aspects regarding the proposed modeling notion of isomers of simple particles. (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 parallel the chemistry notion - same numbers of various atoms, but different spatial arrangements - of molecular isomers.)

This essay generally de-emphasizes possible applications of PR36ISP modeling, except in regard to a discussion of dark energy density. (Regarding dark energy density and PR36ISP, see discussion related to equation (131).)

Before continuing our discussion of GFC modeling, we discuss notions related to group theory and to harmonic oscillator mathematics.

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

Equation (32) echoes mathematics and some ongoing modeling. Here, each of the positive integers

Table 8: PRι_IISP modeling and isomers of simple particles

Note
• The two-word phrase simple particles denotes all elementary particles except G-family elementary particles. The set $\{\Sigma\Phi \vert \Phi \neq \mathrm{G}\}$ of subfamilies correlates with all simple particles.
• 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 two letters PR denote the term physics-relevant. The three letters ISP denote the four-word term isomers of simple particles (or, the five-word term isomers of simple elementary particles). The integer ι_I denotes a number of so-called isomers of the set of all simple particles.
• In this respect, PR1ISP modeling correlates with ongoing modeling.
• Proposed modeling suggests that PR6ISP models explain more astrophysics data and more cosmology data than do PR1ISP models. For example, PR6ISP modeling explains some observed ratios of dark matter to ordinary matter.
• PR36ISP models might explain more data than do PR6ISP models.

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.

$$SU(j_1 + j_2) \supset SU(j_1) \times SU(j_2) \times U(1) \tag{32}$$

We use a symbol of the form g_{group} to denote the number of generators for a group. Equation (33) pertains.

$$g_{SU(j)} = j^2 - 1 \tag{33}$$

For $U(1)$, $g_{U(1)} = 2$. One of the two generators of the group $U(1)$ correlates with the raising operator that equation (2) shows. The other of the two generators of the group $U(1)$ correlates with the lowering operator that equation (3) shows.

We posit that equations (34) and (35) have relevance for the domain $-1 \leq n \leq 0$. We use the symbol $U(1)_b$ to denote a construct that correlates with this pair of one raising operator and one lowering operator. We posit that applications of equation (32) pertain for which one replaces the $U(1)$ (in equation (32)) with $U(1)_b$.

$$b^+|n> = n^{1/2}|n+1> \tag{34}$$

$$b^-|n> = (1+n)^{1/2}|n-1> \tag{35}$$

Ongoing modeling includes the notion of the Poincare group. Equation (36) pertains. The construct for which this essay uses the symbol $S1g$ correlates with conservation of energy and with a group with one generator. One instance of $SU(2)$ correlates with conservation of angular momentum. One instance of $SU(2)$ correlates with conservation of momentum. One instance of $SU(2)$ correlates with boost symmetry.

$$S1g \times SU(2) \times SU(2) \times SU(2) \tag{36}$$

We posit that applications of equation (32) pertain for which one envisions, for one of $k = 1$ and $k = 2$, that j_k equals one and that one replaces the would-be $SU(1)$ with $S1g$.

We posit that - for GTA aspects of GFC modeling - the substitutions (in either of the two directions) that equation (37) suggests can be appropriate when $S1g$ correlates with the $GTA0$ oscillator.

$$SU(j) \;\leftrightarrow\; SU(j-1) \times S1g \tag{37}$$

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

In equation (38), 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). The symbol $\nmid$ denotes the four-word phrase does not divide evenly. For some aspects of proposed modeling, equation (38) correlates with ending the series $SU(3)$, $SU(5)$, $\cdots$ at the item $SU(7)$. (See discussion related to equation (41).) For some aspects of proposed modeling, the series $SU(3)$, $SU(5)$, $SU(7)$, and $SU(17)$ might pertain.

$$g_3|g_5,\ g_3|g_7,\ g_5|g_7 \quad g_5 \nmid g_9,\ g_7 \nmid g_9,\ g_7 \nmid g_{11} \quad g_3|g_{17},\ g_5|g_{17},\ g_7|g_{17} \tag{38}$$

We continue discussion regarding GFC modeling.

Table 9 shows GFC representations for the G-family solutions for which - for each $\lambda \in \Gamma$ - $\lambda \leq 8$. The solutions correlate with symmetries pertaining to ground states. In table 9, the rightmost seven columns comport with double-entry bookkeeping. (See table 9b. Regarding table 9b and the notion of $S1g$ symmetry, see discussion related to equation (37).) Table 9c discusses the notion of span. Information about GTA symmetries has two roles. One role pertains to the number of relevant isomers. (See tables 8 and 9c.) One role pertains to the extent to which solutions correlate with interactions with individual elementary particles. (See discussion related to equation (41).) Some components can interact with multicomponent objects and not with individual elementary particles. Elsewhere, this essay discusses using PR6ISP modeling and the notion of six isomers to explain the observed ratio - of five-plus to one - of dark matter density of the universe to ordinary matter density of the universe. (See discussion related to table 26.)

Table 10 points to some G-family solutions that one might extrapolate from aspects that underlie table 9.

We preview notions regarding some aspects of table 10. We correlate the 4G2468⟦16⟧ solution with an attractive component - of 4G - that might dominate early in the evolution of the universe. (See table 23. See discussion related to equation (113).) Paralleling the notion that some instances of $\lambda = 8$ correlate with rotation, some instances of $\lambda = 16$ might correlate with pulsation (or, with temporal oscillation or ringing). (See table 7b.) The 4G246⟦16⟧ solution might correlate with an attractive KIN octupole component of 4G. The corresponding force might participate regarding ending the inflationary epoch. (See discussion related to equation (116).) This essay de-emphasizes the possible physics relevance of some possible extrapolations. Solution 10G⟦10⟧ provides an example. Per equation (98), a strength factor of four pertains regarding 2G2 and a strength factor of three pertains regarding 4G4. We assume that a strength factor of two pertains regarding 6G6. We assume that a strength factor of one pertains regarding 8G8. We assume that a strength factor of zero pertains regarding 10G⟦10⟧. We correlate some 0GΓ solutions with some elementary bosons. (See table 20.) The following notions provide an example - that is not specific to elementary particles - regarding the 2G248⟦16⟧ row in table 10. For the earth, 2G24 correlates with nominal magnetic dipole moment. 2G248 correlates with non-alignment of the axis of planetary spin and the axis correlating with the nominal magnetic dipole moment. Speculatively, 2G248⟦16⟧ might correlate with periodic reversal of the nominal magnetic dipole moment. However, proposed modeling suggests that pulsation (or, ringing) might correlate with freeable energy and a need to have $6 \in \Gamma$.

We discuss spans for components of G-family forces. We develop the second column - Span (for $\iota_I > 1$) - in table 9a.

For any one value of ι_I (as in PRι_IISP), equation (39) pertains for each simple particle, for each component of G-family force, 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. (The electron does not correlate directly with a GFC solution.) For PR6ISP modeling, for the 4G4 component of 4G, the number of isomers is one and the span of each isomer is six. (Gravity intermediates interactions between the six isomers of simple particles.)

$$\text{(number of isomers)} \times \text{(span of one isomer)} = \iota_I \tag{39}$$

We start from the span of six that we posit for 4G4. We consider GTA symmetries for G-family solutions. (See table 9a.) We aim to develop numbers that belong in the table 9a column that has the label span (for $\iota_I \geq 6$). The number of generators of each of $SU(3)$, $SU(5)$, and $SU(7)$ divides evenly the integer 48, which is the number of generators of $SU(7)$. Regarding 4G4, we posit that the expression $6 = g_{SU(7)}/g_{SU(3)}$ correlates with the span. We generalize. We assert that, for each G-family solution for which a GTA symmetry of $SU(j)$ pertains, equation (40) provides the span. We assume that we can generalize from the assumption that the span of 2G2 is one. (Ordinary matter photons do not interact - or, at least, do not interact much - with dark matter.) For each G-family solution with no GTA $SU(\_)$ symmetry, the span is one. (Here, we consider that the 0G∅ solution is not relevant.) We anticipate that some G-family solutions - for which some λ exceed eight - have relevance and that equation (40) does not pertain. (See discussion related to equation (112).)

$$g_{SU(7)}/g_{SU(j)} \tag{40}$$

We explore the extents to which components of G-family forces interact with simple particles.

Elsewhere, we correlate an $SU(4)$ symmetry with the notion of additivity - across systems or objects - of energy that modeling correlates with ground state total energy of the systems or objects. (See the

Table 9: GFC information regarding G-family solutions for which, for each $\lambda \in \Gamma$, $\lambda \leq 8$

(a) $\Sigma\Phi\Gamma$, GTA symmetries, and other aspects (with NR denoting not relevant)

$\Sigma\Phi\Gamma$	Span (for $\iota_I > 1$)	GTA $SU(\_)$ symmetry	$GTA0$	$GSA0$	$GSA1$ and $GSA2$	$GSA3$ and $GSA4$	$GSA5$ and $GSA6$	$GSA7$ and $GSA8$
0G∅	NR	NR	-1	-1				
2G2	1	None	0	-1	$\pi_{0,@_0}$			
4G4	6	$SU(3)$	0	-1	A0+	$\pi_{0,@_0}$		
ΣG24	1	None	0	-2	$\pi_{0,@_0}$	$\pi_{0,@_0}$		
6G6	2	$SU(5)$	0	-1	A0+	A0+	$\pi_{0,@_0}$	
ΣG26	6	$SU(3)$	0	-2	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	
ΣG46	6	$SU(3)$	0	-2	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
ΣG246	1	None	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	
8G8	1	$SU(7)$	0	-1	A0+	A0+	A0+	$\pi_{0,@_0}$
ΣG28	2	$SU(5)$	0	-2	$\pi_{0,@_0}$	A0+	A0+	$\pi_{0,@_0}$
ΣG48	2	$SU(5)$	0	-2	A0+	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG68	2	$SU(5)$	0	-2	A0+	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG248	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG268	6	$SU(3)$	0	-3	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG468	6	$SU(3)$	0	-3	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG2468	1	None	0	-4	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$

(b) Notes regarding notation that table 9a uses and regarding GTA symmetries

Note
• The symbol A0+ correlates with an oscillator pair for which, for each of the two oscillators, the symbol $@_0$ pertains.
• The symbol $\pi_{0,@_0}$ correlates with the notion that either $n_{GSA(odd)} = 0$ and $n_{GSA(even)} = @_0$ pertains or $n_{GSA(odd)} = @_0$ and $n_{GSA(even)} = 0$ pertains. For example, equation (29) and 2G24 correlate with $n_{GSA1} = @_0$ and $n_{GSA2} = 0$ and $n_{GSA3} = 0$ and $n_{GSA4} = @_0$. Here, the two values of zero anti-align with respect to odd and even. In contrast, 6G24 correlates with $n_{GSA1} = 0$ and $n_{GSA2} = @_0$ and $n_{GSA3} = 0$ and $n_{GSA4} = @_0$. Here, the two values of zero align with respect to odd and even.
• For each row for which table 9a shows a GTA $SU(\_)$ symmetry of none, oscillator $GTA0$ suffices regarding double-entry bookkeeping.
• For the case of GTA $SU(\_)$ symmetry of none, the symmetry $S1g$ pertains.
• For each row for which table 9a shows a GTA symmetry of $SU(j)$, one adds $j-1$ GTA oscillators. For each added $GTAk$ oscillator, the value of n_{GTAk} is zero. The result satisfies double-entry bookkeeping. The $SU(j)$ symmetry correlates with mathematics for an isotropic harmonic oscillator that features j component harmonic oscillators. Here, the set of component oscillators includes $GTA0$.

(c) Notes regarding G-family excitations, regarding information that correlates with specific ΣGΓ, and regarding the notion of span

Note
• An excitation of a ΣG field does not (directly) encode information about a relevant ΣGΓ.
• For PRι_IISP modeling for which $\iota_I > 1$, the word span denotes the isomers among which a specific instance of a specific ΣGΓ intermediates interactions.
• For PRι_IISP modeling for which $\iota_I > 1$, this essay tends (when not discussing specific isomers of simple particles) to use the word span to denote the number of isomers among which a specific instance of a specific ΣGΓ intermediates interactions. (See, for example, table 9a.)
• For PRι_IISP modeling for which $\iota_I > 1$, an excitation of a ΣG field encodes information that specifies relevant isomers of particles. The number of relevant isomers correlates with the Γ of the relevant ΣGΓ. The word span denotes that number of relevant isomers.
• For PRι_IISP modeling for which $\iota_I > 1$, a de-excitation of a ΣG field must correlate with an isomer in the list of isomers that correlates with the relevant excitation.
• For PR1ISP modeling, there is one isomer of simple particles and the span is always one.

Table 10: Some G-family solutions that one might extrapolate from aspects that underlie table 9

Solutions that correlate with table 9 and with the limits $\Gamma \neq \emptyset$ and $\lambda \leq 8$	Other solution, assuming the limits $\Gamma \neq \emptyset$ and $\lambda \leq 16$	Possibilities, regarding the other solution
4G4, 4G48, 4G246, 4G2468x	4G2468⟦16⟧	Might correlate with the dominant force component for an era two eras before inflation.
4G4, 4G246	4G246⟦16⟧	Might correlate with a significant force component around the time of inflation.
2G2, 4G4, 6G6, 8G8	10G⟦10⟧	Seemingly not relevant. The strength of 10G⟦10⟧ would be zero.
0G246, 0G2468	0G2468⟦16⟧	Might correlate with the 0I elementary boson.
0G268	0G268⟦16⟧	Might correlate with the 2U elementary bosons.
2G2, 2G24, 2G248	2G248⟦16⟧	Seemingly not relevant. $6 \notin \Gamma$.
4G4, 4G48	4G48⟦16⟧	Seemingly not relevant. $6 \notin \Gamma$.
8G8	8G8⟦16⟧	Seemingly not relevant. $6 \notin \Gamma$.

row - in table 13 - that discusses ground state total energy.) We deploy equation (37). Here, we assume that an $SU(5)$ symmetry pertains. The $SU(5)$ symmetry correlates with UTA UNI modeling and with ETA ENT modeling. The symmetry pertains - in ENT modeling - for each G-family force ΣG.

We posit that aspects of the UTA UNI modeling $SU(5)$ symmetry and the GTA $SU(\_)$ symmetry column in table 9 combine. For example, for 8G8, a GTA $SU(11)$ symmetry would pertain. (In table 9, seven GTA oscillators pertain. For the symmetry correlating with UTA UNI modeling, five GTA oscillators pertain. The two aspects that combine share their respective $n_{aTA0} = 0$ values. Seven plus five minus one is 11.) For such work, equation (41) pertains. For example, for 4G4, a GTA $SU(7)$ symmetry would pertain. For example, for 2G2 or 2G24, a GTA $SU(5)$ symmetry would pertain. We posit a limit that correlates with aspects of equation (38). We posit that each component that appears in table 9 and has a GTA symmetry of None or $SU(3)$ can interact with simple particles. (Here, combining the GTA symmetry that table 9 shows with the additivity - across objects - of energy symmetry produces, respectively, $SU(5)$ or $SU(7)$.) We posit that components that appear in table 9 and have a GTA symmetry of None or $SU(3)$ can interact with multicomponent objects. We posit that each component that appears in table 9 and has a GTA symmetry of $SU(5)$ or $SU(7)$ does not interact with simple particles. (Here, combining the GTA symmetry that table 9 shows with the UTA UNI modeling 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.

$$SU(j_1) \text{ combines with } SU(j_2) \text{ to correlate with } SU(j_1 + j_2 - 1) \tag{41}$$

For example, 2G68 can interact with an atom but not with an isolated electron. (Table 9 shows, regarding 2G68, a GTA $SU(5)$ symmetry.) We correlate 2G68 with at least the 21-centimeter hyperfine interaction with hydrogen atoms. (See discussion related to equation (130).) Generally, $6 \in \lambda$ can correlate with interactions regarding freeable energies of objects. (See table 12b and table 17.) Generally, $8 \in \lambda$ can correlate with interactions regarding rotations of objects or spins of objects. (See table 7b and table 17.)

We posit conservation laws that might pertain regarding interactions between an elementary fermion and an elementary boson.

Table 11 defines symbols for some possibilities regarding conservation of some properties of an elementary fermion, from before to after an interaction with an elementary boson. This essay uses the symbols to describe aspects that correlate with elementary bosons.

2.1.2. Objects and their properties

We consider the possibility that table 7 points toward useful new modeling regarding objects and properties of objects. Table 7 links aspects of GFC modeling (and, hence, aspects of proposed modeling ENT modeling) with properties that correlate with ongoing modeling KIN models.

We consider the topic of how modeling might characterize an object.

Table 11: Possibilities regarding conservation of some properties of an elementary fermion, from before to after an interaction with an elementary boson

Symbol	Note
CEFG	The symbol denotes conservation of elementary fermion generation. CEFG pertains (at least) regarding isolated interactions between weak interaction bosons and elementary fermions. For example, for an incoming electron (which is a generation one charged lepton) and an incoming W^+ boson, the outgoing neutrino correlates with the same generation - one - as does the incoming charged lepton.
SCEFG	The symbol denotes somewhat conservation of elementary fermion generation, which pertains regarding (at least) interactions (in hadrons) between W bosons and quarks. Ongoing modeling correlates this lack of CEFG with notions of CP violation. The notion of CP-symmetry correlates with the four-word phrase charge conjugation parity symmetry.
CEFM	The symbol denotes conservation of elementary fermion (rest) mass. This notion is similar to conservation of elementary fermion generation, but with an exception if the after-interaction fermion has the same mass as has the before-interaction fermion. (Compare with CEFG and with SCEFG.)
CEFCC	The symbol denotes conservation of elementary fermion color charge. Interactions between gluons and quarks do not necessarily exhibit CEFCC.

We start from a perspective of ongoing modeling KIN modeling for classical physics.

