Specifications for Elementary Particles, Dark Matter, Dark Energy, and Unifying Physics Theories

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Abstract

We suggest united models and specific predictions regarding elementary particles, dark matter, aspects of galaxy evolution, dark energy, and aspects of the cosmology timeline. Results include specific predictions for new elementary particles and specific descriptions of dark matter and dark energy. Some of our modeling matches known elementary particles and extrapolates to predict other elementary particles, including bases for dark matter. Some modeling explains observed ratios of effects of dark matter to effects of ordinary matter. Some models suggest aspects of galaxy formation and evolution. Some modeling correlates with eras of increases or decreases in the observed rate of expansion of the universe. Our modeling framework features mathematics for isotropic quantum harmonic oscillators and provides a framework for creating and unifying physics theories. Aspects of our approach emphasize existence of elementary particles and de-emphasize motion. Some of our models complement traditional quantum field theory and, for example, traditional calculations of anomalous magnetic dipole moments.

Contents

1 Introduction

This unit introduces our work and this manuscript.

1.1 Context for and scope of our work

This unit discusses context for, aspects of, and the scope of our work.

Physics includes issues that have remained unresolved for decades. For example, describe elementary particles that remain to be found. For another example, describe dark matter.

Traditional physics theory has bases in adding quantization to classical modeling of the motion of objects. We pursue an approach that features, from its beginning, quantized concepts and that does not originally address motion.

The approach matches, explains, or predicts phenomena that traditional approaches do not. For example, we suggest - with some specificity - descriptions of new elementary particles, dark matter, and dark energy. We suggest bases for formalism that can complement traditional quantum field theory and that might provide a basis for unifying physics theories.

1.2 Scope of this manuscript

This unit discusses the scope of this manuscript.

This manuscript summarizes aspects of our work. The manuscript does not mention some aspects of the work. The manuscript does not fully cover details leading to some of the results the manuscript shows. Reference [3] provides some of those details.

This manuscript provides more details than a planned conference talk would provide. (See reference [4].)

2 Methods

This unit discusses motivation behind our approach.

Some data point to quantized phenomena for which models do not necessarily need to have bases in motion, even though observations of motion led to making needed inferences from the data. Examples include quantized phenomena with observed integer ratios of observed values, including spin, charge, baryon number, and lepton number; the 24 known elementary particles and some aspects of their properties; and some approximate ratios, including ratios of squares of masses of elementary bosons and ratios of logarithms of masses of quarks and charged leptons. Other data also might be significant. One example features near-integer ratios of dark matter effects to ordinary matter effects. Another example features a numeric relationship between the ratio of the mass of a tauon to the mass of an electron and the ratio, for two electrons, of electromagnetic repulsion to gravitational attraction.

We develop new physics theory that correlates with such observations. We select modeling bases that produce quantized results. Based on quantum modeling techniques that do not necessarily consider motion or theories of motion, we develop models that match known elementary particles and extrapolate to suggest other elementary particles. We see how many observations we can match. This work suggests, for example, descriptions of some components of dark matter. Then, we consider so-called isomer-related symmetries. The work then suggests more components for dark matter and suggests theory that explains observed ratios of effects of dark matter to effects of ordinary matter.

2.1 Inspiration

This unit discusses one inspiration that led to our work.

Traditional physics theory describes photon states via two harmonic oscillators. Traditional physics theory features four space-time dimensions. Why not describe photon states via four harmonic oscillators?

Complementary physics theory describes photon states via four harmonic oscillators. A first hunch might be that doing so adds no insight. However, doing so leads to a framework for physics theories and, eventually, even to insight about photons.

2.2 ALG double-entry bookkeeping

This unit discusses aspects of mathematics-based modeling that underlies our work.

We consider the left-circular polarization mode of a photon. We denote the number of excitations of the mode by n. Here, n is a nonnegative integer. One temporal oscillator pertains. We label that oscillator TA0. The excitation number $n_{TA0} = n$ pertains. Harmonic oscillator mathematics correlates a value of $n + 1/2$ with that oscillator. Three spatial oscillators pertain. Here, $n_{SA0} = -1$, $n_{SA1} = n$, $n_{SA2} = @_0$. Oscillator SA0 correlates with longitudinal polarization and has zero amplitude for excitation. Oscillator SA1 correlates with left-circular polarization. Oscillator SA2 correlates with right-circular polarization. The symbol $@_{\_}$ denotes a value of _ that, within a context, never changes. For left-circular polarization, $@_0$ pertains for oscillator SA2. The sum $n + 1/2$ correlates with each of the one TA-side oscillator and the three SA-side oscillators. For, the SA-side oscillators, the sum equals $-1 + n + 0 + 3/2$.

The following concepts and generalizations pertain.