Ongoing modeling considers attributes - of objects - that people measure or infer. Attributes can include energy, charge, mass (or, rest energy), angular momentum, and momentum.

We consider one object. People deploy notions that measured attributes might change without the object losing its identity. For example, a force might produce a change of momentum but not produce a change of object.

Ongoing modeling includes a notion of ground state. The ground state correlates with a least observable or inferable energy for the object. The notion of least observable or inferable energy correlates with assumptions and modeling. For example, a model for an atom might focus on energy states for the electrons in the atom. The model might not need to consider the rest energies of electrons as being freeable. (For example, the model might not need to take into account possible changes correlating with annihilation - via an incoming positron - of an electron in the atom.)

We posit a generalization. Modeling for each property - such as energy or angular momentum - might embrace three values. The values are an actual value (which people can measure or infer), a minimal value (which depends on the choice of model), and a so-called freeable value. Equation (42) pertains. Equation (43) correlates with proposed modeling uses of equation (42)

$$\text{Actual} = \text{Minimal} + \text{Freeable} \tag{42}$$

$$\text{Minimal} = \text{Actual} - \text{Freeable} \tag{43}$$

For each of angular momentum and momentum, equation (43) pertains three times, based on the relevance of three spatial axes. For each of angular momentum and momentum, additivity - across objects - of actual pertains for each of the three spatial axes. In a system, a total actual property is the sum of actual properties for each object that is part of the system. This notion of additivity correlates with a conservation law. For example, the objects can change their individual z-axis components of momentum, as long as the total - for all objects in the system - z-axis momentum is constant. Ongoing modeling correlates - via the Poincare group - each one of conservation of angular momentum and conservation of momentum with an $SU(2)$ symmetry. (See discussion related to equation (36).) Proposed modeling correlates each of the three generators of $SU(2)$ with one of the three relevant (orthogonal) spatial axes. Notions, similar to notions relevant to actual, pertain regarding freeable. Based on equation (43), we anticipate the relevance - for each of angular momentum and momentum - of two instances of $SU(2)$ symmetry. One of the two instances correlates with actual. One of the two instances correlates with freeable. Proposed modeling uses models that correlate each instance of $SU(2)$ with two harmonic oscillators. Proposed modeling can include modeling that does not consider or assume specific minimal values. Proposed modeling can include modeling for which the minimal value for one property depends on the choices of minimal values for other properties. Here, such choices need to be compatible with aspects correlating with a minimal (or, ground state) energy. (This essay does not explore possible relationships between notions of entropy and the notion of numbers of sums that add to a minimal energy.)

For each of angular momentum and momentum, we posit that the pair of $SU(2)$ symmetries correlates - via equation (32) and $j_1 = j_2 = 2$ - with one instance of $SU(4)$ and with one instance of $U(1)$. We posit that the $U(1)$ symmetry correlates with additivity regarding the actual value. We posit that the $SU(4)$ symmetry correlates with the notion of minimal value.

Ongoing modeling KIN classical physics can treat each of actual angular momentum and actual momentum as a three-vector.

For angular momentum, the freeable $SU(2)$ correlates with $\hbar$, which is a minimum unit of exchange for angular momentum. Here, the three generators of $SU(2)$ correlate with $D = 3$ in equation (44). Equation (44) correlates with the ongoing modeling expression $S(S+1)\hbar^2$ regarding angular momentum for objects with spin S. Equation (44) correlates with an aspect of solutions involving Laplacian operators correlating - in KIN models - with $D = 3$ spatial dimensions. The $SU(2)$ symmetry correlates with an extending - from ongoing modeling pre-quantum modeling - ongoing modeling to include quantized spin and to include the notion of a minimal unit, $\hbar$, of angular momentum that pertains to exchanges - between objects - of angular momentum.

$$S(S + D - 2) = S(S + 1) \tag{44}$$

Regarding momentum, the freeable $SU(2)$ correlates with the $D = 3$ dimensions that are relevant to ongoing modeling KIN models for special relativity. The $SU(2)$ symmetry correlates with an extending - from ongoing modeling pre-special-relativity modeling - ongoing modeling to include special relativity. People correlate the two-word term boost symmetry with this $SU(2)$ symmetry.

The notion of three-vector does not pertain for each one of energy, charge, and mass. Nevertheless, proposed modeling UNI modeling regarding each of energy, charge, and mass includes (based on, in effect, equation (43) and parallels to other notions above) symmetries that parallel the symmetries (two $SU(2)$, one $U(1)$, and one $SU(4)$) that correlate with either one of angular momentum and momentum.

We postpone discussing the case of (total) energy until we complete discussion leading to table 12.

Regarding charge, an $SU(2)$ symmetry correlates with extending pre-quantum-charge ongoing modeling to include a notion of a minimal unit, $|q_e|$, of charge that pertains to exchanges - between objects - of charge. The symbol q_e denotes the charge of the electron. Here, $D = 3$ (again correlates with three dimensions and) correlates with three spatial-like dimensions for a charge-current four-vector.

Similar methods seem not to apply regarding freeable passive gravitational energy. For elementary bosons, some aspects regarding additivity correlate - not with masses but - with squares of masses. (See discussion related to table 20.) For elementary fermions, some aspects of additivity loosely correlate - not with masses but - with logarithms of mass and with either or both of generation and charge. (See discussion related to equation (62).)

Regarding actual passive gravitational energy, the $U(1) \times SU(2)$ symmetry correlates with six isomers.

Regarding freeable passive gravitational energy, the $SU(2)$ symmetry correlates with aspects that depend on the relevant object and the relevant model. (See table 12b.)

We posit that - in accord with table 7 - the following notions pertain. Actual charge correlates with $\lambda = 2$. Actual rest energy correlates with $\lambda = 4$. Actual angular momentum correlates with $\lambda = 8$.

We define aspects of UNI modeling.

Table 12 shows USA aspects of UNI modeling. Table 12a shows modeling regarding a system that includes at least one object. The modeling correlates with ongoing modeling classical physics. The word additivity refers to the notion that modeling correlates with an ability to add, across more than one system, the respective system property. The column with the label USA defines a correlation with oscillators that underlie the modeling. (UNI modeling does not necessarily directly reflect mathematics correlating with excitations of harmonic oscillators.) The assignments comport with aspects of table 6, table 7a, table 8, and table 9. Each instance of $U(1)$ correlates with additivity. (Additivity does not necessarily pertain regarding $U(1)_b$.)

We discuss notions that correlate with table 12. The column - in table 12a - labeled symmetry is compatible with applying - starting with $SU(17)$ - equation (32) four times. (Here, we assume that equation (32) pertains once with $j_1 = 1$.) Table 12b pertains to an object that is part of the system. The column labeled with the two-word phrase object property differentiates cases. For example, the $USA0$ row differentiates between elementary fermions and other objects, including elementary bosons. Relative to table 12a, table 12b has bases in four applications of equation (32). For each application, $j_1 = j_2 = 2$. The symbol k_B denotes the Boltzmann constant. The symbol T denotes temperature.

Table 12: USA symmetries

(a) Some system properties that correlate with classical physics

System property	Trio	USA	Note	Symmetry
-	-	0	Not necessarily applicable, unless the system consists of just one object	$U(1)_b \times S1g$
Charge	3 signs	1-2, 15-16	Additivity pertains for each sign	$U(1) \times SU(4)$
Minimal passive gravitational energy	-	3-6	Scalar quantity	$SU(4)$
Minimal angular momentum	3 axes	7-10	Additivity pertains for each axis	$U(1) \times SU(4)$
Minimal momentum	3 axes	11-14	Additivity pertains for each axis	$U(1) \times SU(4)$

(b) Some object properties that correlate with proposed modeling

Object property	Trio	USA	Note	Symmetry
Nonzero / zero property choice (charge for elementary fermions, mass otherwise)	-	0	Correlates with a binary choice	$U(1)_b$
Charge	3 signs	1-2	Additivity pertains for each sign	$U(1) \times SU(2)$
Passive gravitational energy	-	3-4	Correlates with a scalar quantity and with six isomers of PR1ISP (and with PR6ISP models)	$U(1) \times SU(2)$
Generation (for elementary fermions)	one, two, three	5-6	Three values of freeable energy	$SU(2)$
Freeable passive gravitational energy (any object)	3 spatial dimensions	5-6	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$
Angular momentum (classical physics)	3 axes	7-8	Additivity pertains for each axis	$U(1) \times SU(2)$
Freeable angular momentum (classical physics)	3 axes	9-10	Three axes of freeable angular momentum	$SU(2)$
Quantized unit of angular momentum exchange (some models)	3 spatial dimensions	9-10	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$
Momentum	3 axes	11-12	Additivity pertains for each axis	$U(1) \times SU(2)$
Boost symmetry (special relativity)	3 axes	13-14	Specific to special relativity	$SU(2)$
Non-quantized charge (some models)	-	15-16	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$
Quantized unit of charge exchange (some models)	3 spatial dimensions	15-16	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$
Magnitude of one unit of nonzero charge divided by the magnitude of the charge of an electron	1, 2/3, 1/3	15-16	Allows for quarks	$SU(2)$
Pulsation (or, ringing) energy (some models)	-	15-16	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$

Table 13: UTA symmetries

(a) Some system properties that correlate with classical physics

System property	Trio	UTA	Note	Symmetry
-	-	0	Not necessarily applicable, unless the system consists of just one object	$U(1)_b \times S1g$
-	-	1-2	Not applicable, unless the system consists of just one elementary fermion that interacts with color charge	$SU(2)$
Minimal (or, ground state) total energy	-	3-6	Additivity pertains regarding the scalar quantity	$U(1) \times SU(4)$

(b) Some object properties that correlate with proposed modeling

Object property	Trio	UTA	Note	Symmetry
Property choice (whether an elementary boson or other object models as entangled)	-	0	Correlates with a binary choice	$U(1)_b$
Color charge	red, blue, green	1-2	Correlates with a three-fold choice	$SU(2)$
Total energy (any object)	-	3-4	Correlates with a scalar quantity and with six isomers of PR6ISP (and with PR36ISP models)	$U(1) \times SU(2)$
Temperature (thermodynamics, when applicable)	3 DoF	5-6	$(1/2)k_BT$ per DoF (or, degree of freedom)	$SU(2)$
Freeable total energy (any object)	3 spatial dimensions	5-6	Correlates with a scalar quantity (The symmetry might not be relevant.)	$SU(2)$

We discuss notions of passive gravitational mass, active gravitational mass, and not necessarily gravitational mass. Regarding table 12b, for an object, the passive gravitational energy equals the sum of the minimal passive gravitational energy and the freeable passive gravitational energy. For this essay, the three-word term passive gravitational energy is synonymous with the four-word term passive gravitational rest energy. The three-word term passive gravitational mass denotes the mass that modeling attributes to the object when modeling the gravitational field that the object - in effect - produces. The passive gravitational mass equals c^{-2} times the passive gravitational energy. In this context, each of the three-word term active gravitational mass and the two-word term inertial mass contrasts with passive gravitational mass. Active gravitational mass correlates with the notion of interaction between an object and the gravitational field that other objects - in effect - produce. Inertial mass correlates notions of accelerations and forces (in general). Inertial mass can refer to a ratio of the force (which does not necessarily correlate with gravity) that acts on the object to the acceleration that the object exhibits (because of the force). This essay comports with the notion that people might have yet to identify any quantified differences between passive gravitational mass, active gravitational mass, and inertial mass. We use the four-word phrase not necessarily gravitational mass to denote notions of mass that do not necessarily correlate with passive gravitational mass or with active gravitational mass. Inertial mass provides an example of not necessarily gravitational mass. Equation (110) might correlate with an example of not necessarily gravitational mass that differs from both passive gravitational mass and active gravitational mass.

We engage with the topic of (total) energy. Total energy correlates with UTA aspects of UNI modeling. UTA modeling for total energy exhibits parallels to USA modeling for passive gravitational energy.

Table 13 shows UTA aspects of UNI modeling. Table 13 is a UTA analog to the USA centric table 12. For table 13b, the column labeled symmetry is compatible with applying - starting with $SU(7)$ - equation (32) twice.

We discuss notions correlating with table 12 and with table 13.

Table 14: Aspects correlating with oscillators $zTA0$ and $zSA0$, for ENT modeling and for UNI modeling

Object	Parameters ($z = E$ or U)	Note
Any	$n_{zTA0} = 0$	The model correlates with some notions of no entanglement.
Any	$n_{zTA0} = -1$	The model correlates with entanglement.
Elementary particle	$n_{zTA0} = 0$, $n_{zSA0} = -1$	In a vacuum, the object travels at the speed of light. (The minimal passive gravitational energy equals zero.)
Elementary fermion	$n_{zSA0} = -1$	The object has zero charge.
Elementary boson	$n_{zSA0} = -1$	The object has zero mass.

Table 15: Modeling that catalogs four types of physics constants - masses, $\hbar$, c, and q_e

(a) Catalog that includes four types of physics constants - masses, k_B, $\hbar$, c, and q_e

M_EAotO	Basic	λ	Subtlety	λ	Example re subtlety (freeable, plus ...)
passive gravitational	USA:3-4	4	USA:5-6	6	Δ of mc^2- e.g., regarding Δ of generation for an elementary fermion
angular momentum	USA:7-8	8	USA:9-10	10	$\hbar$ - quantum of exchange of angular momentum
momentum	USA:11-12	12	USA:13-14	14	c - speed of light and speed of gravity
momentum	USA:11-12	12	USA:13-14	14	$p \leq E/c$ for each object
electromagnetic	USA:1-2	2	USA:15-16	16	$\lvert q_e \rvert$ - quantum of exchange of charge

(b) Notes

Note
• The construct M_EAotO abbreviates the seven-element phrase minimal _ energy aspect of the object.
• A symbol λ correlates with the column immediately preceding the column in which the symbol appears.
• The symbol Δ denotes the word change.

Table 14 brings together aspects correlating with oscillators $zTA0$ and $zSA0$, for ENT modeling and for UNI modeling.

For each of table 12 and table 13, the appearances (in a row) of the word additivity and of the symmetry $U(1)$ correlate with a conservation law. Conservation of energy is an example of such a conservation law.

Modeling - for an object - that correlates with a change in minimal (or, ground state) total energy correlates with a change of object or with a change of model.

Table 15 places, in one framework, various physics constants. The constants include masses (for example, of elementary particles), $\hbar$, c, and q_e.

2.2. Elementary particles and dark matter

Table 16 previews elementary particles that proposed modeling suggests. Table 16 alludes to all known elementary particles and to elementary particles that proposed modeling suggests. Elsewhere, we depict some aspects regarding elementary particles. (See figure 2.)

Discussion related to table 26 provides details about proposed modeling regarding dark matter. Table 27 alludes to data - related to dark matter - that proposed modeling seems to explain. (For more details, see table 34.) Elsewhere, we depict some aspects regarding dark matter and ordinary matter. (See figure 5.)

2.2.1. Elementary particles

We show a method for matching known elementary particles and suggesting new elementary particles. We use the method. We suggest elementary particles that people have yet to find.

We review proposed modeling ENT models for the photon. We note a correlation between proposed modeling ENT models and the ongoing modeling elementary particle Standard Model.

Table 2 pertains. Aspects related to oscillator $ETA0$ correlate with the ongoing modeling Standard Model notion that a $U(1)$ symmetry pertains regarding the photon.

Table 16: Known and proposed elementary particles (with SM correlating with known; with PM denoting proposed; with (Di) denoting the seven-word phrase if the particles model as Dirac fermions; with (Ma) denoting the seven-word phrase if the particles model as Majorana fermions; and with TBD denoting to be determined)

Description	Sub-family	Spin	Models as free or entangled	Mass	Number of zero-charge particles (includes anti-particles)	Number of charged particles (includes anti-particles)	Number of modes	Status: Standard Model or (if not SM) proposed modeling
Higgs boson	0H	0	Free	>0	1	0	-	SM
Aye	0I	0	Entangled	=0	1	0	-	PM
Charged leptons	1C	1/2	Free	>0	0	6	-	SM
Neutrinos	1N	1/2	Free	>0	6(Di) or 3(Ma)	0	-	SM
Quarks	1Q	1/2	Entangled	>0	0	12	-	SM
Arcs	1R	1/2	Entangled	>0	6(Di) or 3(Ma)	0	-	PM
Weak interaction bosons	2W	1	Free	>0	1	2	-	SM
Gluons	2U	1	Entangled	=0	8	0	-	SM
Jay	2J	1	Entangled	=0	1	-	-	PM
Photon	2G	1	Free	=0	-	-	2	SM
Graviton	4G	2	Free	=0	-	-	2	PM
TBD	6G	3	Free	=0	-	-	2	PM
TBD	8G	4	Free	=0	-	-	2	PM

(a) Notes regarding items designated as PM in table 16

Item	Note
0I	Aye (or, inflaton) - would be a zero-mass analog to the Higgs boson; might have a role during the inflationary epoch
1R	Arcs - would-be zero-charge fermions; might be analogs to quarks and, if so, might be components of (dark matter) hadron-like particles (This essay assumes that the notions of analogs to quarks and of components of hadron-like particles pertain.); might be analogs to neutrinos and, if so, would model as free (Elsewhere, this essay de-emphasizes the notion of analogs to neutrinos. However, possibly, people could not use current data to distinguish between the possibility of analogs to quarks and the possibility of analogs to neutrinos.)
2J	Jay - would be a zero-mass spin-one boson; might have a role before inflation; might correlate with the Pauli exclusion force
4G	Graviton - would be a zero-mass spin-two boson; might correlate with ongoing modeling notions regarding quantum gravity
6G	Name to be determined - would be a zero-mass spin-three boson; might correlate with observations which people interpret as implying that there are at least two distinct rest energies for neutrinos
8G	Name to be determined - would be a zero-mass spin-four boson

We discuss proposed modeling ENT models for the weak interaction bosons.

Each of the Z and W bosons has nonzero mass. Three spin states can pertain. Regarding KIN modeling, equation (45) pertains. The ENT equation (46) pertains. We extend work regarding 2G. We correlate $ESA1$ with left circular polarization. We correlate $ESA2$ with right circular polarization. We correlate $ESA0$ with longitudinal polarization.

$$n_{KSA0} = 0,\ n_{KSA1} = 0,\ n_{KSA2} = 0 \tag{45}$$

$$n_{ESA0} = 0,\ n_{ESA1} = 0,\ n_{ESA2} = 0 \tag{46}$$

Double-entry bookkeeping suggests that equation (47) pertains. We correlate n_{ETA2} with the W^+ boson and with positive charge. We correlate n_{ETA1} with the W^- boson and with negative charge. (Alternatively, one might reverse the roles of $ETA2$ and $ETA1$.) We correlate n_{ETA0} with the Z boson and with zero charge. Equation (48) pertains for ground states.

$$\{ETAj\} = \{ETA2, ETA1, ETA0\} \tag{47}$$

$$n_{ETA0} = 0,\ n_{ETA1} = 0,\ n_{ETA2} = 0 \tag{48}$$

We discuss a thought experiment that correlates with the ongoing modeling notion of an excitation of one W^- boson during an isolated interaction that converts an electron into a neutrino. Proposed modeling suggests modeling in which - for the W^- boson - the $ETA1$ oscillator excites by one unit and one of the three $ESAj$ oscillators excites by one unit. The four other oscillators do not excite. One pair from those four oscillators correlates with an $SU(2)$ symmetry that correlates with CEFG (or, conservation of elementary fermion generation). The other pair from those four oscillators correlates with an $SU(2)$ symmetry that does not necessarily pertain for this thought experiment. For interactions between W bosons and quarks, the symmetry correlates with CEFCC (or, conservation of elementary fermion color charge).

We discuss a thought experiment that correlates with ongoing modeling notions of CP violation within a hadron. Ongoing modeling considers the production of two virtual W bosons. Exciting once each of a W^+ and a W^- correlates - regarding proposed modeling ENT models - with an ETA factor of one (or, $(1+0)^{1/2} \cdot (1+0)^{1/2}$). (See equation (2).) Raising one $ESAj$ by two units would produce a factor of $2^{1/2}$ (or $(1+0)^{1/2} \cdot (1+1)^{1/2}$). The mismatch between one and $2^{1/2}$ violates double-entry bookkeeping. Double-entry bookkeeping suggests that the ESA result should feature - for some $j \neq k$ - $n_{ESAj} = 1$ and $n_{ESAk} = 1$. We let l denote the one integer that satisfies $0 \leq l \leq 2$, $l \neq j$, and $l \neq k$. Only $ETA0$ and $ESAl$ remain relevant regarding relevant symmetries. Proposed modeling correlates $ETA0$ and $ESAl$ with an $SU(2)$ symmetry and with CEFCC. CEFG does not pertain.

Overall, for interactions involving W bosons, SCEFG pertains.

Aspects related to oscillators $ETA2$, $ETA1$, and $ETA0$ correlate with the ongoing modeling Standard Model notion that an $SU(2) \times U(1)$ symmetry pertains regarding the weak interaction bosons. From the ground state and for any j such that $2 \geq j \geq 0$, an excitement of n_{ETAj} correlates a $U(1)$ symmetry with oscillator $ETAj$ and an $SU(2)$ symmetry with the other two $ETAk$ oscillators.

We discuss proposed modeling ENT models for the Higgs boson.

Proposed modeling interpretation of ongoing modeling for the Higgs boson correlates with the set $\{KSAj\}$ having one member - $KSA0$. Longitudinal polarization and nonzero mass pertain. Circular polarization does not pertain.

Proposed modeling ENT models use that notion that excitation correlates with the oscillator pair $ETA0$-and-$ESA0$. For a ground state, $n_{ETA0} = n_{ESA0} = 0$. Regarding each of oscillators $ETA2$, $ETA1$, $ESA1$, and $ESA2$, $n_{E\_A\_} = -1$. Two $SU(2)$ symmetries pertain. One $SU(2)$ symmetry correlates with CEFG (or, conservation of elementary fermion generation). One $SU(2)$ symmetry correlates with CEFCC (or, conservation of elementary fermion color charge). Here, CEFG contrasts with SCEFG for W bosons. For W bosons, the word somewhat (in SCEFG) pertains regarding entangled excitations that feature two different particles - the W^- and the W^+. (See discussion related to equation (48).) For Higgs bosons, there is only one relevant particle and only one relevant polarization. CEFG pertains.

We discuss proposed modeling ENT models for the aye boson.

ENT modeling for the aye boson reflects ENT modeling for the Higgs boson. For the aye boson, $n_{ETA0} = -1$ and $n_{ESA0} = -1$ pertain for the ground state. Excitation correlating with n_{ETA0} can occur in entangled environments. The CEFG and CEFCC aspects that pertain for the Higgs boson pertain for the aye boson.

We discuss proposed modeling ENT models for gluons.

The following notions correlate with modeling for the ground state of gluons. The expression $n_{ESA0} = -1$ correlates with zero mass. The expressions $n_{ESA1} = -1$ and $n_{ESA2} = -1$ pertain. We invoke double-entry bookkeeping. The expressions $n_{ETA2} = -1$, $n_{ETA1} = -1$, and $n_{ETA0} = -1$ pertain. For each j for which $2 \geq j \geq 0$, $ETAj$ correlates with a color charge.

Based on the notion of entangled environment, oscillators $ESA1$ (left circular polarization) and $ESA2$ (right circular polarization) can excite. Modeling for each possible excitement preserves $n_{ESA0} = -1$. We invoke double-entry bookkeeping. We consider phenomena pertaining to one interaction vertex. Modeling regarding absorption (by a gluon) of a unit of color charge and depositing (by the gluon) of a unit of (possibly different) color charge preserves one $n_{ETAj} = -1$. The corresponding $ETAj$-and-$ESA0$ $SU(2)$ symmetry correlates with CEFG. CEFCC does not pertain.

Aspects related to oscillators $ETA2$, $ETA1$, and $ETA0$ correlate with the ongoing modeling Standard Model notion that an $SU(3)$ symmetry pertains regarding gluons.

We discuss proposed modeling ENT models for the jay boson.

The following notions correlate with modeling for the ground state of the jay boson. The expression $n_{ESA0} = -1$ correlates with zero mass. The expressions $n_{ESA1} = -1$ and $n_{ESA2} = -1$ pertain. We invoke double-entry bookkeeping. The expressions $n_{ETA2} = -1$, $n_{ETA1} = -1$, and $n_{ETA0} = -1$ pertain.

Aspects related to oscillators $ETA2$, $ETA1$, and $ETA0$ parallel similar aspects regarding the weak interaction bosons. An $SU(2) \times U(1)$ symmetry pertains regarding the jay boson.

We explore the topic of the properties with which the jay boson interacts. We suggest that the symmetry of $SU(2) \times SU(1)$ pertains and correlates with six isomers. We suggest that one property with which the jay boson interacts is isomer. The span of 2G2 is one. (See table 9a.) Each isomer of simple particles correlates, in effect, with its own isomer of charge. We suggest that - regarding properties with which the jay boson interacts - the jay boson differentiates between isomers of charge. We suggest that - regarding PR36ISP modeling - the jay boson differentiates between isomers of mass.

Discussion just above suggests the possibility of one jay boson with two modes. (Compare with the representation, in table 2, for the photon.) For this case, oscillator $ESA0$ does not excite. Discussion regarding the 0I and 2U bosons might suggest that modeling might embrace the notion that oscillator $ESA0$ can excite. For this case, there would be one particle with three spin states. (This essay does not make a selection among these two - and possibly other - cases.) Here and elsewhere - we use wording that assumes that there is just one jay boson.

The symbol 2J_- correlates with left circular polarization. The symbol 2J_+ correlates with right circular polarization. The symbol 2J_0 correlates with the possibility of nonzero longitudinal polarization. This essay continues to discuss the notion of 2J_0. Seemingly, proposed modeling results that this essay shows do not depend on 2J_0 being physics relevant.

We consider proposed ENT models for (elementary particle) subfamilies that do not necessarily correlate with the notions of exactly three $ETAj$ oscillators and exactly three $ESAj$ oscillators.

We discuss proposed modeling ENT models for charged leptons.

ENT modeling for charged leptons reflects ENT modeling for weak interaction bosons. An electron has negative charge. Modeling uses $n_{ETA2} = -1$ and $n_{ETA1} = 0$. Regarding one of the two possible spin states, $n_{ESA1} = 0$, and $n_{ESA2} = -1$. The $ETA2$-and-$ESA2$ oscillator pair correlates with an $SU(2)$ symmetry. The three generators of $SU(2)$ correlate with three generations. (For this spin state, equation (25) might seem to pertain explicitly.) Regarding the other one of the two possible spin states, $n_{ESA1} = -1$, and $n_{ESA2} = 0$. The $ETA2$-and-$ESA1$ oscillator pair correlates with an $SU(2)$ symmetry. The three generators of $SU(2)$ correlate with three generations. (For this spin state, a notion similar to equation (25) might seem to pertain implicitly.) This modeling correlates with the electron, muon, and tauon. A swap featuring $n_{ETA2} \leftrightarrow n_{ETA1}$ leads to modeling for the three respective antiparticles.

We discuss proposed modeling ENT models for neutrinos.

ENT modeling for neutrinos reflects ENT modeling for charged leptons. Neutrinos have zero charge. The expression $n_{ETA2} = n_{ETA1} = -1$ correlates with zero-charge. Double-entry bookkeeping suggests that one of $n_{ESA1} = -1$ and $n_{ESA2} = -1$ pertains. The choice of $n_{ESA1} = 0$ and $n_{ESA2} = -1$ comports with observations that suggest that (ordinary matter) neutrinos are left-handed. This essay does not recommend extents to which neutrinos model as Dirac fermions and as Majorana fermions. The case of Dirac fermions correlates with six neutrinos. The case of Majorana fermions correlates with three neutrinos, with each neutrino being its own antiparticle.

We discuss proposed modeling ENT models for quarks.

Compared to modeling for charged leptons, modeling for quarks adds one $ETAj$ oscillator and the $ESAj$ oscillator. We can set each of the corresponding two n_{E_Aj} to minus one. The $ETAj$-and-$ESAj$

Table 17: Some correlations between G-family elementary particles and some properties of objects

ΣG	Property of the object
2G	Charge
4G	Passive gravitational energy (or, equivalently, passive gravitational mass)
6G	Generation (for elementary fermions). Also, freeable passive gravitational energy.
8G	Spin (or, S - as in $S(S+1)\hbar^2$)

oscillator pair correlates with an $SU(2)$ symmetry and three generators. The three generators correlate with three color charges. These notions correlate with quarks for which the magnitude of charge is two-thirds of the charge of a positron. The same notions correlate with quarks for which the magnitude of charge is one-third of the charge of a positron. For each magnitude of charge, swapping n_{ETA1} and n_{ETA2} correlates with changing the sign of charge.

We discuss proposed modeling ENT models for arcs.

ENT models for arcs reflect ENT models for quarks. (Perhaps, note remarks - in table 16a - regarding 1R particles.) Arcs have zero charge. The expression $n_{ETA2} = n_{ETA1} = -1$ correlates with zero-charge. Double-entry bookkeeping suggests that one of $n_{ESA1} = -1$ and $n_{ESA2} = -1$ pertains. This essay does not recommend extents to which arcs model as Dirac fermions and as Majorana fermions. The case of Dirac fermions correlates with six arcs. The case of Majorana fermions correlates with three arcs, with each arc being its own antiparticle.

We discuss proposed modeling ENT models for G-family elementary particles.

Table 17 correlates G-family elementary particles with some properties of objects. An interaction between a G-family elementary particle and an object might - in effect - measure the property of the object. For an interaction that does not change the object, the interaction does not change the property. (Regarding an interaction that ionizes an atom, modeling generally correlates with not leaving the atom intact.) Table 17 correlates with and extends aspects of table 12. (The notion of Σ in ΣG in table 17 differs from notions of λ, such as in $USA\lambda$ in table 12.)

Proposed modeling suggests that 2G correlates with ongoing modeling classical physics notions of electromagnetism. Proposed modeling suggests that 2G correlates with ongoing modeling quantum physics notions of the photon. We are not aware of any evidence that photons correlate with other than CEFCC and CEFG. Proposed modeling adds - to the representation that table 2 shows - oscillators $ETA2$ and $ETA1$. Proposed modeling adds - to the representation that table 2 shows - oscillators $ESA3$ and $ESA4$. For each of the four added oscillators, $n_{E\_A\_} = @_0$ pertains. The two added $ETAj$ oscillators correlate with CEFCC. The two added $ESAj$ oscillators correlate with CEFG.

Proposed modeling suggests that 4G correlates with ongoing modeling classical physics notions of gravity. Proposed modeling suggests that 4G correlates with ongoing modeling quantum physics notions of a would-be graviton. (Note equation (25).) Compared to ENT modeling for the photon, ENT modeling for the graviton, swaps n_{ESA1} and n_{ESA3} and swaps n_{ESA2} and n_{ESA4}. Oscillator $ESA3$ correlates with left circular polarization and spin two. Oscillator $ESA4$ correlates with right circular polarization and spin two. The expressions $n_{ESA1} = @_0$ and $n_{ESA2} = @_0$ pertain. Proposed modeling suggests the following notions. (See, also, discussion related to equation (83).) All neutrinos have the same rest mass. Gravity (or, 4G) catalyzes neutrino oscillations. Interactions intermediated by 6G lead to effects that people interpret via ongoing modeling as correlating with differences between neutrino masses. CEFCC and CEFM pertain for 4G.

Proposed modeling suggests that 6G correlates with $n_{ESA1} = n_{ESA2} = @_0$, $n_{ESA3} = n_{ESA4} = @_0$, and $n_{ESA5} = n_{ESA6} = 0$. Each one of CEFM and CEFG pertains for 6G. Oscillator $ESA5$ correlates with left circular polarization and spin three. Oscillator $ESA6$ correlates with right circular polarization and spin three. Strengths of interactions correlating with 6G468 can vary based on elementary fermion generation. Proposed modeling might explain observations that people suggest correlate with would-be differences - between generations - of neutrino masses. (Compared to 4G, an additional pair of oscillators for which $n_{ETAj} = n_{ETA(j-1)} = @_0$ pertains. Possibly, an $SU(4)$ symmetry pertains. Possibly, CEFCC does not pertain. This essay does not pursue this topic.)

Proposed modeling suggests that 8G correlates with - compared to 6G - four additional instances of $n_{\_A\_}$. Here, $n_{ESA5} = n_{ESA6} = @_0$. The corresponding $SU(2)$ symmetry correlates with three spatial axes. Strengths of interactions correlating with 8G2468a or with 8G2468b can vary based on spin orientation (for example, the spin orientation of an elementary fermion). Each one of CEFM and CEFG pertains. (Compared to 6G, an additional pair of oscillators for which $n_{ETAj} = n_{ETA(j-1)} = @_0$ pertains. Possibly, an $SU(6)$ symmetry pertains. Possibly, CEFCC does not pertain. This essay does not pursue this topic.)

Table 18 summarizes information regarding spans for simple particles, for hadron-like particles, and for some components of long-range forces. The table summarizes information regarding types of objects with which boson simple particles and some long-range 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. (See discussion regarding equation (106).) The symbol 1R⊗2U correlates with possible hadron-like particles. (See discussion regarding equation (107).) 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 18 shows the extent to which each of the simple bosons and some of the long-range 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 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. Table 18c summarizes some concepts relevant to tables 18a and 18b.

Equation (49) shows notation for denoting the span, s, for an elementary particle or for a component of a long-range force.

$$\Sigma(\mathrm{s})\Phi \quad \text{or} \quad \Sigma(\mathrm{s})\Phi\Gamma \tag{49}$$

Table 19 shows the span for each component of G-family forces for which λ does not exceed eight and Σ does not exceed eight. (This essay de-emphasizes discussing the possible relevance - to G-family physics - of ΣG for which $\Sigma \geq 10$.) The table pertains for PR6ISP modeling. Rows in table 19a list $\Sigma\gamma$ components. Table 19a lists 2(6)G248 and does not list 2(1)G248. Rows in table 19b list G-family force components that do not correlate with $\Sigma\gamma$.

We discuss concepts regarding the 2(2)G68 solution and regarding interactions between dark matter and ordinary matter. Here, we assume that PR6ISP modeling comports with nature.

Elsewhere, we posit that 2(2)G68 correlates with some electromagnetic (or, $\Sigma = 2$) interactions with atoms and other objects. (See discussion regarding table 9.) 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 non-ordinary-matter dark matter objects (for the case in which PR6ISP 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) interacts with ordinary matter via 2(2)G68.

We discuss other aspects that correlate with table 7a and table 9.

Table 9 does not point to a G-family solution that would correlate with an interaction with nonzero magnetic monopole moment. To the extent that proposed modeling adequately comports with nature, proposed modeling ENT modeling seems to suggest that nature does not exhibit magnetic monopole elementary particles.

Table 9 does not point to a G-family solution that would correlate with a nonzero electric dipole moment for an object that does not feature - within the object - non-uniformity of charge. To the extent that an elementary particle models - with respect to KIN modeling - as having zero size, proposed modeling ENT modeling seems to suggest that the particle has zero electric dipole moment.

2.2.2. Properties of elementary bosons

We discuss the masses of elementary bosons.