- The above example correlates with the term ALG modeling. ALG is an abbreviation for the word algebraic. Later we discuss PDE modeling. PDE abbreviates the three-word term partial differential equation.
- For ALG modeling, the expression $0 = A^{ALG} = A^{ALG}_{TA} - A^{ALG}_{SA}$ pertains. The one-element term double-entry pertains. For example, increasing a TA-side excitation number by one requires either decreasing a different TA-side excitation by one or increasing an SA-side excitation by one. The two-element term double-entry bookkeeping pertains.
- The expression $A^{ALG} = 0$ provides a basis for avoiding traditional physics theory concerns about unlimited sums of ground state energies.
- Some aspects of ALG modeling include notions that people might consider to correlate with the three-word term below ground state. For example, consider the SA-side representation for the ground state of the left-circular polarization mode. The complementary physics theory ground state sum is one-half. People might think that the ground state sum for a three-dimensional isotropic quantum harmonic oscillator should be three-halves, as in $3 \cdot (0 + 1/2)$.
- For some, but not all, modeling, complementary physics theory considers pairs of oscillators. Pairs can include, for example, TA8-and-TA7, TA6-and-TA5, $\cdots$, TA2-and-TA1, TA0-and-SA0, SA1-and-SA2, $\cdots$, and SA7-and-SA8.
- The following symmetries can pertain regarding oscillator pairs. Here, either all the oscillators are TA-side or all the oscillators are SA-side.
  - $U(1)$ pertains for some aspects that add. Examples of property-related additive aspects include charge, baryon number, and lepton number. Another example of an aspect that adds is excitations of a polarization mode of a photon.

- $U(1)$ pertains for conservation laws that pertain for property-related aspects that add. An exact conservation law pertains regarding charge. An exact conservation law pertains regarding lepton number minus baryon number. Approximate conservation laws pertain for each of lepton number and baryon number.
- $SU(2)$ pertains for the fermion aspect of generations. Here the property is mass.
- $SU(2)$ pertains for an approximate conservation law that pertains, for some interactions, regarding fermion generations.
- $SU(2)$ pertains for each of the kinematics conservation laws conservation of linear momentum and conservation of angular momentum.
- $SU(2)$ pertains for the special relativity concept of boost.
- $SU(2) \times U(1)$ pertains for some aspects regarding the weak interaction.

• The following symmetry can pertain regarding the TA0-and-SA0 oscillator pair.

- $U(1)$ pertains for some binary choices, such as regarding zerolike or non-zero mass. The word zerolike denotes the notion of either zero for both of traditional physics theory and complementary physics theory or zero or small for traditional physics theory and zero for complementary physics theory.

• The following symmetries can pertain regarding sets of j oscillators. Here, either all the oscillators are TA-side or all the oscillators are SA-side.

- $SU(3)$ pertains for aspects regarding the strong interaction.
- $SU(j)$, for $j = 3$, $j = 5$, or $j = 7$, correlates somewhat indirectly with so-called spans for long-range forces.
- $SU(5)$ correlates with a complementary physics theory notion of conservation of energy. This notion contrasts with traditional physics theory notions of a one-generator symmetry. The one-generator symmetry correlates with an aspect of the Poincare group.

2.3 PDE double-entry bookkeeping

This unit discusses aspects of mathematics-based modeling that underlies our work.

Complementary physics theory includes modeling based on an analog, $0 = A^{PDE} = A^{PDE}_{TA} - A^{PDE}_{SA}$, to $0 = A^{ALG} = A^{ALG}_{TA} - A^{ALG}_{SA}$. Each of A^{PDE}_{TA} and A^{PDE}_{SA} is an operator.

The following perspective pertains.

Equations (1) and (2) correlate with an isotropic quantum harmonic oscillator. Here, r denotes the radial coordinate and has dimensions of length. The parameter η_{SA} has dimensions of length. The parameter η_{SA} is a non-zero real number. The magnitude $|\eta_{SA}|$ correlates with a scale length. The positive integer D correlates with a number of dimensions. Each of ξ_{SA} and ξ'_{SA} is a constant. The symbol $\Psi(r)$ denotes a function of r and, possibly, of angular coordinates. The symbol ${\nabla_r}^2$ denotes a Laplacian operator. In some traditional physics applications, Ω_{SA} is a constant that correlates with aspects correlating with angular coordinates. Our discussion includes the term Ω_{SA} and, otherwise, tends to de-emphasize some angular aspects. We associate the term SA-side with this use of symbols and mathematics, in anticipation that the symbols used correlate with spatial aspects of physics modeling and in anticipation that TA-side symbols and mathematics pertain for some modeling.

$$\xi_{SA}\Psi(r) = (\xi'_{SA}/2)(-(\eta_{SA})^2{\nabla_r}^2 + (\eta_{SA})^{-2}r^2)\Psi(r) \tag{1}$$

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

Including for $D = 1$, each of equation (1), equation (2), and the function Ψ pertains for the domain equation (3) shows.

$$0 < r < \infty \tag{3}$$

We consider solutions of the form equation (4) shows.

$$\Psi(r) \propto (r/\eta_{SA})^{\nu_{SA}} \exp(-r^2/(2(\eta_{SA})^2)), \text{ with } (\eta_{SA})^2 > 0 \tag{4}$$

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

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

Equations (5) and (6) characterize solutions. The parameter η_{SA} does not appear in these equations. Equation (7) correlates with the domain of D and ν_{SA} for which normalization pertains for $\Psi(r)$. For $D+2\nu_{SA}=0$, normalization pertains in the limit $(\eta_{SA})^2\to 0^+$.

$$\xi_{SA}=(D+2\nu_{SA})(\xi'_{SA}/2) \tag{5}$$

$$\Omega_{SA}=\nu_{SA}(\nu_{SA}+D-2) \tag{6}$$

$$D+2\nu_{SA}\geq 0 \tag{7}$$

The following notions pertain.

- Some applications feature one temporal dimension (or, $D^*_{TA}=1$) and three spatial dimensions (or, $D^*_{SA}=3$).
  - SA-side aspects correlate with $D^*_{SA}=3$ via values of Ω_{SA} that satisfy $\Omega_{SA}=\sigma S(S+D^*_{SA}-2)=\sigma S(S+1)$. Here, σ is one of $+1$ and -1. Here, $2S$ is a nonnegative integer. For some solutions, $D\neq D^*_{SA}$. Here, S can correlate with traditional physics notions of spin divided by $\hbar$.
  - PDE solutions are radial with respect to t, the TA-side analog to the SA-side radial coordinate r, as well as with respect to r.
  - Solutions for which $\nu=-1/2$ can correlate with notions of fields for elementary fermions.
  - Solutions for which $\nu=-1$ can correlate with notions of fields for elementary bosons.
  - Solutions for which $\nu=-3/2$ can correlate with notions of particles for elementary fermions.
  - TA-side aspects correlate with $D^*_{TA}=1$ via values of Ω_{TA} that satisfy $\Omega_{TA}=\sigma S'(S'+D^*_{TA}-2)=\sigma S'(S'-1)$. Here, σ is one of $+1$ and -1. Here, $2S'$ is an integer that exceeds one. For some solutions, $D\neq D^*_{TA}$.
- Some applications feature a notion of $D''=2$. For these cases, we, in effect, separate some PDE aspects into PDE aspects correlating with oscillator pairs. Examples of such oscillator pairs include the TA0-and-SA0 oscillator pair and the SA1-and-SA2 oscillator pair.
  - For some cases correlating with $D^*_{TA}=1$ and $D^*_{SA}=3$, $D''=2$ pertains for each of the TA0-and-SA0 oscillator pair and the SA1-and-SA2 oscillator pair.
  - Solutions for which $\nu=-1$ can correlate with notions of particles for elementary bosons.

Table 1 provides details leading to equations (5) and (6). We consider equations (1), (2), and (4). The table assumes, without loss of generality, that $(\xi'_{SA}/2)=1$ and that $\eta_{SA}=1$. More generally, we assume that each of the four terms $K\_$ and each of the two terms $V\_$ includes appropriate appearances of $(\xi'_{SA}/2)$ and η_{SA}. The term V_{+2} correlates with the right-most term in equation (1). The term V_{-2} correlates with the right-most term in equation (2). The four $K\_$ terms correlate with the other term in equation (2). The sum of the two $K_0\_$ terms correlates with the factor $D+2\nu_{SA}$ in equation (5).

The following remarks are speculative. Possibly, PDE-based modeling correlates with some aspects of unification of the strong, electromagnetic, and weak interactions. We consider modeling for which

$2\nu_{SA}$ is a non-negative integer. Based on the r^{-2} spatial factor, the V_{-2} term might correlate with the square of an electrostatic potential. Based on the r^2 spatial factor, the V_{+2} term might correlate (at least, within hadrons) with the square of a potential correlating with the strong interaction. The sum $K_{0a} + K_{0b}$ might correlate with the strength of the weak interaction. (The effective range of the weak interaction is much smaller than the size of a hadron. Perhaps, the spatial characterization r^0 correlates with an approximately even distribution, throughout a hadron, for the possibility of a weak interaction occurring.) Based on the V_{-2} term, we expect that ξ'_{SA} includes a factor $\hbar^2$.

2.4 Physics modeling

This unit discusses steps and concepts underlying our theories and models. Such theories and models suggest means to catalog and predict elementary particles and to augment and/or complement traditional physics theory aspects such as quantum field theory and quantum chromodynamics.

We developed complementary physics theory based on the following steps and concepts.

- Develop a catalog of known and suggested elementary particles and a catalog of known and suggested so-called long-range forces. Do the following.
  - Recognize four possibly somewhat distinguishable notions - objects, forces, motion, and internal changes to objects. Focus first on cataloging elementary particles and long-range forces. For such cataloging activities, de-emphasize the notion that forces affect motion and affect internal states of objects. Postpone considering traditional physics theory kinematics conservation laws and kinematics theories.
  - Use a framework that has a basis in solutions for which, for each elementary particle or long-range force, at least one ALG $n\_$ is negative and/or at least one PDE ν is negative.
  - Observe that the catalog of elementary particles suggests new particles.
  - Observe that the catalog of long-range forces suggests a quantum description of gravity and dark energy forces.
  - Observe that the catalog of long-range forces suggests a complementary physics theory explanation for anomalous magnetic dipole moments. Note that the explanation correlates with a sum of a finite number of terms and might avoid complexities people associate with traditional physics theory QED (or quantum electrodynamics).
- Anticipate expanding use of the framework that the cataloging activity uses. We call the framework the CUSP framework. CUSP is an acronym for the four-word phrase concepts uniting some physics. Uses of the framework include the following.
  - Match known and predict new elementary particles and long-range forces.
  - Embrace and incorporate traditional physics theory kinematics conservation laws and kinematics theories.
  - Develop complements to traditional physics theory quantum field theory, quantum electrodynamics, and quantum chromodynamics.
  - Integrate aspects of traditional physics theory and complementary physics theory.
- Develop aspects of a complementary physics theory QFT (or, quantum field theory).
  - Catalog interaction vertices.
    - For example, for each of some vertices, assume that the sum, over incoming objects, of the values of the SA-side field-centric ν equals both $-3/2$ and the sum, over outgoing objects, of the values of the SA-side field-centric ν.
    - The following symbols symbolize interaction vertices - 0f1b→2f0b, 2f0b→0f1b, 1f1b→1f1b, 1f1b→3f0b, 3f0b→1f1b, and 0f2b→0f2b. Each symbol correlates with the notion of incoming particles → (or, produce) outgoing particles. An element of the form nf denotes n fermions. An element of the form nb denotes n bosons. Regarding 1f1b→1f1b vertices, one (but not both) of the 1b states can be a ground state. An element of the form 0b denotes such a ground state.
  - Note that each interaction vertex correlates with a point with respect to a temporal space-time coordinate. Note that each of some interaction vertices can correlate with a non-zero volume with respect to spatial space-time coordinates.