We suggest that equation (50) comports with current data. (For data, see reference [1].) The most accurately known of the masses is the mass of the Z boson. We use the nominal mass of the Z boson as a base for calculations. Regarding the Higgs and W bosons, the larger deviation from equation (50) correlates with the 9 : 7 ratio. Equation (50) suggests a W boson mass that is about 3.4 standard deviations high with respect to the measured mass of the W boson.

$$(m_{\text{Higgs boson}})^2 : (m_Z)^2 : (m_W)^2 \;::\; 17 : 9 : 7 \tag{50}$$

Discussion regarding table 5 alludes to 0GΓ solutions. Within the constraints of $\Gamma \neq \emptyset$ and $\lambda \leq 8$, there are three 0GΓ solutions - 0G2468, 0G246, and 0G268. Removing the constraint of $\Gamma \neq \emptyset$ admits the 0G$\emptyset$ solution. For each of the four solutions, we define j_λ to be the number of λ elements in Γ.

Table 18: Particles and solutions that correlate with one isomer and particles and solutions that might correlate with more than one isomer; plus, the extents to which simple bosons and some long-range force components interact with simple fermions and with multicomponent objects (with the symbol 1f+1b→1f+1b denoting interactions for which one elementary fermion and one elementary boson enter and for which one elementary fermion and one elementary boson exit; and with the symbol MCO denoting multicomponent objects)

(a) Particles

Standard Model entities	Possible entities	PRι_IISP span	1b interactions: 1f+1b→1f+1b	1b interactions with MCO
0H	0I	1	Yes - CEFG	No
1C	-	1	-	-
1N	-	1	-	-
1Q	1R	1	-	-
2U	-	1	Yes - CEFG	No
2W	-	1	Yes - SCEFG	No
-	2J	ι_I	Yes - SCEFG	Yes
1Q⊗2U	1R⊗2U	1	-	-
2G	-	(See table 18b.)	Yes - CEFG	Yes
-	4G	(See table 18b.)	Yes - CEFM	Yes
-	6G	(See table 18b.)	Yes - CEFG, CEFM	Yes
-	8G	(See table 18b.)	Yes - CEFG, CEFM	Yes

(b) Selected G-family components (with symbols of the form (†_) denoting aspects that table 18c discusses)

G-family component	PR1ISP span	PR6ISP span	PR36ISP span (†36)	1b interactions: 1f+1b→1f+1b	1b interactions with MCO
2G2	1	1	1	Yes	Yes
2G24	1	1	1	Yes	Yes
2G248	1	6	6	Yes	Yes
2G68	1	2 (†2G)	2	No	Yes
4G4	1	6	6	Yes	Yes
4G48	1	2 (†4G)	2	Yes	Yes
4G246	1	1	1	Yes	Yes
4G246⟦16⟧	1	? (†G4)	? (†G4)	Yes	Yes
4G2468a	1	1	1	Yes	Yes
4G2468b	1	1	1	Yes	Yes
4G2468⟦16⟧	1	6 (†G5)	36 (†G5)	Yes	Yes
6G6	1	2	2	No	Yes
6G468	1	6	6	Yes	Yes
8G8	1	1	1	No	Yes
8G2468a	1	1	1	Yes	Yes
8G2468b	1	1	1	Yes	Yes

(c) Notes regarding spans

Note
• (†36): For 2(>1)GΓ and 4(>1)GΓ, the span of 2(>1)GΓ is orthogonal to the span of 4(>1)GΓ.
• (†2G) and (†4G): For PR6ISP modeling, the following notions pertain. For one of 4GΓ_4 with a span of two and 2GΓ_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 (4GΓ_4 and 2GΓ_2), different pairings might pertain.
• (†G4): For PR6ISP modeling, might be one or six. For PR36ISP modeling, might be one, might be six, or might be 36. (Perhaps note that six equals 288/48, which equals $g_{SU(17)}/g_{SU(7)}$. Perhaps, see discussion related to equation (116).) Possibly, ⟦16⟧∈ Γ implies that the span is ι_I. (This possibility might correlate with the following notions. $\lambda = 16$ correlates with $USA16$. $USA16$ correlates with charge. Each isomer correlates with its own isomer of 2G2 and, therefore, with its own isomer of charge.)
• (†G5): See discussion related to equation (113).

Table 19: A catalog of components of G-family forces for which $\Sigma \leq 8$ and λ does not exceed eight

(a) G-family force components for which $\Sigma \in \Gamma$, $\Sigma \leq 8$, and λ does not exceed eight (with r^{-k} correlating with KIN modeling RSDF)

$\Sigma \in \Gamma$	S	GFC monopole	GFC dipole	GFC quadrupole	GFC octupole
Yes	1	2(1)G2 (r^{-2})	2(1)G24 (r^{-3})	2(6)G248 (r^{-3})	
Yes	2	4(6)G4 (r^{-2})	4(2)G48 (r^{-3})	4(1)G246 (r^{-4})	4(1)G2468a (r^{-5})
Yes	2				4(1)G2468b (r^{-5})
Yes	3	6(2)G6 (r^{-2})		6(6)G468 (r^{-3})	
Yes	4	8(1)G8 (r^{-2})			8(1)G2468a (r^{-4})
Yes	4				8(1)G2468b (r^{-4})

(b) G-family force components for which $\Sigma \notin \Gamma$, $\Sigma \leq 8$, and λ does not exceed eight

$\Sigma \in \Gamma$	S	GFC monopole	GFC dipole	GFC quadrupole	GFC octupole
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	

We use the notation and the expression that equation (51) shows. (This essay does not explore the extent to which Z_{T4} correlates with $UTA4$.)

$$Z_{T4} = (j_\lambda)^2 + 1 \tag{51}$$

We use - for each of the values of λ of two, four, six, eight, and 16 - the notation $Z_{S\lambda}$. Passive gravitational energy correlates with Z_{S4}. Freeable energy correlates with Z_{S6}. Spin correlates with Z_{S8}. Charge correlates with one of Z_{S2} and Z_{S16}. In this essay, we assume (seemingly without inducing problems) that charge correlates with Z_{S2} and that we can de-emphasize Z_{S16}. We assume that Z_{S2} is zero for zero-charge elementary bosons and is two for non-zero charge elementary bosons. We assume that Z_{S6} is zero for all elementary bosons. We assume that Z_{S8} is zero for zero-spin elementary bosons and is one for spin-one elementary bosons. We posit that equation (52) pertains for the 0H, 2W, and 2J bosons. We explore the notion that equation (53) shows. (The rightmost relationship follows from equation (52).)

$$Z_{T4} \approx Z_{S2} + Z_{S4} + Z_{S6} + Z_{S8} \tag{52}$$

$$m^2 \propto Z_{S4} \approx Z_{T4} - Z_{S2} - Z_{S6} - Z_{S8} \tag{53}$$

Table 20 shows modeling that interrelates all elementary bosons to which table 18a alludes. The first three rows of table 20a correlate with equation (50) and equation (53). The first four rows of table 20a use equation (53). Each G-family boson has representation in (table 20a) via a corresponding $Z_{S\Sigma}$. The ordering of the columns (in table 20a) correlating with $USA\Sigma$ aspects correlates with the ordering of terms in equation (53). The one 0I boson represents a zero-mass correlation to the one 0H boson. (Compare with table 10.) The eight 2U bosons represent zero-mass correlations to the two weak interaction bosons.

Table 20 correlates with a notion that G-family solutions might point to all elementary bosons and, thus perhaps, to the notion that table 16 points to all elementary particles. (Note discussion - following on from equation (47) - that seemingly relates all elementary fermions to weak interaction bosons.)

Elsewhere, we speculate regarding a possible correlation between Z_{S2} and magnetic moment. (See discussion related to equation (132).)

2.2.3. Properties of elementary fermions

We discuss formulas that - based on the accuracy of measured quantities - predict a tauon mass that is consistent with and would be more accurate than the measured tauon mass.

Equation (54) shows an experimental result for the tauon mass, m_τ. (See reference [1].)

$$m_{\tau,\text{ experimental}} \approx 1776.86 \pm 0.12 \text{ MeV}/c^2 \tag{54}$$

Table 20: Some relationships among all elementary bosons to which table 18a alludes

(a) Relationships between non-G-family elementary bosons and GFC items for which $\Sigma = 0$

0GΓ	j_λ (for $[\![16]\!] \notin \Gamma$)	j_λ (for $[\![16]\!] \in \Gamma$)	Z_{S4}	Z_{T4}	Z_{S2}	Z_{S6}	Z_{S8}	Bosons	n_{aTA0}
0G2468	4	-	17	17	0	0	0	0H (or, Higgs)	$+1$
0G246 or 0G268	3	-	9	10	0	0	1	2W: Z	$+1$
0G268 or 0G246	3	-	7	10	2	0	1	2W: W	$+1$
0G∅	0	-	0	1	0	0	1	2J	-1
0G2468$[\![16]\!]$	-	i	0	0	0	0	0	0I	-1
0G268$[\![16]\!]$	-	0	0	1	0	0	1	2U	-1

(b) Notes regarding table 20a

Note
• In table 20a, i denotes a square root of minus one.
• For $[\![16]\!] \notin \Gamma$, the integer j_λ denotes the number of integers λ that appear in the Γ that correlates with 0GΓ.
• Except regarding the column with the label Z_{S4}, each integer in the columns labeled with the expression of the form $Z_{\_\,\_}$ satisfies - for some k in the set $\{i$, 0, 1, 2, 3, or 4$\}$ - the expression $k^2 + 1$.
• This essay does not fully address the topic of which of 0G246 and 0G268 correlates with the Z boson. (The other of 0G246 and 0G268 correlates with the W boson.)
• Regarding table 20a and table 12, the notion of Z_{S10} does not have relevance. A term correlating with momentum is not appropriate for the purposes of table 20a.

Equation (55) defines the symbol β'. Equation (56) defines β. Here, m denotes mass, e denotes electron, q denotes charge, ε_0 denotes the vacuum permittivity, and G_N denotes the gravitational constant. Equation (57) possibly pertains. Equation (57) predicts a tauon mass, which equation (58) shows. (For relevant data, see reference [1].) Eight standard deviations fit within one experimental standard deviation of the nominal experimental result. Equation (59) shows an approximate value of β that we calculate, using data that reference [1] shows, via equation (56).

$$\beta' = m_\tau / m_e \tag{55}$$

$$(4/3) \times \beta^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{56}$$

$$\beta' = \beta \tag{57}$$

$$m_{\tau,\text{ calculated}} \approx 1776.8400 \pm 0.0115 \text{ MeV}/c^2 \tag{58}$$

$$\beta \approx 3477.1891 \pm 0.0226 \tag{59}$$

We discuss formulas that - based on the accuracy of measured quantities - fit the masses of the six quarks and three charged leptons.

Table 21 shows, regarding the rest energies of quarks and charged leptons, data that people report and numbers that we calculate via equation (62). Below, we discuss the table and the data before we discuss the equation and the calculations. Equation (62) results from fitting data. (Equation (62) provides - for elementary fermions - a somewhat analog to equation (53) for elementary bosons. For elementary fermions, a notion of $\log(m/m_{ref})$ - and not a notion of m^2 - pertains. The choice of a positive value of m_{ref} can be arbitrary. Equation (62) correlates with $m_{ref} = m_e$. This essay does not show modeling that would generate equation (62).)

Table 21: Approximate rest energies (in MeV) for quarks and charged leptons (with the symbol q denoting charge)

M''	Legend	M'=3, $q=-1\cdot\lvert q_e\rvert$	M'=2, $q=+(2/3)\cdot\lvert q_e\rvert$	M'=1, $q=-(1/3)\cdot\lvert q_e\rvert$
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	$m_e c^2 \approx 0.511\times 10^0$	$m_u c^2 \approx 2.2\times 10^0$	$m_d c^2 \approx 4.8\times 10^0$
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 data in table 21 reflect information from reference [1]. For each particle other than the top quark, reference [1] provides one estimate. For the top quark, reference [1] provides estimates correlating with each of three bases. For each quark, table 21 shows a data range that runs from one standard deviation below the minimum nominal value that reference [1] shows to one standard deviation above the maximum nominal value that reference [1] 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 (62). Use of modular arithmetic in equation (64) anticipates uses of equation (62) that pertain to neutrino masses and that pertain regarding inferences about dark matter. The notion of $M''=3/2$ correlates with modeling. (No elementary particle correlates with $M''=3/2$.) Regarding equations (66) and (67), uses of $M'=0$ anticipate uses of equation (62) that pertain to arc masses. Equation (60) 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 (61) produces a meaningful value of $m(M'',3/2)$. (No elementary particle correlates with $M'=3/2$. The notion of $M'=3/2$ correlates with the average of $M'=2$ and $M'=1$ and correlates with equation (61). Aspects of equations (62), (66), and (67) correlate with the concept that $m(M'',3/2)$ values have meaning. The concepts of $M'=3/2$ and $m(M'',3/2)$ are useful mathematically, though not necessarily directly relevant to physics.) Within each cluster of rows - in table 21 - for which $M''\neq 3$, the fine-structure constant plays a role regarding linking the masses that pertain for that cluster of rows. (Aspects of equation (62) comport with this role.) Regarding equations (68), (69), and (70), we choose values that fit data. Regarding each charged lepton, our calculations fit data to more significant figures than the numbers in table 21 show.

$$m(3,1)m(3,2)=m(3,0)m(3,3) \tag{60}$$

$$(m(M'',3/2))^2=m(M'',2)m(M'',1) \tag{61}$$

The following concepts pertain regarding developing and using equation (62). We use equation (56) to calculate β. Equation (62) calculates the same value of m_τ that equation (58) calculates.

Equation (62) 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_e, 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 (63).) 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 (61).) Regarding charged leptons, $M'=3$, the term $g(M')$ is zero, and the factor - in equation (62) - that includes the fine-structure constant is one. (See equation (66).)

$$m(M'', M') = m_e \times (\beta^{1/3})^{M'' + (j''_{M''})d''} \times (\alpha^{-1/4})^{g(M') \cdot (1+M'') + j'_{M'} d'(M'')} \tag{62}$$

$$\alpha = ((q_e)^2/(4\pi\varepsilon_0))/(\hbar c) \tag{63}$$

$$j''_{M''} = 0, +1, 0, -1 \text{ for, respectively, } M'' \bmod 3 = 0, 1, 3/2, 2 \tag{64}$$

$$d'' = (2 - (\log(m_\mu/m_e)/\log(\beta^{1/3}))) \approx 3.840679 \times 10^{-2} \tag{65}$$

$$g(M') = 0, 3/2, 3/2, 3/2, 3/2, \text{ for, respectively, } M' = 3, 2, 3/2, 1, 0 \tag{66}$$

$$j'_{M'} = 0, -1, 0, +1, +3 \text{ for, respectively, } M' = 3, 2, 3/2, 1, 0 \tag{67}$$

$$d'(0) \sim 0.318 \tag{68}$$

$$d'(1) \sim -1.057 \tag{69}$$

$$d'(2) \sim -1.5091 \tag{70}$$

$$m(1, 3) \approx 8.59341 \text{MeV}/c^2 \tag{71}$$

We explore possibly useful variations and extensions regarding uses of equation (62).

Equations (72), (73), and (74) characterize a possible approach to re-estimating rest energies for the six quarks.

$$d'(0) \approx 0.264835 \tag{72}$$

$$d'(1) = -1 \tag{73}$$

$$d'(2) = -3/2 \tag{74}$$

The calculations yield new calculated rest energies for the six quarks. (See table 22.) Of the six quarks, the rest energies that one calculates via equation (62) differ from measured values (that reference [1] provides) by more than 1.2 units of estimated error for, at most, $m(1, 2)$ or the charm quark and $m(2, 2)$ or the top quark. (Our calculations use the estimated errors - regarding experimental data - that reference [1] provides.) For the charm quark, the calculated number differs from the experimental number by about 4.6 units of estimated error. For the top quark, the largest (of the three differences correlating with the three experimental interpretations) difference would be about 4.0 units of estimated error and one other difference would be about 0.6 units of estimated error.

To the extent that table 22 comports with nature, various straightforward equations interrelate the masses of elementary fermions. Equation (75) provides an example.

$$(m_s)^2 m_\mu = m_e m_\tau m_c \tag{75}$$

Equation (76) points to possibilities for estimating rest energies for arcs and neutrinos. Equations (77) and (78) would pertain.

$$m(M'', 0) = m(M'', 1) \cdot (m(M'', 1)/m(M'', 2)) \tag{76}$$

$$m(0, 0) \approx m(1, 0) = m(1, 3) \tag{77}$$

$$m(2, 0) = m(2, 3) \tag{78}$$

Table 22: Suggested rest energies for some elementary fermions

Particles	Approximate rest energy	Note
Tauon	1776.8400 ± 0.0115 MeV/c^2	The error reflects the measured error re G_N
Up quark	2.335 MeV/c^2	
Down quark	4.479 MeV/c^2	
Charm quark	1.178×10^3 MeV/c^2	
Strange quark	1.006×10^2 MeV/c^2	
Top quark	1.695×10^5 MeV/c^2	
Bottom quark	4.232×10^3 MeV/c^2	
Arcs - generation one	8.593 MeV/c^2	
Arcs - generation two	8.593 MeV/c^2	
Arcs - generation three	1.0566×10^2 MeV/c^2	Equals the muon rest energy
Neutrinos	3.4475×10^{-2} eV/c^2	

To the extent that $m(0,0)$, $m(1,0)$, and $m(2,0)$ correlate with masses of arc particles, approximate rest energies (in MeV/c^2) for arcs are 8.593 for generation one, 8.593 for generation two, and 105.66 for generation three.

We consider the possible extension that has bases in equations (79) and (80).

$$m(-1,3) = (\beta')^{-1} m(2,3) \tag{79}$$

$$d'(-1) = 0 \tag{80}$$

Equation (81) pertains.

$$m(-1,M')c^2 \approx 3.0386 \times 10^{-2} \text{ MeV, for } M' = 3, 2, 3/2, 1, \text{ and } 0 \tag{81}$$

We discuss possible rest energies for neutrinos.