- Anticipate that complementary physics theory QFT does not necessarily require modeling that uses notions of virtual particles.
- Anticipate that complementary physics theory can embrace notions of tachyon-like behavior regarding particles within so-called confined environments. (An example of a confined environment is a proton or other hadron. The word confined correlates with the quarks and gluons in the proton or other hadron. Tachyon-like behavior correlates with modeling for which interaction vertices model as having non-zero volume with respect to spatial space-time coordinates. The two-word term free environment contrasts with the two-word term confined environment.)

- Consider a notion that nature includes nnn isomers of a set of, at least, non-zero-charge elementary particles. Here, $L6N = \log_6(\text{nnn})$ is a non-negative integer.
  - Traditional physics theory correlates with $L6N = 0$. Only one isomer of each charged particle pertains.
  - The ratio of inferred density of the universe of dark matter to inferred density of the universe of ordinary matter is somewhat more than five. (See reference [16].) Traditional physics theory does not explain the ratio of five-plus to one.
  - We posit that a positive value of $L6N$ pertains.
  - The following thought experiment, posits an explanation for the ratio of five-plus to one.
    * Assume that $L6N = 1$. Assume that each of the six isomeric sets correlates with its own photons. Assume that there is only one isomer of gravity. Assume that gravity interacts with each of the six isomeric sets.
    * One isomeric set correlates with ordinary matter. The other five isomer sets correlate with dark matter.
    * Assume that something not related to the isomeric sets also contributes to inferences that correlate with dark matter. (Below, we propose that so-called 1R⊗2U hadron-like particles are such a candidate something.) Assume that such a contribution correlates with the difference between a ratio of five-plus to one and a ratio of five to one.
    * Complementary physics theory explains the ratio of densities of the universe.
    * Complementary physics theory might explain other inferred ratios of dark matter effects to ordinary matter effects.
  - We explore that extent to which $L6N = 1$ modeling explains other observed ratios of dark matter effects to ordinary matter effects.
    * We develop a galaxy evolution scenario that correlates with observations of ratios and with complementary physics theory.
    * We explain observed ratios pertaining to some galaxies and to some galaxy clusters.
  - We also explore notions that $L6N$ is two or three.
    * For $L6N = 2$, complementary physics theory offers that possibility that so-called dark energy density of the universe correlates with the existence, in nature, of isomers of the $L6N = 1$ set that includes both one instance of gravity and six instances of the set of, at least, non-zero-charge elementary particles.

- Embrace and explore aspects of kinematics and dynamics.
  - Embrace kinematics by adding, within the framework, traditional physics theory symmetries correlating with conservation of linear momentum and conservation of angular momentum.
  - Explore possibilities for a complementary physics theory QCD (or, quantum chromodynamics). Here, conservation of energy, linear momentum, and angular momentum can pertain to hadrons but do not necessarily pertain to individual quarks or to gluons.
  - Explore modeling for refraction, especially regarding neutrinos and regarding long-range forces. Consider the notion that neutrino oscillations may correlate with refraction of neutrinos.
  - Explore modeling that includes aspects correlating with velocity and/or that includes traditional physics theory modeling techniques such as special relativity and general relativity.

- Propose means to merge aspects of complementary physics theory and aspects of traditional physics theory. Topics include the following.

Tab. 2: A catalog of elementary particles

Entities	Spin	Σ	$\sigma=-1$		$\sigma=+1$	
			$m \doteq 0$	$m>0$	$m \doteq 0$	$m>0$
Elementary particles	0	0	0K (1)	0P (1)	0I (1)	0H (1)
"	1/2	1	1R (6)	1Q (6)	1N (3)	1C (3)
"	1	2	2U (8)	2T (2)	-	2W (2)
Unimpeded long-range forces	≥ 1	≥ 2	-	-	ΣG (NA)	-

  - The elementary particle Standard Model.
  - General relativity.
  - Aspects of the cosmology timeline.
  - Aspects of galaxy evolution.

- Discuss other notions that complementary physics theory suggests. Topics include the following
  - A suggested relationship between a ratio of two elementary fermion masses and a ratio of two long-range force strengths. This relationship predicts a tauon mass that would be consistent with, and more accurate than, present experimental results.
  - A formula that approximately links the masses of the three charged leptons and the six quarks. This formula suggests a new use of the fine-structure constant.
  - Augmentations to or an alternative to aspects of traditional physics theory nuclear physics.

3 Results

This unit discusses results regarding elementary particles, relationships between masses of elementary particles, so-called long-range forces, hadron-like particles, the nature of dark matter, explanations regarding ratios of dark matter effects to ordinary matter effects, the evolution of some galaxies, dark energy forces and eras regarding the rate of expansion of the universe, dark energy densities, baryon asymmetry, neutrino oscillations, a complementary physics theory approach to the topic of anomalous magnetic dipole moments, and possibilities for complementary physics theory approaches to modeling aspects of nuclear physics. This unit correlates our results with results of observations.

3.1 Elementary particles, including an analog to the periodic table for elements

This unit shows a table of all known elementary particles and all elementary particles that complimentary physics theory predicts.

Table 2 provides a candidate periodic table analog for elementary particles. Here, we separate unimpeded long-range forces from elementary particles. We de-emphasize using this table to display a detailed catalog of unimpeded long-range forces. For elementary particles, each row correlates with one value of spin S. Here, $\Sigma = 2S$. The value of Σ appears as the first element of each two-element symbol $\Sigma\Phi$. The letter value of Φ denotes a so-called family of elementary particles. For $\sigma = -1$, the particles model as if they occur only in so-called confined environments. Examples of confined environments include hadron-like environments and atomic nuclei. Examples of hadron-like environments include hadrons and possible seas made of 2U (or, gluons) and at least one of 1Q (or, quarks) and 1R particles. For $\sigma = +1$, the particles model as if they can occur in confined environments and can occur outside of confined environments. We use the two-word term free environment to contrast with the two-word term confined environment. The expression $m \doteq 0$ denotes a notion of zerolike mass. Complementary physics models correlate the relevant particles with zero mass. Traditional physics models do or might correlate the relevant elementary fermions with small positive masses. The expression $m > 0$ correlates with positive mass. A number in parenthesis denotes a number of elementary particles. The symbol NA denotes the two-word term not applicable. Possibly, each cell in which a dash appears does not pertain to nature.

We discuss the elementary particles for which $\sigma = +1$ and $m > 0$. The 0H particle is the Higgs boson. The three 1C particles are the three charged leptons - the electron, the muon, and the tauon. The two 2W particles are the two weak interaction bosons - the Z boson and the W boson.

We discuss the elementary particles for which $\sigma = +1$ and $m \doteq 0$. The 0I, or so-called aye, particle is a suggested zero-mass relative of the Higgs boson. The three 1N particles are the three neutrinos.

We discuss the elementary particles for which $\sigma = -1$ and $m > 0$. The 0P, or so-called pi, particle provides an attractive component of the residual strong force. The 0P particle provides a possible aspect for alternative modeling regarding atomic nuclei. The six 1Q particles are the six quarks. The two 2T, or so-called tweak, particles are analogs to the weak interaction bosons. The charge of the one non-zero-charge 2T particle is one-third the charge of the W boson. The non-zero-charge tweak particle may have played a role in the creation of baryon asymmetry.

We discuss the elementary particles for which $\sigma = -1$ and $m \mathrel{\hat{=}} 0$. The 0K, or so-called cake, particle provides a repulsive component of the residual strong force. The 0K particle provides a possible aspect for alternative modeling regarding atomic nuclei. The six 1R, or so-called arc, particles are zero-charge zerolike-mass analogs of the six quarks. Hadron-like particles made from arcs and gluons contain no charged particles and measure as dark matter. The eight 2U particles are the eight gluons.

3.2 Objects and some of their properties

This unit correlates some traditional physics theory internal properties of objects with aspects of complementary physics theory modeling.

For modeling that correlates with free environments, interacting objects correlate with $\sigma = +1$ and the following notions pertain.

- Each object can be, but does not have to be, an elementary particle.
- Oscillator pair SA1-and-SA2 correlates with charge. Oscillator pair TA2-and-TA1 correlates with conservation of charge.
- Oscillator pair SA3-and-SA4 correlates with generation for elementary fermions and with rest mass for objects. Oscillator pair TA4-and-TA3 correlates with approximate conservation of generation for elementary fermions.
- Oscillator pair SA5-and-SA6 correlates with baryon number. Oscillator pair TA6-and-TA5 correlates with approximate conservation of baryon number.
- Oscillator pair SA7-and-SA8 correlates with lepton number. Oscillator pair TA8-and-TA7 correlates with approximate conservation of lepton number.
- Conservation of lepton number minus baryon number pertains.

For modeling that correlates with confined environments and elementary particles for which $\sigma = -1$, the following notions pertain.

- Oscillator pairs TA2-and-TA1 and SA1-and-SA2 correlate with charge and with conservation of charge.
- Oscillator pair SA3-and-SA4 correlates with generation for elementary fermions. Oscillator pair TA4-and-TA3 correlates with possible conservation of generation for elementary fermions. Here, conservation of generation correlates with the traditional physics notion of an approximate symmetry.
- Oscillator pair SA5-and-SA6 correlates with baryon number. Oscillator pair TA6-and-TA5 correlates with possible conservation of baryon number for elementary fermions.
- Oscillator pair SA7-and-SA8 correlates with lepton number. Oscillator pair TA8-and-TA7 correlates with possible conservation of lepton number elementary fermions.
- Conservation of lepton number minus baryon number pertains.

3.3 Long-range forces, including an analog to the periodic table for elements

This unit shows a table of all known long-range forces and all long-range forces that complimentary physics theory predicts.