Equation (82) provides ongoing modeling limits for the sum, across three generations, of neutrino masses. (The limits have bases in interpretations of astrophysics data. See reference [1].) The integer j correlates with generation.

$$0.06\text{eV}/c^2 \lesssim \sum_{j=1}^{3} m_j \lesssim 0.12\text{eV}/c^2 \tag{82}$$

Extending work that produces equation (81) produces equation (83). Here, $m(-4,3) = (\beta')^{-1}m(-1,3)$ pertains. (Compare with equation (79).) Equation (80) extends to the notion that $d'(-4) = 0$ pertains. For any one neutrino and regarding all three neutrinos, this rest energy is not incompatible with equation (83).

$$m(-4,0)c^2 = m(-4,3/2)c^2 \approx 3.4475 \times 10^{-2} \text{ eV}/c^2 \tag{83}$$

We discuss neutrino oscillations. CEFG symmetry does not pertain regarding 4G interactions with neutrinos. Gravity catalyzes neutrino oscillations. (See discussion related to table 17. CEFM symmetry pertains regarding 4G interactions with neutrinos.) Ongoing modeling interpretations of data suggest that the squares of masses of neutrinos might differ from each other. (See, for example, reference [1].) Proposed modeling suggests that such inferred differences regarding squares of masses might correlate with effects of neutrino interactions with at least one of 6G468, 8G2468a, and 8G2468b. (See discussion related to table 17.)

Table 22 lists approximate rest energies that proposed modeling suggests for some elementary fermions. (Some results regarding quarks differ from those that table 21 shows. Equations (72), (73), and (74) lead to results that table 22 shows for quarks.)

We discuss the possibility that proposed modeling can produce useful results regarding the topic of anomalous magnetic dipole moments for charged leptons. (This essay de-emphasizes discussing the extent to which the 2G248 solution might correlate with anomalous magnetic dipole moments for elementary particles. Perhaps, note table 7a.)

Equations (84), (85), and (86) show ongoing modeling KIN interpretations of results of experiments regarding anomalous magnetic dipole moments. (See reference [1].) The subscripts e, μ, and τ denote, respectively, electron, muon, and tauon. The symbol a correlates with anomalous magnetic dipole moment.)

$$a_e \approx 0.00115965218091 \tag{84}$$

$$a_\mu \approx 0.0011659209 \tag{85}$$

$$-0.052 < a_\tau < +0.013 \tag{86}$$

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 (87) shows a result correlating with a first-order Standard Model (or, ongoing modeling) calculation. (See reference [2].)

$$a_{\tau,\mathrm{SM}} \approx +1.177 \times 10^{-3} \tag{87}$$

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 $\gamma 2$.) Relevant G-family solutions (for which $\lambda \leq 8$) might be 4G26, 6G24, 6G28, 8G26, and (if we allow $\Sigma \geq 10$) 10G28. However, 6G28 and 10G28 do not interact with individual simple fermions. (Each of 6G28 and 10G28 correlates with a $GTA\ SU(5)$ symmetry. See table 9a. Perhaps, note table 18.) 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.

For each of solutions 4G26 and 8G26, $4 \notin \Gamma$. Solutions 4G26 and 8G26 might correlate with results that do not vary with charged lepton rest mass. For solution 6G24, $4 \in \Gamma$. Solution 6G24 might correlate with a result that varies with charged lepton rest mass.

We explore modeling for which equation (88) pertains. Here, the subscript cl can be any one of e, μ, and τ. The symbol $a_{4\mathrm{G}26^*}$ correlates with the notion of combining effects of 4G26 and 8G26. We explore the notions that t_{cl} might be one of $(\log(m_{\mathrm{cl}}/m_e))^2$, $(M'')^2$, and $(\text{generation})^2$. For each of the three possibilities regarding t_{cl}, $(a_\tau - a_{\tau,\mathrm{SM}})/a_{\tau,\mathrm{SM}}$ is more than -0.003 and less than -0.0006.

$$a_{\mathrm{cl}} \approx a_{4\mathrm{G}26^*} + a_{6\mathrm{G}24} t_{\mathrm{cl}} \tag{88}$$

Proposed modeling might provide modeling relevant to anomalous magnetic dipole moments for charged leptons.

2.2.4. Strengths of long-range forces

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, that models as not entangled.

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 elementary bosons equals the number of outgoing elementary bosons. Equation (89) shows an interaction in which the fermion absorbs a photon. Conservation of angular momentum pertains. The spin of the fermion flips. Trying to replace, in equation (89), 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 (90) can pertain. (Equation (90) does not portray an interaction - mediated by a 2J boson - between two fermions. One can consider that the 2J particle in equation (90) is a $2\mathrm{J}_\pm$. See table 24. One might want to consider the notion that equation (90) pertains regarding modeling and - in the current state of the universe - does not necessarily pertain regarding easily directly observable physics. Such modeling might involve the notion of virtual particles.)

$$1\mathrm{F} + 2\mathrm{G} \rightarrow 1\mathrm{F} + 0\mathrm{I} \tag{89}$$

$$1\mathrm{F} + 4\mathrm{G} \rightarrow 1\mathrm{F} + 2\mathrm{J} \quad (90)$$

The notion that $1\mathrm{F} + 4\mathrm{G} \rightarrow 1\mathrm{F} + 0\mathrm{I}$ 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 identical charged leptons - of electromagnetism and gravity. We use KIN Newtonian modeling.

For each of the three charged leptons, equation (91) 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 (92) shows notation regarding the masses of charged leptons. (See discussion related to table 21.) Here, the three in $m(M'', 3)$ correlates with charged leptons. (Compare with equation (62), which pertains to the masses of quarks and charged leptons.) Equation (93) repeats equation (55). Equation (94) shows results that reflect data. (We used data that reference [1] shows.) Equation (95) provides a 4G4 analog to the 2G2 equation (91). The symbol G_N denotes the gravitational constant. The equation correlates with a magnitude of the force. Here, the interaction is attractive.

$$r^2 F = (q_e)^2/(4\pi\varepsilon_0) \quad (91)$$

$$m(M'', 3) = m_x, \text{ for the pairs } M'' = 0, x = e;\ M'' = 2, x = \mu;\text{ and } M'' = 3, x = \tau \quad (92)$$

$$\beta' = m_\tau/m_e \quad (93)$$

$$m(M'', 3) = y_{M''}(\beta')^{M''/3} m_e, \text{with } y_0 = y_3 = 1 \text{ and } y_2 \approx 0.9009 \quad (94)$$

$$r^2 F = G_N(m(M'', 3))^2 \quad (95)$$

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 (96) pertains within experimental errors regarding relevant data. (Reference [1] provides the data.) Here, in essence, the equation $y_{18} = y_0 = 1$ pertains. Equation (96) echoes equation (56).

$$((q_e)^2/(4\pi\varepsilon_0))/4 = (G_N(m(18, 3))^2)/3, \text{ with } m(18, 3) = (\beta')^6 m_e \quad (96)$$

The following notes pertain. Equation (96) links the ratio of the masses of two simple particles to a ratio of the strengths of two G-family force components. Equation (96) links the strength of 2G2 interactions to the strength of 4G4 interactions. Equation (97) correlates the fine-structure constant, α, with a function of the tauon mass and the electron mass. (Regarding the fine-structure constant, see equation (63).) Equation (98) recasts equation (56) 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.) Equation (99) shows a ratio that pertains for interactions between two electrons.

$$\alpha = ((q_e)^2/(4\pi\varepsilon_0\hbar c)) = (4/3) \times (m_\tau/m_e)^{12} G_N(m_e)^2/(\hbar c) \quad (97)$$

$$(4/3)((G_N(m_\tau)^2)/(G_N(m_e)^2))^6 = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \quad (98)$$

$$(((q_e)^2/(4\pi\varepsilon_0))/4)\ /\ ((G_N(m_e)^2)/3) \approx 3.124 \times 10^{42} \quad (99)$$

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 (100) provides one definition of the fine-structure constant. (Compare with equation (63), which provides a more common definition.) In equation (100), $(q_e)^2/(4\pi\varepsilon_0 c)$ correlates with the strength of 2G2.

$$\alpha = ((q_e/\hbar)^2/(4\pi\varepsilon_0 c)) \cdot \hbar \quad (100)$$

Equation (100) provides a link between the strength of 2G2 and the strength of 2G24. The equation includes the term $(q_e/\hbar)^2$. The Josephson constant K_{J} equals $2q_e/h$ (or, $q_e/(2\pi\hbar)$). Ongoing modeling considers that magnetic flux is always an integer multiple of $h/(2q_e)$. (We note the existence of an analog - to equation (100) - for which $\alpha = (\cdots)\cdot K_{\mathrm{J}}$. Elsewhere, this essay links spin to aspects pertaining to the squares of masses of elementary bosons. See, for example, discussion related to equation (50). 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 (50). Possibly, the $\alpha = (\cdots)\cdot K_{\mathrm{J}}$ analog to equation (100) has relevance to aspects pertaining to squares of masses of elementary bosons. This essay does not further discuss possible relevance of the $\alpha = (\cdots)\cdot K_{\mathrm{J}}$ analog to equation (100).)

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 Σ/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.

We explore the relative strengths of interactions regarding G-family bosons with spins of at least two.

Equations (101) and (102) parallel equation (90). Compared to equation (90), equation (101) requires dissipation (from the incoming G-family boson) of one more unit (of magnitude $\hbar$) of spin. Compared to equation (101), equation (102) requires dissipation (from the incoming G-family boson) of one more unit (of magnitude $\hbar$) of spin.

$$1\mathrm{F} + 6\mathrm{G} + 0\mathrm{I} \rightarrow 1\mathrm{F} + 2\mathrm{J} + 2\mathrm{J} \tag{101}$$

$$1\mathrm{F} + 8\mathrm{G} + 0\mathrm{I} + 0\mathrm{I} \rightarrow 1\mathrm{F} + 2\mathrm{J} + 2\mathrm{J} + 2\mathrm{J} \tag{102}$$

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 one of 6G6 and 8G8 interacts with elementary fermions. (See table 18b.)

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 (103) pertains.

$$|\Sigma_2 - \Sigma_1|/4 \text{ is an integer} \tag{103}$$

We interpret equation (100) as suggesting that a factor of α might pertain regarding modeling the absorbing of a unit of spin. For a step from equation (90) to equation (102), two factors of α would pertain.

We discuss the adjustments - to the strength of 4G4 - to which table 7a alludes.

Table 23 discusses some aspects regarding the strength of gravitation and some components of 4γ.

2.2.5. Interactions involving the jay boson

We note one observational result that might correlate with effects correlating with the jay boson.

Reference [3] reports a possible 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 [4].) Equation (104) states a transition frequency. The observed value of transition frequency correlates with the energy that correlates with the transition. Equation (105) correlates with ongoing modeling. The observed energy might exceed the predicted energy. Reference [3] characterizes the transition via the expression $2^3S_1 \rightarrow 2^3P_0$.

$$18501.02 \pm 0.61 \text{ MHz} \tag{104}$$

$$18498.25 \pm 0.08 \text{ MHz} \tag{105}$$

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

Table 24 discusses aspects regarding physics, interactions, and modeling involving the jay (or, 2J) boson.

Table 25 shows some possible reactions involving pairs of jay bosons. The leftmost column describes the pair of incoming jay bosons. We discuss, as an example, the case of incoming $2\mathrm{J}_{\pm}+2\mathrm{J}_{\mp}$. 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 possible. The outgoing pair 2G+0I is not possible. The outgoing circular polarizations would sum to plus one or minus one.

Table 23: Aspects regarding the strength of gravitation and some components of 4γ

Components and aspect
• 4G4: We consider a thought experiment in which a first object has a spherically symmetric distribution of matter and has no charge. A second object has a spherically symmetric distribution of the same matter and has some net charge. The second object uses - more than does the first object - more freeable energy to maintain its net charge. (Without use of that energy, the charge would repel itself and the object would bulge outward.) A lesser amount of freeable energy correlates with a lesser amount of passive gravitational energy. (Perhaps, note a parallel to equation (53).) Net charge correlates with a repulsive component that detracts from attraction that correlates with 4G.
• 4G48: We consider a thought experiment in which a first object has a spherically symmetric distribution of matter and has no spin. A second object has a spherically symmetric distribution of the same matter and has some spin. The second object uses - more than does the first object - more freeable energy to maintain its shape. (Without use of that energy, the second object would bulge near its equator and flatten near its poles.) A lesser amount of freeable energy correlates with a lesser amount of passive gravitational energy. (See discussion regarding table 12b. Also, perhaps, note a parallel to equation (53).) 4G48 does not interact with the first object. 4G48 interacts with the second object. 4G48 correlates with a repulsive component that detracts from attraction that correlates with 4G.
• 4G246: We consider a thought experiment in which a first object has a spherically symmetric distribution of matter and has no spin. A second object has a non-spherically symmetric distribution of the same matter and has no spin. The second object has - more than does the first object - more freeable energy. (The second object would - during a transition to having the shape of the first object - lose freeable energy. A greater amount of freeable energy correlates with a greater amount of passive gravitational energy. See discussion regarding table 12b.) 4G246 does not interact with the first object. 4G246 interacts with the second object. 4G246 correlates with an attractive component that augments attraction that correlates with 4G.
• 4G246⟦16⟧: We consider a thought experiment in which a first object has a distribution of matter and does not exhibit ringing (or, pulsations). A second object has the same distribution of the same matter and exhibits ringing. The second object has - compared to the first object - more freeable energy. (The second object would - during a transition to having the characteristics of the first object - lose freeable energy. A greater amount of freeable energy correlates with a greater amount of passive gravitational energy. See discussion regarding table 12b.) 4G246⟦16⟧ does not interact with the first object. 4G246⟦16⟧ interacts with the second object. 4G246⟦16⟧ correlates with an attractive component that augments attraction that correlates with 4G.
• 4G2468a and 4G2468b: We consider a thought experiment in which a first object has a non-spherically symmetric distribution of matter and has no spin. A second object has the same non-spherically symmetric distribution of the same matter and has some spin. The second object uses - more than does the first object - more freeable energy to maintain its shape. A lesser amount of freeable energy correlates with a lesser amount of passive gravitational energy. (See discussion regarding table 12b.) 4G2468a and 4G2468b correlate with repulsive components that detract from attraction that correlates with 4G.
• 4G2468⟦16⟧: We consider a thought experiment in which a first object has a distribution of matter, perhaps has some spin, and does not exhibit ringing. A second object has the same distribution of the same matter, has the same spin, and exhibits ringing. The second object has - compared to the first object - more freeable energy. (The second object would - during a transition to having the characteristics of the first object - lose freeable energy. A greater amount of freeable energy correlates with a greater amount of passive gravitational energy. See discussion regarding table 12b.) 4G2468⟦16⟧ does not interact with the first object. 4G2468⟦16⟧ interacts with the second object. 4G2468⟦16⟧ correlates with an attractive component that augments attraction that correlates with 4G.

Table 24: Aspects regarding the 2J boson

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

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 KIN aspects. 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 (104).) • Some interaction vertices that involve an incoming spin-one-half elementary fermion, an incoming or outgoing ΣG for which $\Sigma \geq 4$, and an outgoing spin-one-half elementary fermion. (See discussion related to equation (90). 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 (115). For this example, two 2J bosons correlate with, in effect, two units of spin that correlate with an outgoing component of a graviton. Each unit of spin correlates with $\hbar$.)

(b) Suggested aspects regarding the 2J boson

Aspect
• The Pauli exclusion force (in ongoing modeling) correlates with (in proposed modeling) a repulsive force based on $2J_{\pm}$. The proposed modeling 2J force, in effect, tries to flip the spin of a fermion. • The positronium energy shift involves the notion that the two fermions - an electron and a positron - have identical properties (including the spin orientations), except for the signs of the charges. We posit that an energy level shift (regarding at least one of the two positronium states) correlates with, in effect, aspects of $2J_{\pm}$. Here, at least with respect to ongoing modeling based on the Dirac equation, a notion correlating with charge exchange (between the electron and positron) might be appropriate. • We posit that the 2J boson correlates 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 (90).) • We posit that the 2J boson can correlate with some interaction vertices that involve no fermions. (See, for example, discussion related to equation (115).)

Table 25: Some possible reactions involving pairs of jay bosons

Incoming particles	Allowed outgoing particles	Precluded outgoing particles
$2J_{\pm}+2J_{\pm}$	4G+0I	2G+0I
$2J_{\pm}+2J_{\mp}$	0I+0I	2G+0I
$2J_0+2J_0$	0I+0I	2G+0I

Table 26: 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.
• Correlates with a $U(1) \times SU(2)$ symmetry to which table 12b alludes.
• Echoes the notion that ENT modeling intertwines 2G-related aspects and 4G-related aspects in ways that ongoing modeling does not. (See, for example, equation (62).)
• Echoes the exponent of six that equation (96) discusses.
• Echoes the six ranges that equation (108) and table 30 feature.

2.2.6. Dark matter particles

We discuss one type of dark matter.

We introduce the symbols that equations (106) and (107) show. The symbol 1Q⊗2U denotes a particle that includes (regarding non-virtual particles) just quarks and gluons. The word hadron pertains for the particle. The one-element term hadron-like pertains for the particle. Examples of 1Q⊗2U 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 (non-virtual) quarks.

$$1\text{Q} \otimes 2\text{U} \tag{106}$$

$$1\text{R} \otimes 2\text{U} \tag{107}$$

A 1R⊗2U hadron-like particle contains no (non-virtual) 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.

If we correlate notions above with PR1ISP modeling, the existence of 1R⊗2U hadron-like particles seems insufficient to explain observed ratios of dark matter effects to ordinary matter effects (for example) of five-plus to one for densities of the universe.

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 9c.)

The notion of isomer correlates with a $U(1) \times SU(2)$ symmetry . (See table 12b.)

GFC modeling correlates interactions with charge with the 2G2 component of the 2G force. We posit that nature includes six isomers of charge. GFC 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 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 mostly as ordinary matter. (The previous sentence also pertains regarding PR1ISP modeling. Regarding PR6ISP modeling, the one isomer of charge, nominal magnetic dipole moment, and simple particles correlates with 1R ⊗ 2U hadron-like particles that measure as dark matter. Hence, we used the word mostly.) 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. 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 (mostly) 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 some (perhaps, most) galaxy clusters.