Table 3 provides a candidate periodic table analog for long-range forces. Each cluster of rows correlates with one value of spin S. Here, $\Sigma = 2S$. For each G-family solution, the value of Σ appears as the first element of a three-element symbol ΣGΓ. Table 3 shows four-element symbols of the form Σ(s)GΓ. Each Γ is a list of one, two, three, or four unique integers. The symbol λ denotes such an integer. Values

Tab. 3: A catalog of long-range forces

S	$\Sigma = 2S$	Monopole (SDF $= r^{-2}$)	Dipole (SDF $= r^{-3}$)	Quadrupole (SDF $= r^{-4}$)	Octupole (SDF $= r^{-5}$)
1	2	2(1)G2	2(1)G24, 2(6)G46, 2(2)G68	2(6)G248, 2(6)G468	
2	4	4(6)G4	4(6)G26, 4(2)G48	4(1)G246, 4(6)G268	4(1)G2468a, 4(1)G2468b
3	6	6(2)G6	6(1)G24, 6(2)G28	6(6)G248, 6(6)G468	
4	8	8(1)G8	8(6)G26	8(1)G246	8(1)G2468a, 8(1)G2468b
5	10		10(2)G28, 10(6)G46	10(6)G248, 10(6)G468	
6	12		12(2)G48	12(1)G246, 12G268	12(1)G2468
7	14		14(2)G68	14(6)G248	
8	16			16(6)G268	16(1)G2468
9	18			18(6)G468	
10	20				20(1)G2468

for λ can be two, four, six, and eight. For the SA($\lambda - 1$)-and-SAλ oscillator pair, a first conceptual excitation can be either to $n_{SA\text{odd}} = 1$ and $n_{SA\text{even}} = 0$, which correlates with left-circular polarization, or to $n_{SA\text{odd}} = 0$ and $n_{SA\text{even}} = 1$, which correlates with right-circular polarization. (We use the two-word phrase conceptual excitation because we are discussing symmetries and not excitations. Here, $n_{SA\text{odd}}$ denotes $n_{SA(\lambda-1)}$ and $n_{SA\text{even}}$ denotes $n_{SA\lambda}$.) For each ΣGΓ, the number of SA-side oscillator pairs that correlate with conceptual excitation is $-n_{SA0}$. Regarding the Σ in ΣGΓ, Σ denotes both $2S$ and the absolute value of the arithmetic combination across conceptually excitable SA-side oscillators of $+2S_{\text{oscillator}}$ for each left-circular conceptual excitation and $-2S_{\text{oscillator}}$ for each right-circular conceptual excitation. For example, for ΣG24, Σ can be two, as in $|-2+4|$, or six, as in $|+2+4|$. The symbol s correlates with span for cases for which $L6N$ is a positive integer. (See table 4.) In table 3, the symbol SDF denotes the four-word phrase spatial dependence of force. We have yet to introduce notions of motion for objects. The use of Newtonian physics notions of variation with distance r between the centers of two adequately small and adequately symmetric objects is appropriate. We assume the non-Newtonian physics notion that, absent refraction, G-family effects propagate at the speed of light. We use the symbol $\Sigma\gamma$ to denote sets of ΣGΓ for which $\Sigma \in \Gamma$. (The symbol $\in$ denotes the four-word phrase is a member of.) We use the symbol $\gamma\lambda$ to denote sets ΣGΓ for which $\lambda \in \Gamma$ and $\Sigma \notin \Gamma$. (The symbol $\notin$ denotes the five-word phrase is not a member of.)

We discuss the 2γ long-range force. Solution 2G2 correlates with interaction with charge. Solution 2G24 correlates with interaction with nominal magnetic dipole moment. Solution 2G248 correlates with interaction with a lack of alignment between an axis correlating with spin and an axis correlating with nominal magnetic dipole moment. Such a separation of notions of a traditional physics theory photon into components is not necessarily bad. For example, for the earth, the nominal magnetic dipole moment does not correlate with a notion of overall charge.

We discuss the 4G4 solution, which is a component of 4γ. Solution 4G4 correlates with interaction with rest energy.

Beyond the 2γ and 4G4 solutions, each of the ΣGΓ solutions that table 3 lists does not necessarily correlate with traditional physics theory.

The following notes pertain regarding ΣGΣ solutions.

- 2G2 interacts with charge.
- 4G4 interacts with rest energy.
- 6G6 interacts with baryon number.
- 8G8 interacts with lepton number.

We anticipate that 4γ solutions other than 4G4 correlate with dark energy forces. We anticipate that $\gamma 2$ solutions correlate with a complementary physics theory approach to the traditional physics topic of anomalous magnetic dipole moments. We anticipate that, for models for much astrophysics, we can de-emphasize G-family solutions other that $\Sigma\gamma$ solutions. (A model for depletion of cosmic microwave background radiation, or CMB, provides an exception.)

The following notes pertain regarding 4γ solutions.

- 4(6)G4 correlates with a property of rest energy.
- 4(2)G48 might correlate with rotation of spherically distributed rest energy.
- 4(1)G246 might correlate with a non-zero quadrupole distribution of rest energy.
- Each of 4(1)G2468a and 4(1)G2468b might correlate with precession correlated with at least one of an axis of minimal moment of rotational inertia and an axis of maximal moment of rotational inertia.

The following notes pertain regarding ΣGΓ solutions. (For further details, see reference [3].)

- Modeling for excitations correlates with modeling for excitation for the ΣGΣ solution. This notion correlates with ALG double-entry bookkeeping and with discussion above regarding conceptual excitation.
- The n correlating with SDF of r^{-n} equals one plus the number of (one-digit) numeric items in the list Γ.
- For so-called saturated Γ, no TA-side $SU(j)$ symmetry pertains. The notion of saturated Γ correlates with each of the lists 2, 24, 246, 2468, 2468a, and 2468b. We use the one-element term GsatΓ to correlate with these instances of ΣGΓ solutions.
- For other than saturated Γ, a TA-side symmetry of $SU(\lambda - 1)$ pertains, with λ being the largest (one-digit) integer in the list Γ. We use the one-element term GunsatΓ to correlate with these instances of ΣGΓ solutions.
- For each solution for which the TA-side symmetry is $SU(5)$ or $SU(7)$, the solution correlates with interactions with multicomponent objects and does not correlate with interactions with individual elementary particles. (See table 4.)
- The upper limit of eight for items in lists Γ correlates with a notion of channels. (See discussion, regarding equation (10), regarding channels.)

3.4 Spans for objects and long-range forces

This unit discusses the notion that nature embraces more than one isomer for each of some elementary particles, long-range forces, and hadron-like particles.

For each of each elementary particle, each hadron-like particle, and each long-range force, the one-word term span denotes the number of isomers of the set of, at least, non-zero-charge elementary particles with which the particle or force interacts.

For $L6N = 0$, only one isomer pertains. Each elementary particle, each hadron-like particle, and each long-range force has a span of one.

For $L6N = 1$, the results that the nnn equals 006 column of table 4 shows pertain. (See reference [3].) In the table, nnn equals 6^{L6N}. In the symbol PRnnnINe, the two letters PR denote the one-element term physics-relevant, and the three letters INe denote the four-word phrase instances of the electron. Here, the word instance is a synonym for the word isomer. The table separates, based on a complementary physics theory view, elementary particle Standard Model aspects from aspects that the Standard Model does not embrace. The symbol 1Q$\otimes$2U correlates with known and possible hadrons. Regarding the G-family, the table includes just the $\Sigma\gamma$ solutions. Regarding the cases for which nnn is at least 006, the span for 2G68 is two.

Tab. 4: Particles and/or solutions that correlate with one isomer and particles and/or solutions that might correlate with more than one isomer; plus, the extent to which elementary bosons and long-range forces interact with elementary fermions and with multicomponent objects

Entities - Particle sets and/or solution sets (hadron-like particles, elementary particles, and long-range forces)		Span, for PRnnnINe				Direct interactions with	
		nnn				Elem	Mc
Standard Model	Possible	001	006	036	216	ferm	obj
1C ($\sigma = +1$)	-	1	1	1	1	-	-
1N ($\sigma = +1$)	-	1	6	36	36	-	-
1Q ($\sigma = -1$)	-	1	1	1	1	-	-
-	1R ($\sigma = -1$)	1	6	36	36	-	-
2U ($\sigma = -1$)	-	1	6	36	36	Y	N
2W: Z ($\sigma = +1$)	2T: $2T^0$ ($\sigma = -1$)	1	1	6	6	Y	N
2W: $W^\pm$ ($\sigma = +1$)	2T: $2T^\pm$ ($\sigma = -1$)	1	1	1	1	Y	N
1Q$\otimes$2U ($\sigma = +1$)	-	1	1	1	1	-	-
-	1R$\otimes$2U ($\sigma = +1$)	1	6	36	36	-	-
0H ($\sigma = +1$)	-	1	1	6	36	Y	N
-	0P ($\sigma = -1$)	1	1	(6)	(36)	N	Y
-	0I ($\sigma = +1$)	1	6	36	216	Y	N
-	0K ($\sigma = -1$)	1	(6)	(36)	(216)	?	Y
2G2 ($\sigma = +1$)	-	1	1	1	1	Y	Y
2G24 ($\sigma = +1$)	-	1	1	1	1	Y	Y
2G248 ($\sigma = +1$)	-	1	1	6	6	Y	Y
-	4G4 ($\sigma = +1$)	1	6	6	6	Y	Y
-	4G48 ($\sigma = +1$)	1	2	2	2	N	Y
-	4G246 ($\sigma = +1$)	1	1	1	1	Y	Y
-	4G2468a ($\sigma = +1$)	1	1	1	1	Y	Y
-	4G2468b ($\sigma = +1$)	1	1	1	1	Y	Y
-	6G6 ($\sigma = +1$)	1	1	1	2	N	Y
-	6G468 ($\sigma = +1$)	1	1	1	6	Y	Y
-	8G8 ($\sigma = +1$)	1	1	1	1	N	Y
-	8G2468a ($\sigma = +1$)	1	1	1	1	Y	Y
-	8G2468b ($\sigma = +1$)	1	1	1	1	Y	Y

3.5 Elementary boson interactions and long-range force interactions

This unit discusses the extents to which boson elementary particles and long-range forces interact with fermion elementary particles and interact with objects that include more than one fermion elementary particle.