Table 26 provides perspective regarding PR6ISP modeling.

Regarding each one of the six isomers that correlate with PR6ISP models, we suggest that each combination - that table 21 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 30.)

Table 27: Cumulative features of various types of modeling (with NR denoting not relevant)

Modeling	ι_I	New descriptions and new explanations	New subtleties
Ongoing modeling	NR	• (Baseline)	-
PR1ISP	1	• New simple particles and long-range forces • Some dark matter	• Eras regarding the rate of expansion of the universe
PR6ISP	6	• More dark matter • Ratios of dark matter effects to ordinary matter effects • Objects, smaller than galaxies, that feature dark matter	• Spans • Eras regarding the rate of expansion of the universe

Table 28: Relationships regarding PR1ISP, PR6ISP, and G-family forces

Aspect
• 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 exhibit differing matches between generation of charged lepton and mass of charged lepton. (See discussion related to table 30.) • In PR6ISP models, the main interactions between PR1ISP-like isomers correlate - except before the era of inflation - with the monopole component (or, 4G4) of gravity (or, 4G). Some other interactions between PR1ISP-like isomers correlate with a KIN dipole (or, 4G48) component of gravity (or, 4G). Some other interactions between PR1ISP-like isomers correlate with a KIN dipole component (or, 2G248 - which correlates with the notion of GFC quadrupole) of electromagnetism (or, 2G).

For example, for isomer one, the generation three charged lepton may have the same mass as the ordinary matter electron. (See table 21.) The ordinary matter electron has a generation number of one.

Table 9c discusses the symbol ι_I. Discussion just above pertains regarding PRι_IISP, with ι_I being one or six.

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

Table 27 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.

Table 28 shows relationships regarding PR1ISP, PR6ISP, and G-family forces.

2.2.7. Isomers of quarks and charged leptons

We consider PR6ISP modeling.

Table 29 lists aspects that seem to correlate with each other regarding the one isomer that correlates with ordinary matter (and some dark matter) and the five isomers that correlate with (most) dark matter.

We explore modeling that correlates each of the six relevant isomers with a range of M''. (Regarding M'', perhaps see discussion related to equation (62).) In equation (108), the integer n numbers the isomers. The ordinary matter isomer correlates with $n = 0$.

Table 29: Aspects that seem to correlate with each other regarding the one isomer that correlates with ordinary matter (and some dark matter) and the five isomers that correlate with (most) dark matter

Aspect
• The exponent of six in equation (96) correlates with the notion of six isomers, one of which correlates with ordinary matter and five of which correlate with (most) dark matter. • The number, six, of isomers correlates with the number, six, of generators of a $U(1) \times SU(2)$ symmetry. (See table 12b.) • The $U(1) \times SU(2)$ symmetry breaks - across the six isomers - based on aspects that correlate with relationships between - for charged leptons - gravitational mass and generation.

Table 30: Relationships between quark generation and charged lepton aspects

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

$$\text{isomer } n \leftrightarrow 3n \leq M'' \leq 3n+3, \text{ for } 0 \leq n \leq 5 \tag{108}$$

Table 30 shows, for each value of n, relationships between quark generation and charged lepton aspects. For each n, the order for quarks is generation one, generation two, and then generation three. We de-emphasize the following notions. Dark matter lepton passive gravitational masses might correlate with $m(M'', 3)$ and $M'' > 3$. 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 30 has roots in models that correlate with the relative strengths of 2G2 and 4G4. We posit that, for each item (in table 30) that correlates with a particle, equation (109) provides the (passive and active) gravitational mass. Here, the notions of $n = 0$ and $m_{grav}(M'', M')$ correlate with work that correlates with isomer zero and equation (62). For example, for the dark matter lepton for which $n = 1$ and M''=3, the generation is three and the gravitational mass equals the gravitational mass of the ordinary matter electron.

$$m_{grav}(M'' + 3n, M') = m_{grav}(M'', M'), \text{ for } 0 \leq n \leq 5 \tag{109}$$

We speculate regarding the extent to which aspects of table 30 correlate with origins for baryon asymmetry.

Aspects of ongoing modeling consider that early in the universe baryon symmetry likely 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 [5].)

Observed baryon asymmetry correlates with isomer zero (or, ordinary matter).

We think that some aspects of proposed modeling might shed light on baryon asymmetry. For example, a modeling centric notion of baryon symmetry might pertain regarding the combination of isomer zero and isomer three.

We consider a thought experiment. We consider that modeling for isomer three quarks parallels modeling for isomer zero quarks. Per table 30, modeling for isomer three leptons can differ from modeling for isomer zero leptons. One difference might correlate with handedness, for example regarding (let us use the word interactive) neutrinos. Such differences might correlate with the two-fold symmetry that correlates with the $U(1)$ component of the $U(1) \times SU(2)$ symmetry that table 12b shows regarding the oscillator pair $USA1$-and-$USA2$.

Table 31: Opportunities for advances regarding cosmology

Opportunity
• Describe aspects of the universe that occurred before inflation.
• Identify - within a context that is broader than inflation - the inflaton elementary particle that ongoing modeling hypothesizes.
• Describe mechanisms underlying three eras in the rate of expansion of the universe.
• Explain the magnitude of the current increase in the rate of expansion of the universe.
• Describe bases leading to the ratio of dark matter density of the universe to ordinary matter density of the universe.

2.2.8. Right-handed W bosons and neutrinos

Reference [6] notes that the (ongoing modeling) Standard Model predicts that the fraction f_+ of W bosons - produced by decays of top quarks - that are right-handed is $f_+ = 3.6 \times 10^{-4}$. Reference [1] suggests that, with a confidence level of 90 percent, the rest energy of a W_R (or, right-handed W) would exceed 715 GeV. (Perhaps, note also, reference [7].)

Proposed modeling suggests that each of isomers one through five includes its own isomer of W bosons. The suggested passive gravitational mass for dark matter W bosons is the same as the passive gravitational mass for the ordinary matter W boson.

We suggest that leptons correlating with isomers zero, two, and four correlate with left-handedness and that leptons correlating with isomers one, three, and five correlate with right-handedness. (Note the pattern that table 30 exhibits regarding leptons.) We suggest that W bosons correlating with isomers zero, two, and four correlate with left-handedness and that W bosons correlating with isomers one, three, and five correlate with right-handedness. Table 29 and equation (96) suggest that equation (110) pertains regarding measurements that feature aspects centric to ordinary matter and interactions intermediated by span-six aspects of 2G. (Note, for example, 2(6)G248 in table 19a.) We know of no measurements that correlate with interactions intermediated by 4G. To the extent that equation (110) has relevance to nature, one might use the four-word phrase not necessarily gravitational mass to describe $m_{W_R(\text{isomer one}), \text{ inferred not via 4G}}$.

$$m_{W_R(\text{isomer one}), \text{ inferred not via 4G}} c^2 = \beta m_W c^2 \approx 2.8 \times 10^5 \text{ GeV} \tag{110}$$

We consider a thought experiment. We consider a possibly relevant notion that would have bases in statistics related to inferable not necessarily gravitational masses. Perhaps equation (111) approximates fractions of non-longitudinal polarization W bosons observed via ordinary matter non-4G interactions. (For isomers not numbered as zero or one, the $m_{W_R(\text{isomer \_}), \text{ inferred} \ldots} c^2$ would be larger than $m_{W_R(\text{isomer one}), \text{ inferred} \ldots} c^2$. Effects based on the existence of isomer three W bosons and isomer five W bosons would be small compared to effects correlating with each of isomer zero W bosons and isomer one W bosons.)

$$f_+/f_- \sim e^{(\beta^{-1})} \approx \beta^{-1} \approx 2.9 \times 10^{-4} \tag{111}$$

Equation (111) is not necessarily incompatible with the estimate - $f_+ = 3.6 \times 10^{-4}$ - based on the Standard Model.

Regarding neutrinos, similar notions might pertain. Proposed modeling suggests that neutrinos do not interact with 2G. Direct inferences of the presence of right-handed neutrinos might correlate with isomer one neutrinos and with interactions - mediated by 4G - with isomer zero. This essay de-emphasizes discussing the question of when people might have observations that would point to right-handed neutrinos.

2.3. Cosmology

Table 31 lists opportunities for advances regarding cosmology. Proposed modeling suggests advances regarding each opportunity.

2.3.1. An earlier of two eras that might occur before inflation

We discuss possibilities regarding times before the inflationary epoch.

We explore possibilities pertaining to an era before a later (but also before inflation) era that proposed modeling associates with prominence for the jay boson and the 4G2468x components of 4γ. (Regarding the later of the two eras before inflation, see discussion related to equation (115). Regarding the symbol 4G2468x, see discussion related to table 6.)

We assume that modeling correlating with G-family solutions for which the RSDF is r^{-6} pertains. No solutions of the form ΣG2468⟦10⟧ comport with $\Sigma = 4$. One solution of the form ΣG2468⟦16⟧ comports with $\Sigma = 4$. (Here, $|-2-4-6-8+16|$ equals four. Perhaps, see table 10.) Regarding KIN Newtonian modeling, the RSDF (or, radial spatial dependence of force) would be r^{-6}. Table 23 notes that attraction (not repulsion) pertains. (Perhaps, also note that extrapolation based on aspects of table 33 might point to attraction.)

We consider interactions between two similar, neighboring, non-overlapping objects (or clumps of energy). Equation (112) suggests scaling for a 4G2468⟦16⟧ component of G-family force. Here, υ is a non-dimensional scaling factor that correlates with linear size (or, a length) pertaining to each object and that correlates with the distance between the centers of the objects, ρ is the relevant object property for the case for which $\upsilon = 1$, and r is the distance (for the case of $\upsilon = 1$) between the centers of the objects. The factor υ^3 provides for scaling for an object that has three spatial dimensions. The force would be independent of υ. That independence might suggest, from a standpoint of physics, that a 4G2468⟦16⟧ component of 4G would correlate with concentrating matter or energy before the suggested era in which much of the matter in the universe consists of jay bosons.

$$(\upsilon^3\rho)^2/(\upsilon r)^6 \tag{112}$$

The method that we use to calculate spans for other components of G-family forces would not pertain for 4G2468⟦16⟧. (See discussion regarding equation (40).) We assume that the span ι_I - as in PRι_IISP - pertains for 4G2468⟦16⟧. The notation that equation (113) shows pertains.

$$4(\iota_I)\mathrm{G}2468\,[\![16]\!] \tag{113}$$

We assume that 4G provides the dominant phenomena that pertain early in this era. (For later eras, we identify a combination of stuff - or non-G-family phenomena - and dominant components of G-family forces.)

We assume that interactions of the form that equation (114) shows pertain. Here, we assume that the net circular polarization for before the interaction is zero.

$$4(\iota_I)\mathrm{G}2468[\![16]\!]{+}4(\iota_I)\mathrm{G}2468[\![16]\!] \rightarrow 2(\iota_I)\mathrm{J}_-{+}2(\iota_I)\mathrm{J}_+ \tag{114}$$

2.3.2. The later of two eras that might occur before inflation

We explore the notion that, just before the inflationary epoch, the main component of the universe might have consisted of jay bosons.

Ongoing modeling seems to suggest that nature creates photons (or, 2G) primarily after the inflationary epoch. Regarding times just before inflation, we assume that the allowed reactions that table 25 shows pertain.

We assume that the particle density is sufficiently large that modeling can correlate the production of 4G with the 4G2468x components of 4G.

Equation (115) describes a possible interaction. For PRι_IISP models for which ι_I exceeds one, we posit that modeling suggests roughly equal creation of ι_I isomers for each of 4G2468x and 0I.

$$2(\iota_I)\mathrm{J}_- + 2(\iota_I)\mathrm{J}_- \rightarrow 4(1)\mathrm{G}2468\mathrm{x} + 0(1)\mathrm{I} \tag{115}$$

4G4 has a span of six. To the extent that ι_I exceeds one, isomers interact with each other during and after this period.

Table 25 suggests that interactions between pairs of jay bosons do not create photons. A lack of photons is compatible with ongoing modeling that suggests that significant presence of photons starts after inflation.

2.3.3. Inflation

We discuss possibilities regarding the inflationary epoch.

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. 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 [8] summarizes aspects related to inflation, points to references regarding ongoing modeling, and discusses some ongoing modeling work.)

Reference [9] suggests the possibility that a repulsive aspect of gravity drove phenomena correlating with the inflationary epoch. The reference suggests that the composition of the universe was nearly uniform spatially. The reference suggests the importance of a so-called inflaton field.

Proposed modeling suggests the possibility that, during the inflationary epoch, aye particles (or, 0I particles) provided a major non-long-range-force component of the universe. The aye particle matches ongoing modeling notions of a boson with zero spin. (See reference [8].) 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. (Components 4G4268x correlate with GFC octupole and with KIN octupole.) Those components interact with individual simple particles and are repulsive. Equation (116) shows such an interaction. Here, x and y might be either of a and b.

$$0(1)\mathrm{I} + 4(1)\mathrm{G2468x} \rightarrow 0(1)\mathrm{I} + 4(1)\mathrm{G2468y} \tag{116}$$

Around the time of the inflationary epoch, octupole attraction correlating with 4G246⟦16⟧ might play a role. (Perhaps, see table 23.)

2.3.4. Just after inflation

The end of the inflationary epoch might correlate with a change, regarding effects of 4γ, 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 or, for example, some phenomena regarding positronium - 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.

Proposed modeling suggests the possibility that, for some time just after the inflationary epoch, the aye particle might have been a dominant non-long-range-force component of the universe. Interactions between aye particles would produce components of 2G forces. (See equation (117).) Interactions of 2G with itself produce matter-and-antimatter pairs of simple fermions. Proposed modeling suggests the possibility that attraction based on the (quadrupole) 4G246 component of 4γ contributed to clumping.

$$0\mathrm{I} + 0\mathrm{I} \rightarrow 2\mathrm{G} + 2\mathrm{G} \tag{117}$$

2.3.5. Dissimilarities between isomers

We consider a thought experiment regarding isomer zero (or, the isomer that includes ordinary matter) and a so-called isomer alt zero. Here, alt zero is one of one, two, four, and five.

The stuff that correlates with isomer alt zero and the stuff that correlates with isomer zero exhibit similarities with respect to phenomena involving quarks, gluons, and W-family bosons.

We consider a time at which the densities of stuff are high and the isomers are essentially similar. Similar evolution would occur to the extent that one considers just quarks, gluons, and W-family bosons.

We consider three-quark baryons (real or virtual) that consist of generation three quarks. The charged baryons are more massive than the neutral (or, charge-neutral) baryons. (Consider the masses - per table 22 - of the constituent quarks.)

For the alt zero isomer, generation three leptons are less massive than the tauon that correlates with isomer zero generation three. Interactions that produce generation three leptons (and produce or consume W bosons) facilitate - in the alt zero isomer compared to isomer zero - more transitions from all-generation-three charged baryons to all-generation-three neutral baryons.

Over time, in both isomers, generation three quarks and generation two quarks evolve, via interactions that entangle multiple W bosons, into generation one quarks.

We consider a time when the transitions to all-generation-one quarks have just completed. Densities of stuff have dropped. We consider all-generation-one baryons. Compared to isomer zero, the alt isomer contains more alt neutrons than isomer zero contains neutrons. The mass of the alt isomer generation one charged lepton exceeds the mass of the isomer zero generation one charged lepton (or, the mass of

Table 32: Ordinary matter, four cold dark matter isomers, and the one other dark matter isomer

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

Table 33: Aspects regarding three eras correlating with the expansion of the universe

Aspect	Era: Inflation	Era: Next billions of years	Era: Most recent billions of years
Observed changes in the rate	?	Decrease	Increase
Ongoing modeling KIN model-based changes in the rate	Increase	Decrease	Increase
Proposed modeling ENT model-based changes in the rate	Increase	Decrease	Increase
Drivers, as suggested by ENT modeling and GFC modeling (4G components that dominate between largest objects)	4G2468a, 4G2468b	4G246	4G48
KIN RSDF for the 4G components	r^{-5}	r^{-4}	r^{-3}
Proposed modeling interpretation of KIN modeling for the net force correlating with the components	Repulsive	Attractive	Repulsive

the electron). The (already more abundant, compared to isomer zero) alt one neutrons have difficulties (compared to isomer zero neutrons) decaying into charged baryons.

From then on, the alt isomer has, compared to isomer zero, more neutrons and fewer protons. The alt isomer has, compared to isomer zero, fewer charged leptons. The alt isomer has, compared to isomer zero, fewer charged leptons with masses equal to the mass of the isomer zero electron.

Even to the extent that stuff correlating with isomer alt zero forms some stars, isomer alt zero becomes cold dark matter consisting mainly of alt neutrons and alt hydrogen atoms. Also, the collection of - mostly old - alt isomer photons cools.

We consider isomer zero and isomer three.

Presumably, similar evolution pertains regarding isomer three and isomer zero. For example, isomer three stuff forms stars in numbers similar to isomer zero numbers.

Table (32) pertains.

2.3.6. 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.

2.3.7. The rate of expansion of the universe

Table 33 posits concepts regarding three eras in the rate of expansion of the universe. (Regarding observations that correlate with the eras that correlate with decrease and recent increase, see references [10], [11], [12], and [13].) We know of no observations that pertain directly to the era of inflation. Ongoing modeling suggests the existence of an era of inflation.

The uses, in table 33, of the word repulsive and the word attractive comport with table 23.

Two thought experiments provide notions that lead to table 33.

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

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

Interactions between galaxy-like clumps transit to 4G4 RSDF r^{-2} dominance quickly compared to the current age of the universe. Mutual attraction occurs. Interactions between adequately larger clumps can still exhibit 4G48 RSDF r^{-3} dominance. Mutual repulsion occurs.

Table 33 suggests correlations between repulsion and 4G2468a, 4G2468b, and 4G48. Table 33 suggests correlations between attraction and 4G246. We suggest these correlations, based on data.

Work elsewhere in this essay reinforces the notions that 4G246 correlates with attraction and that 4G2468a, 4G2468b, and 4G48 correlate with repulsion. (See table 23.)

People suggest that ongoing modeling underestimates recent increases in the rate of expansion. (See, for example, reference [14], reference [15], reference [16], and reference [17]. However, some people note possible objections to some notions of underestimates. See, for example, references [18] and [19].) People suggest phenomenological remedies regarding the modeling. (See, for example, reference [20].)

Proposed modeling suggests a reason for such underestimates.

We consider a thought experiment.

Here, we assume that people use models that correlate with data about the rate of expansion during the era of decreases in that rate. We assume that the models have bases in equations of state and in general relativity.

Proposed modeling correlates dominant effects - for the era of decreasing rate - with the span of one that correlates with 4G246. Proposed modeling correlates dominant effects for the recent era with the span of two that correlates with 4G48.

Applying decreasing-rate era equations of state and general relativity to current era phenomena correlates with underestimating a key factor - 4G48 repulsion - by, conceptually, a factor of two.

2.3.8. Dark matter density of the universe

Ongoing modeling discusses five partial densities of the universe. The symbol $\Omega_{\rm c}$ denotes dark matter (or, cold dark matter) density of the universe. The symbol $\Omega_{\rm b}$ denotes ordinary matter (or, baryonic matter) density of the universe. The symbol Ω_ν denotes neutrino 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 (118) pertains regarding the total density of the universe, Ω.

$$\Omega = \Omega_{\rm c} + \Omega_{\rm b} + \Omega_\nu + \Omega_\gamma + \Omega_\Lambda \tag{118}$$

Reference [1] provides the data that equations (119), (120), (121), and (122) show.

$$\Omega_{\rm c} \approx 0.265 \pm 0.007 \tag{119}$$

$$\Omega_{\rm b} \approx 0.0493 \pm 0.0006 \tag{120}$$

$$\Omega_\nu \leq 0.003, \text{ also } \Omega_\nu \geq 0.0012 \tag{121}$$

$$\Omega_\gamma \approx 0.0000538 \pm 0.0000015 \tag{122}$$

In ongoing modeling, the symbol $\Omega_{\rm c}$ correlates with all dark matter. To the extent that proposed modeling PR6ISP modeling comports with nature, the symbol $\Omega_{\rm c}$ correlates with all of the three aspects - isomer zero 1R⊗2U hadron-like particles, the four dark matter isomers that we correlate above with the word cold, and the one dark matter isomer that we do not necessarily correlate above with the word cold - that proposed modeling correlates with the term dark matter.

Proposed modeling suggests considering - for each isomer j, with $0 \leq j \leq 5$ - equation (123). (Technically, the isomers share a fraction of Ω_γ, but the total Ω_γ is small.) The symbol $\Omega_{\rm 1R2U,j}$ denotes the density of the universe that correlates with the 1R⊗2U hadron-like particles that correlate with isomer

Table 34: Opportunities for advances regarding astrophysics

Opportunity
• Describe mechanisms leading to an observed amount of depletion - some of which has bases in hyperfine interactions with hydrogen atoms - of cosmic microwave background radiation.
• Hone scenarios correlating with the formation of galaxies.
• Explain data - that ongoing modeling seems not to explain - about the following.
○ Large clumps of ordinary matter gas and of dark matter.
○ Ratios of dark matter to ordinary matter in galaxy clusters.
○ Amounts of stuff that does and does not pass through - with mainly just gravitational interactions - collisions of galaxy clusters.
○ Some aspects of interactions between galaxies.
○ Ratios - within galaxies - of dark matter to ordinary matter.
○ Dark matter effects within the Milky Way galaxy.

j. From here on, we de-emphasize the densities of neutrinos and the densities of photons. Equation (124) pertains. Even though isomers evolve differently with respect to quark-based hadrons, we assume that there is adequate similarity in evolution so that equation (125) pertains. Equations (126) and (127) pertain.

$$\Omega_j = \Omega_{\mathrm{b},j} + \Omega_{\mathrm{1R2U},j} + \Omega_{\nu,j} + \Omega_{\gamma,j} \tag{123}$$

$$\Omega_{\mathrm{b}} + \Omega_{\mathrm{c}} \approx \sum_{j=0}^{5} \Omega_j \tag{124}$$

$$\Omega_{\mathrm{1R2U},j} \approx \Omega_{\mathrm{1R2U},0}, \text{ for } 0 \leq j \leq 5 \tag{125}$$

$$\Omega_{\mathrm{b}} + \Omega_{\mathrm{c}} \approx \Omega_{\mathrm{b}} + \Omega_{\mathrm{1R2U},0} + 5(\Omega_{\mathrm{1R2U},0} + \Omega_{\mathrm{b}}) \tag{126}$$

$$\Omega_{\mathrm{1R2U},0} \approx (\Omega_{\mathrm{c}} - 5\Omega_{\mathrm{b}})/6 \tag{127}$$

Equation (128) estimates $\Omega_{\mathrm{1R2U},0}$ for the current state of the universe.

$$\Omega_{\mathrm{1R2U},0} \approx 0.0031 \tag{128}$$

Except possibly regarding dark energy density (or, Ω_Λ), proposed modeling suggests that ratios of the actual values of the various $\Omega\_$ in equation (118) remain constant for essentially the entire history of the universe. (This essay does not speculate - regarding this topic - regarding the very earliest times after the Big Bang. Regarding Ω_Λ, see discussion related to equation (131).) PR6ISP proposes no significant mechanisms for transferring stuff between ordinary matter and dark matter. (We assume that net transfers based on components - for which the spans are greater than one - of 2G are negligible.)

We discuss measurements via which people infer densities - of dark matter and ordinary matter - of the universe.

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 - to which equations (119), (120), (121), and (122) point. A ratio of five-plus to one might pertain for billions of years.

Regarding data based on CMB, 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 (129) pertains. That time range starts somewhat after 380,000 years after the Big Bang and continues through now.

$$\Omega_\gamma \ll \Omega_{\mathrm{b}} \text{ and } \Omega_\nu \ll \Omega_{\mathrm{b}} \tag{129}$$

2.4. *Astrophysics*

Table 34 lists opportunities for advances regarding astrophysics. Proposed modeling suggests advances regarding each opportunity.

We discuss ratios that proposed modeling PR6ISP models might predict or explain.

Table 35: Approximate ratios of dark matter effects to ordinary matter effects (with DM denoting dark matter; with OM denoting ordinary matter; with A denoting amount; and with OM CMB denoting cosmic microwave background radiation)

Approximate DMA:OMA	Amounts
5^+:1	Density of the universe
5^+:1	Amount of stuff in some galaxy clusters
1:1 or 1^+:1	Amount of absorption of OM CMB via some 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

Table 35 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 ratio that people observe regarding densities of the universe. Here, the five correlates with dark matter isomers of simple elementary particles (that is, of elementary particles other than 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 36.) Discussion regarding 2(2)G68 correlates with the approximately one to one ratio. (See discussion related to equation (41) and discussion related to equation (130).) DMA:OMA ratios of zero-plus to one, four to one, and one to zero-plus comport with roles of non-monopole components of gravity in scenarios regarding galaxy formation. (See discussion related to table 38.) DMA:OMA ratios of zero-plus to one, four to one, and 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 38.)

2.4.1. CMB depletion via hyperfine interactions

People measure specific depletion of CMB and attribute some of that depletion to hyperfine interactions with (ordinary matter) hydrogen atoms. (See reference [21].) 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 [22].)

Proposed modeling suggests the following explanation. Solution 2(2)G68 (or, 2G68) might correlate with hyperfine interactions. (See discussion related to equation (41). Perhaps, also note equation (130).) Solution 2G68 has a span of two. (See table 18b.) Solution 2G68 does not correlate with interactions with individual simple fermions. (See table 18b.) Half or somewhat less than half of the observed absorption correlates with the ordinary matter isomer of hydrogen atoms. An approximately equal amount of the observed effect correlates with hydrogen-atom isomers that correlate with one dark matter isomer.

$$2\mathrm{G}68 \notin 2\gamma,\ \ 2\mathrm{G}68 \notin \gamma 2 \tag{130}$$

To the extent that the absorption by ordinary matter is less than half of the total absorption, the following explanations might pertain regarding the difference between less than half and equal to half. 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 $2\mathrm{G}\Gamma$ solutions with spans of at least two. Each one of solutions 2(6)G46 and 2(6)G468 might pertain. For each one, the solution is not a member of 2γ and is not a member of $\gamma 2$. The number six appears in both the Γ for 2(6)G46 and the Γ for 2(6)G468. Solution 2(6)G46 correlates with a KIN spatial dipole effect. Solution 2(6)G468 correlates with a KIN spatial dipole effect (and with the notion of GFC quadrupole solution).

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 [23].)

2.4.2. Large clumps of ordinary matter gas and of dark matter

Reference [24] discusses observations that point to the notion that - on a large scale - clumping of matter - ordinary matter gas and dark matter - might be less than ongoing modeling models suggest. Observed phenomena have bases in gravitational lensing of light. The article alludes to a dozen observational studies and points to at least two papers - reference [25] and reference [26]. Clumps would be - to use wording from reference [24] - too thin. (Reference [24] 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 [17] - too smooth. Reference [17] 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 19a and table 23.) 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. Also, effects of dilution might carry into the times for which 4(6)G4 attraction dominates.

2.4.3. 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 [27] and [28] report ratios of five-plus to one. The observations have bases in gravitational lensing. Reference [29] reports, for so-called massive galaxy clusters, a ratio of roughly 5.7 to one. (Perhaps, note reference [30].) The observations have bases in X-ray emissions.

Proposed modeling PR6ISP modeling is not incompatible with these galaxy cluster centric ratios.

Reference [31] 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 dark matter and ordinary matter.

2.4.4. Galaxy clusters - collisions

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 during the collision. For each of the two clusters, stars move along trajectories generally consistent with just gravitational interactions during the collision. 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, across the six (five dark matter and one ordinary matter) isomers, there would not be enough $1R\otimes2U$ 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 cold dark matter and that one dark matter isomer exhibits behavior similar to behavior that ordinary matter exhibits. (See discussion related to table 30 and see table 32.)

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 $1R\otimes2U$ would pass through. For isomer zero, incoming $1R\otimes2U$ (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 36: Aspects regarding a collision between two galaxy clusters (with the assumption that each of the two galaxy clusters has not undergone earlier collisions)

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 significantly interacts non-gravitationally with dark matter and, based on non-gravitational interactions, 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 $1R\otimes2U$ passes through the collision with just gravitational interactions having significance.

Table 36 lists aspects regarding a collision between two galaxy clusters. Here, we assume that each of the two galaxy clusters has not undergone earlier collisions.

We 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.

2.4.5. Interactions between galaxies

Reference [32] reports measurements pertaining to external gravitational effects on components of individual galaxies. The article suggests that - compared to expected results based on notions that correlate with the strong equivalence principle and with general relativity - observations point to unexpected effects regarding galaxy rotation curves. The article suggests the possibility of correlating the unexpected effects with the notion of an external field effect and possibly with aspects of MOND (or, Milgromian dynamics or modified Newtonian dynamics).

Proposed modeling provides the possibility that the unexpected results correlate with differences in spans between 4G4 (for which the span is six) and (perhaps just) 4G48 (for which the span is two) and (maybe also) other components of 4γ (for which the spans are one).

2.4.6. Galaxies - formation

We discuss scenarios regarding galaxy formation and evolution. We anticipate that such galaxy formation and evolution scenarios will explain galaxy centric data that table 35 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. (Reference [33] and

Table 37: A scenario for the formation and evolution of a galaxy for which the original clump contains essentially just one isomer (with the two-word phrase featured isomer correlating with that one isomer)

Step
• 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.

reference [34] discuss data that pertains regarding a time range from about one billion years after the Big Bang to about 1.5 billion years after the Big Bang. Observations suggest that, out of a sample of more than 100 galaxies or galaxy-like rotating disks of material, about 15 percent of the objects might have been untouched.)

We assume that differences - in early evolution - regarding the various isomers do not lead, for the present discussion, to adequately significant differences - regarding 4G interactions and galaxy formation - between isomers. (We think that this assumption can be adequately useful, even given our discussion regarding the Bullet Cluster. Regarding the Bullet Cluster, see discussion related to table 36.)

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 37 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 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.

2.4.7. Galaxies - ratios of dark matter to ordinary matter

We continue to explore the realm of one-isomer clumps.

One of two cases pertains. For so-called case A, one isomer of 4(2)G48 spans (or connects) isomers zero and three. (Regarding numbering for isomers, see n in table 32.) For so-called case B, one isomer of 4(2)G48 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 38a and the rightmost column in table 38b.) 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 38 pertains. (See table 35.) The following sentences illustrate the notion that some statements in table 38 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. (Table 35 defines the three-letter terms DMA and OMA.) 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$\otimes$2U hadron-like particles.

Table 38 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 38 features might 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 - via collisions - from spiral to elliptical.

Table 38: 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 cold dark matter over time. Can get to DMA:OMA≈4:1, with most DM in a halo. Might be a spiral galaxy.
A3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the four other DM isomers over time. Some OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
AX	Any one of 1, 2, 4, and 5	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three or four DM isomers in a halo. Might become an elliptical galaxy.

(b) Case B

Label	Featured isomer (n)	Early aspects regarding the galaxy	Possible later aspects regarding the galaxy
B0	0	Forms some ordinary matter stars early on. Starts at DMA:OMA=0^+:1.	Attracts isomer three and three cold dark matter isomers over time. Can get to DMA:OMA≈4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BP	The DM isomer that 4(2)G48 connects to the OM isomer	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the other DM isomers over time. OM stars can form over time. Can settle at DMA:OMA=1:0^+. The three-word term dark matter galaxy pertains.
B3	3	Forms some dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three DM isomers in a halo. Might appear to be an elliptical galaxy.
BY	Any one of the other three DM isomers	Might form dark matter stars early on. Starts at DMA:OMA=1:0^+.	Attracts the OM isomer and three other DM isomers over time. OM stars can form over time. Can get to DMA:OMA≈4:1, with three or four DM isomers in a halo. Might appear to be an elliptical galaxy.

We explore the extent to which the galaxy formation scenarios comport 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 35 comports with these results. We suggest that visible early galaxies correlate with generalization of label-A0 or with generalization of label-B0. (See table 38.) Label-A3 or label-B3 evolves similarly to label-A0 or label-B0, but is not necessarily adequately visible early on.

- Reference [35] provides data about early-stage galaxies. (See, for example, figure 7 in reference [35]. 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 [36] suggests that redshifts of at least seven pertain to times ending about 770 million years after the Big Bang.

- Reference [37] 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 35 comports with these results.

- Reference [38] discusses some MED09 spiral - or, disk - galaxies. A redshift of approximately $z = 1.57$ pertains. (See reference [39].) The redshift correlates with a time of 4.12 billion years after the Big Bang. (We used reference [36] to calculate the time.) Reference [38] 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 38 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 38.)
  - 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 DMA:OMA 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 [40] 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 [36] 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 [41].) 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 38.)

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 35 seems to comport with these results. (See table 38.)

- Reference [42] discusses six baryon-dominated ultra-diffuse galaxies that seem to lack dark matter, at least to the radii studied (regarding 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 [43] 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 [44] 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 [45] 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 [38] 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 38 shows can pertain.

- The galaxy NGC1052-DF4 might correlate with a ratio of much less than one to one. (See reference [46].) 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 [47].) 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 might have been - 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 [48].) 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 35 and table 38 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 [49].) 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 [50].) 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 [51].) 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 [52].)

- 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 [53].)

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.

2.4.8. Some components of galaxies

We discuss effects, within galaxies, that might correlate with dark matter.

Reference [54] 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. Reference [55] 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 38.) 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 [56] 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 38.) 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 38 is not incompatible with the notion that visible stars do not include much dark matter.

Discussion related to table 38 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 [57] and [58].)

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 [59].) 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 4(2)G48 repulsion pertains. Effects of 4(2)G48 repulsion would vary based on the amounts of various isomers that each black hole in a pair of colliding black holes features.

2.4.9. Dark matter effects within the Milky Way galaxy

People look for possible 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 [60].) 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 [61].) 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 [61] and [62].) 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.

3. Results

This unit summarizes results that proposed modeling produces.

3.1. Physics properties

Table 12 and table 13 show an organizing and a uniting of various properties of objects. Examples of ongoing modeling properties include charge, energy, angular momentum, and momentum. The property of isomer (of simple elementary particles) arises from proposed modeling. Figure 1 summarizes some aspects of table 12.

Principles for organizing and uniting the properties come from proposed modeling models that feature components of long-range forces. (See, for example, table 7, table 8, and table 9.)

3.2. *Elementary particles*

Table 16 alludes to all known elementary particles and to candidate elementary particles that proposed modeling suggests. Figure 2 summarizes some information about elementary particles. Figure 3 shows suggested rest energies for all elementary fermions other than the electron and muon (for which people have determined masses rather accurately).

This essay suggests that particles correlating with table 16 might suffice - from the standpoint of elementary particles - to explain data that ongoing modeling does not yet explain and to predict data that ongoing modeling does not necessarily predict. Some of that data correlates with the field of cosmology. Some of that data correlates with the field of astrophysics. Some of that data correlates with the field of elementary particles.

Proposed modeling points to various correlations among properties of elementary particles and strengths of interactions.

3.3. *Cosmology*

Proposed modeling suggests advances correlating with the opportunities that table 31 lists. Figure 4 suggests eras - in the evolution of the universe - that might precede inflation. Figure 4 also suggests insight regarding mechanisms leading to eras regarding the rate of expansion of the universe. Figure 5 depicts information about the ratio of dark matter density of the universe to ordinary matter density of the universe.

3.4. *Astrophysics*

Proposed modeling suggests advances correlating with the opportunities that table 34 lists and with data to which table 35 alludes. Figure 5 depicts information about the ratio of dark matter density of the universe to ordinary matter density of the universe. Figure 6 notes seemingly prevalent ratios of dark matter to ordinary matter. This essay discusses aspects of galaxy formation and other phenomena that seem to lead to the seemingly prevalent ratios.

3.5. *Physics modeling*

Proposed modeling suggests perspective about modeling and about notions correlating with the word object. For example, table 12 and table 13 suggest perspective about relationships between models, modeling that purports to discuss distinguishable (or, generally non-entangled) objects, and properties that correlate with objects.

Figure 7 suggests that ongoing modeling provides a framework for cataloging, comparing, and uniting aspects of proposed modeling and aspects of ongoing modeling. Figure 7 uses and extends notions that table 12, table 13, and figure 1 show.

4. Discussion

This unit provides perspective about some physics topics and about proposed modeling.

4.1. *Dark energy density*

We explore possible explanations for nonzero dark energy density.

Equation (131) shows a ratio of presently inferred density of the universe of dark energy to presently inferred density of the universe of dark matter plus ordinary matter plus (ordinary matter) neutrinos plus (ordinary matter) photons. (Reference [1] provides the five items of data.) Inferences that reference [63] discusses might suggest that inferred dark energy density increases with time. Reference [64] suggests that an inferred dark energy density of essentially zero correlates with times around 380,000 years after the Big Bang. We know of no inferences that would not comport with a somewhat steady increase - regarding the inferred ratio correlating with equation (131) - from approximately zero over time since somewhat after the Big Bang.

$$\Omega_\Lambda/(\Omega_\mathrm{c} + \Omega_\mathrm{b} + \Omega_\nu + \Omega_\gamma) \approx 2.18 \tag{131}$$

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 such ongoing modeling. Nevertheless, we discuss possibilities for proposed modeling that might explain nonzero dark energy density.

For any one of PR1ISP modeling, PR6ISP modeling, and PR36ISP modeling, aspects related to the aye (or, 0I) boson or the jay (or, 2J) boson might lead to phenomena similar to effects that ongoing modeling correlates with vacuum energy, vacuum fluctuations, or quintessence. (See discussion related to equations (89) and (90). Perhaps, also note discussion related to equation (112).)

For PR6ISP modeling, proposed modeling includes the notion of 2(6)G248, whereas ongoing modeling correlates with the notion of 2(1)G248. 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 nonzero dark energy density. The difference correlates with interactions between ordinary matter and dark matter.

PR36ISP modeling offers another possibility. (This possibility correlates with a six-fold symmetry that correlates with the instance of $U(1) \times SU(2)$ that table 13b shows.) We assume that the spans of 4(6)G4 and the other 4($>$1)GΓ components are orthogonal to the spans of 2(6)G248 and the other 2($>$1)GΓ components. The PR36ISP universe correlates with six isomers of a PR6ISP sub-universe. Each PR6ISP sub-universe includes its own isomer of 4(6)G4. We continue to correlate ordinary matter with isomer zero and most dark matter with isomers one through five. We use the numbers six, 12, 18, 24, and 30 to number the five isomers for which 2(6)GΓ components intermediate interactions with isomer zero. We use the three-word term doubly dark matter to correlate with isomers six through 35. Doubly dark matter isomers do not interact with ordinary matter via 4G. Dark matter isomers do not interact with ordinary matter via 2G. Differences between 2($>$1)GΓ and 2(1)GΓ correlate with interactions between ordinary matter plus dark matter and doubly dark matter. All interactions - mediated by 2G - that PR6ISP modeling would correlate with interactions between ordinary matter and dark matter isomers become - for PR36ISP modeling - interactions between ordinary matter and doubly dark matter. Dark energy density might correlate with stuff correlating with the 30 doubly dark matter isomers. Modeling suggests an upper bound of approximately five regarding a possible future value for the ratio that correlates with equation (131).

4.2. W boson mass and full magnetic moment

Reference [1] suggests that the full magnetic moment of the W boson might exceed a nominal magnetic moment that correlates with the number two. Reference [1] provides the value that equation (132) shows.

$$\mu_W = 2.22^{+0.20}_{-0.19} \tag{132}$$

We explore the notion that, for the W boson, Z_{S2} correlates generally with magnetic moment and specifically with a full magnetic dipole moment. (See discussion related to equation (52).) We note two calculations.

For charged leptons, ongoing modeling provides a first-order correction to the nominal magnetic dipole moment of $g = 2$. The correction has the form $(g-2)/2 = \alpha/(2\pi)$ or $g \approx 2 + (\alpha/\pi)$. We experiment, based on a possibly somewhat arbitrary assumption. Using $Z_{S2} \approx 2 + (\alpha/\pi)$ (and not using $Z_{S2} = 2$) with equation (53) would suggest a W boson rest energy of 80.3932 GeV, which is about 1.2 standard deviations above the measured value that reference [1] provides. The value $g \approx 2+(\alpha/\pi)$ is not necessarily incompatible with equation (132). A W boson rest energy of 80.3932 GeV might be more - than the rest energy equation (50) suggests - compatible with (future) data. However, the rest energy that equation (50) suggests is not necessarily incompatible with data.

If, instead, one uses $Z_{S2} = 2.22$ (from equation (132)), one calculates a W boson rest energy of 66.5 GeV, which is not acceptable.

We know of no currently available path to further explore the accuracy of equation (50).

4.3. 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 [65].) 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 [66] and [67].)

Some ongoing modeling models suggest a maximum neutron star mass of about $1.5M_\odot$. (See reference [67].)

Observations correlate with most known neutron star pairs having masses in the range that equation (133) shows and one neutron star pair having a mass of about 3.4 solar masses. (See references [68] and [69].) 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.

$$2.5M_{\odot} \lesssim M \lesssim 2.9M_{\odot} \tag{133}$$

People speculate - based on, at least, the GW190425 result - about needs for new modeling regarding neutron stars. (See references [68] and [67].)

Detection GW190814 suggests that people have inferred the existence of an object for which equation (134) pertains. (See reference [70].) People speculate that the object might have been a high-mass neutron star or might have been a low-mass black hole.

$$M \approx 2.6M_{\odot} \tag{134}$$

We discuss possible bases for high-mass neutron stars.

The 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.

4.4. Physics properties

Equation (135) points to oscillator pairs that correlate with some physics constants. The case of $j = 1$ correlates with m_e (and with other masses, such as m_{Higgs}). The case of $j = 2$ correlates with $\hbar$. The case of $j = 3$ correlates with c. (Perhaps note that, in table 12b, translational momentum correlates with USA: 11-12.) The case of $j = 4$ correlates with q_e (and with other charges).

$$USA(4j-1) \text{ and } USA(4j) \tag{135}$$

Ongoing modeling suggests new notions regarding physics properties.

We consider PR6ISP modeling. We discuss properties - as interpreted via isomer zero observations and experiments - of isomer one simple particles. The notion of ΣGΓ provides a basis for this discussion.

We consider gravitational rest energies and other properties.

Notions correlating with 4G4 pertain. 4G4 has a span of six. For isomer one objects, isomer zero measures the same passive gravitational rest energies as isomer one measures. For isomer one objects, isomer zero measures the same active gravitational rest energies as isomer one measures. For isomer one objects, when isomer zero measures aspects that correlate with 2G, isomer zero measurements do not necessarily agree with isomer one measurements. Isomer zero measurements attribute charges of zero to isomer one objects that have nonzero isomer one charges. Isomer zero measurements attribute nominal magnetic dipole moments of zero to isomer one objects that have nonzero isomer one nominal magnetic dipole moments. Isomer zero measurements attribute the same nominal magnetic quadruple moments to isomer one objects as do isomer one measurements.

Discussion elsewhere suggests the possibility that - regarding measurements (made via isomer zero 2(1)G techniques) of not necessarily gravitational masses (perhaps, including inertial masses) of isomer one objects - the isomer zero inference of not necessarily gravitational masses (perhaps, including inertial masses) of the isomer one objects might differ from the passive gravitational masses of the isomer one objects by a factor of β. (See, for example, discussion related to equation (110) or aspects related to table 30.)

4.5. Proposed modeling

The following notions were essential to the development of proposed modeling.

There might be a straightforward explanation for three eras in the rate of expansion of the universe.

There might be a straightforward explanation for the ratio of dark matter density of the universe to ordinary matter density of the universe.

Solutions - that were seemingly previously essentially unknown and that ongoing modeling might consider to correlate with the three-word term below ground state - regarding harmonic oscillator mathematics exist and might have use in physics modeling.

People might use observational data about dark matter and objects (especially, but not only just, galaxies) to evaluate the usefulness - regarding elementary particle physics, astrophysics, and cosmology - of proposed modeling.

The following notions might pertain regarding proposed modeling.

People might find that some aspects of proposed modeling are incomplete or are not compatible with data. We suggest that people might be able to adjust proposed modeling - to remedy such lacks of completeness or compatibility - without abandoning much of proposed modeling. Some incompleteness might feature the extents to which neutrinos and arcs model as being Dirac fermions or Majorana fermions.

5. Concluding remarks

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 suggests applied mathematics techniques that might 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, development of data analysis techniques, numerical simulations, and theoretical research regarding elementary particle physics, astrophysics, and cosmology.

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References

[1] P.A. Zyla et al. Review of Particle Physics. *PTEP*, 2020(8):083C01, 2020. 2.2.2, 2.2.3, 2.2.3, 2.2.3, 2.2.3, 2.2.3, 2.2.3, 2.2.3, 2.2.4, 2.2.4, 2.2.8, 2.3.8, 4.1, 4.2, 4.2

[2] G. A. Gonzalez-Sprinberg and J. Vidal. Tau magnetic moment. *J. Phys. Conf. Ser.*, 912(1):012001, 2017. 2.2.3

[3] 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. 2.2.5

[4] Matteo Rini. A Fine Positronium Puzzle. *Physics*, 13, August 2020. Link: https://physics.aps.org/articles/v13/s99. 2.2.5

[5] Johanna L. Miller. Closing in on neutrino CP violation. *Phys. Today*, 2020(1):0423a, April 2020. 2.2.7

[6] V. M. Abazov, B. Abbott, M. Abolins, et al. Search for right-handed W bosons in top quark decay. *Phys. Rev. D*, 72:011104, July 2005. 2.2.8

[7] Paul Langacker and S. Uma Sankar. Bounds on the mass of W sub R and the W sub L - W sub R mixing angle. zeta. in general SU(2) sub L times SU(2) sub R times U(1) models. *Phys. Rev. D*, 40(5):1569–1585, September 1989. 2.2.8

[8] Mark P. Hertzberg. Structure Formation in the Very Early Universe. *Physics Magazine*, 13(26), February 2020. Link: https://physics.aps.org/articles/v13/16. 2.3.3

[9] Brian Green. *Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe*. Alfred A. Knopf, February 2020. 2.3.3

[10] N. G. Busca, T. Delubac, J. Rich, et al. Baryon acoustic oscillations in the Lya forest of BOSS quasars. *A&A*, 552(A96), April 2013. 2.3.7

[11] 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. 2.3.7

[12] 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. 2.3.7

[13] 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. 2.3.7

[14] L. Verde, T. Treu, and A. G. Riess. Tensions between the early and late Universe. *Nature Astronomy*, 3(10):891–895, September 2019. 2.3.7

[15] Johanna L. Miller. Gravitational-lensing measurements push Hubble-constant discrepancy past 5σ. *Phys. Today*, 2020(1):0210a, February 2020. 2.3.7

[16] Thomas Lewton. What Might Be Speeding Up the Universe's Expansion? *Quanta Magazizne*, May 2020. Link: https://www.quantamagazine.org/why-is-the-universe-expanding-so-fast-20200427/. 2.3.7

[17] Christopher Wanjek. Dark Matter Appears to be a Smooth Operator. *Mercury*, 49(3):10–11, October 2020. 2.3.7, 2.4.2

[18] Natalie Wolchover. New Wrinkle Added to Cosmology's Hubble Crisis. *Quanta Magazine*, February 2020. Link: https://www.quantamagazine.org/new-wrinkle-added-to-cosmologys-hubble-crisis-20200226/. 2.3.7

[19] 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. 2.3.7

[20] 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. 2.3.7

[21] 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. 2.4.1

[22] Rennan Barkana. Possible interaction between baryons and dark-matter particles revealed by the first stars. *Nature*, 555(7694):71–74, March 2018. 2.4.1

[23] Paolo Panci. 21-cm line Anomaly: A brief Status. In *33rd Rencontres de Physique de La Vallee d'Aoste*, July 2019. 2.4.1

[24] Charlie Wood. A New Cosmic Tension: The Universe Might Be Too Thin. *Quanta Magazine*, September 2020. Link: https://www.quantamagazine.org/a-new-cosmic-tension-the-universe-might-be-too-thin-20200908/. 2.4.2

[25] 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. 2.4.2

[26] 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. 2.4.2

[27] 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. 2.4.3

[28] 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. 2.4.3

[29] Lawrence Rudnick. The Stormy Life of Galaxy Clusters: astro version. January 2019. Link: https://ned.ipac.caltech.edu/level5/March19/Rudnick/frames.html. 2.4.3

[30] Lawrence Rudnick. The stormy life of galaxy clusters. *Phys. Today*, 72(1):46–52, January 2019. 2.4.3

[31] 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. 2.4.3

[32] Kyu-Hyun Chae, Federico Lelli, Harry Desmond, et al. Testing the Strong Equivalence Principle: Detection of the External Field Effect in Rotationally Supported Galaxies. *The Astrophysical Journal*, 904(1):51, November 2020. 2.4.5

[33] Whitney Clavin. Rotating Galaxies Galore. April 2020. Link: https://www.caltech.edu/about/news/rotating-galaxies-galore. 2.4.6

[34] O. LeFevre, M. Bethermin, A. Faisst, et al. The ALPINE-ALMA [CII] survey: Survey strategy, observations and sample properties of 118 star-forming galaxies at $4<z<6$. October 2019. Link: https://arxiv.org/abs/1910.09517. 2.4.6

[35] 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. 2.4.7

[36] Nick Gnedin. Cosmological Calculator for the Flat Universe, 2015. Link: http://home.fnal.gov/˜gnedin/cc/. 2.4.7

[37] 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. 2.4.7

[38] 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. 2.4.7

[39] 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. 2.4.7

[40] 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. 2.4.7

[41] Shannon Hall. Ghost galaxy is 99.99 per cent dark matter with almost no stars. *New Sci.*, August 2016. Link: https://www.newscientist.com/article/2102584-ghost-galaxy-is-99-99-per-cent-dark-matter-with-almost-no-stars/. 2.4.7

[42] 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. 2.4.7

[43] 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. 2.4.7

[44] Pieter van Dokkum, Shany Danieli, Yotam Cohen, et al. A galaxy lacking dark matter. *Nature*, 555(7698):629–632, March 2018. 2.4.7

[45] 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. 2.4.7

[46] 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. 2.4.7

[47] 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. 2.4.7

[48] 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. 2.4.7

[49] 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. 2.4.7

[50] 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. 2.4.7

[51] 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. 2.4.7

[52] Heather Hill. Massive galaxies from the early universe found hiding in plain sight. *Phys. Today*, September 2019. 2.4.7

[53] 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. 2.4.7

[54] 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. 2.4.8

[55] Maria Temming. Dark matter clumps in galaxy clusters bend light surprisingly well. *Sci. News*, September 2020. Link: https://www.sciencenews.org/article/dark-matter-clumps-galaxy-clusters-bend-light-surprisingly-well. 2.4.8

[56] 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. 2.4.8

[57] M. Volonteri. Evolution of Supermassive Black Holes. In *ESO Astrophysics Symposia*, pages 174–182. Springer Berlin Heidelberg, 2007. 2.4.8

[58] Francesca Civano, Nico Cappelluti, Ryan Hickox, et al. Cosmic evolution of supermassive black holes: A view into the next two decades, May 2019. Link: https://ui.adsabs.harvard.edu/abs/2019BAAS...51c.429C/abstract. 2.4.8

[59] Elizabeth Landau. Black hole seeds missing in cosmic garden. *Jet Propulsion Laboratory News*, September 2019. Link: https://www.jpl.nasa.gov/news/news.php?feature=7504. 2.4.8

[60] 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. 2.4.9

[61] David Ehrenstein. Mapping Dark Matter in the Milky Way. *Phys. Magazine*, 12(51), May 2019. Link: https://physics.aps.org/articles/v12/51. 2.4.9

[62] Lina Necib, Mariangela Lisanti, and Vasily Belokurov. Inferred Evidence for Dark Matter Kinematic Substructure with SDSS–Gaia. *ApJ*, 874(1):3, March 2019. 2.4.9

[63] G. Risaliti and E. Lusso. Cosmological constraints from the Hubble diagram of quasars at high redshifts. *Nature Astronomy*, 3(3):272–277, January 2019. 4.1

[64] Anonymous. Content of the universe - pie chart. National Aeronautics and Space Administration, April 2013. Link: https://map.gsfc.nasa.gov/media/080998/index.html. 4.1

[65] 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. 4.3

[66] 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. 4.3

[67] Heather Hill. Strange matter interacts strongly with nucleons. *Phys. Today*, 2020(1):0327a, March 2020. 4.3, 4.3

[68] Dana Najjar. 'Radical Change' Needed After Latest Neutron Star Collision. *Quanta Magazine*, February 2020. Link: https://www.quantamagazine.org/radical-change-needed-after-latest-neutron-star-collision-20200220/. 4.3, 4.3

[69] 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: https://inspirehep.net/literature/1775566. 4.3

[70] 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. 4.3