Table 4 shows the extent to which each of the elementary bosons and some of the long-range forces interact directly with each of at least some elementary fermions and with each of at least some multicomponent objects. (Regarding the case of elementary fermions, the column label is Elem ferm. Regarding the case of multicomponent objects, the column label is Mc obj.) The symbol Y denotes that interactions occur. The symbol N denotes that interactions do not occur. Possibly, regarding interactions between the 0K boson and elementary fermions, Y pertains to the extent that modeling correlates the 0K boson with the traditional physics theory notion of a Higgs mechanism and that modeling correlates the Higgs mechanism with the notion that each of some elementary fermions has non-zero mass.

The following notions lead to some aspects that table 4 shows. (See discussion, regarding kinematics conservation laws, below.)

For GsatΓ solutions, embracing conservation of linear momentum and conservation of angular momentum leads, via double-entry bookkeeping to a TA-side symmetry of $SU(5)$, which correlates with conservation of energy.

Traditional physics theory includes, for leptons and W bosons, 1f1b$\rightarrow$1f0b interaction vertices. In complementary physics theory, W bosons correlate with a TA-side $SU(3)$ symmetry. Conservation of energy for such a 1f1b$\rightarrow$1f0b vertex correlates with the notion that a W boson TA-side $SU(7)$ symmetry can correlate with conservation of energy. Complementary physics theory suggests that, for GunsatΓ solutions for which the TA-side symmetry is $SU(3)$, interactions with individual elementary fermions can occur.

Various aspects of complementary physics theory seem not to comport with $SU(9)$ or $SU(11)$ TA-side symmetries. (See reference [3].) One such aspect correlates with the notion of zero channels for a would-be 10G$[\![10]\!]$ monopole long-range force. (Here, $[\![10]\!]$ denotes that notion that the value of λ is ten. Here, that λ would be the only member of the list Γ.)

For GunsatΓ long-range forces for which a TA-side symmetry of $SU(5)$ pertains, a lack of a possible $SU(9)$ conservation of energy symmetry pertains. A possible $SU(7)$ conservation of energy symmetry pertains to the extent one of conservation of linear momentum and conservation of angular momentum does not pertain. For GunsatΓ long-range forces for which a TA-side symmetry of $SU(5)$ pertains, interactions do not involve individual elementary particles. Interactions can involve changes of state within multicomponent objects.

For GunsatΓ long-range forces for which a TA-side symmetry of $SU(7)$ pertains, interactions do not involve individual elementary particles. Interactions can involve changes of state within multicomponent objects.

3.6 The rate of expansion of the universe

This unit discusses dark energy forces and suggests an explanation for three eras regarding the rate of expansion of the universe.

Table 5 summarizes, regarding the rate of expansion of the universe, eras and 4G forces. In this context, the eras pertain to the largest objects that people can directly infer. (Regarding observations and eras, see references [5], [11], [13], and [14]. For each of various redshifts those references mention and regarding estimating relevant times after the big bang, possibly see reference [8].) Early acceleration pertains (except possibly during and/or before the possible inflationary epoch) for some time after the big bang. Then, deceleration pertains for some billions of years. Acceleration pertains for the most recent few billion years. Regarding smaller objects, dominant forces within objects and between neighboring objects have, at least conceptually, generally transited the first three eras and now generally exhibit behavior correlating with SDF of r^{-2}. Quasar formation via ejection of stuff from near or inside black holes might constitute an exception. Black hole jets might constitute an exception. Blazars jets might constitute an exception. For these cases, r^{-3} net repulsion might pertain. The column labeled A/R notes net effects, across forces dominating for each era. The column labeled components of 4γ lists solutions that might correlate with significant forces. Complementary physics theory suggests that, for the components of 4γ that table 5 lists, the two-word term net repulsive correlates with a notion of essentially always repulsive (though sometimes not significantly repulsive). Complementary physics theory suggests that, for the components of 4γ that table 5 lists, the two-word term net attractive correlates with a notion of essentially always attractive (though sometimes not significantly attractive).

Tab. 5: Eras and 4G forces, regarding expansion of the universe

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

* - Equals 1 for PR001INe models

Complementary physics theory suggests that the traditional physics theory notion of dark energy forces (or, dark energy pressure) correlates with the components, other than 4(6)G4, of 4γ.

We note possible concerns regarding the term rate of expansion of the universe. Concerns feature use of the word universe. Observed rates of expansions correlate with objects that emit 2G (or, light) that people detect. Observed rates do not correlate with objects too distant for people to detect. Observed rates do not necessarily correlate with $1R\otimes2U$ hadron-like particles. Observed rates do not necessarily correlate with objects that correlate with isomers that, while not correlating with PR006INe, might correlate with PRnnnINe for nnn being at least 036. In addition, for example, of the components shown, only 4G4 has a span of six and each other component has a span of one or two.

3.7 Galaxies, galaxy clusters, and ratios of dark matter effects to ordinary matter effects

This unit discusses, for galaxies and galaxy clusters, observed ratios of dark matter effects to ordinary matter effects. This unit suggests aspects of the evolution of some galaxies, such that the evolution correlates with observations and such that complementary physics theory dovetails with the aspects of evolution.

People report inferred ratios of dark matter effects to ordinary matter effects.

- For some galaxies, approximately 10 billion years ago, the following ratio pertains.
  - Zero to one or zero-plus to one, based on velocities of stars within galaxies (or, galaxy rotation curves). (See reference [7].)
- For some galaxies, recently, the following ratios pertain.
  - Somewhat less than four to one, based on observations correlating with gravitational lensing. (See reference [9].)
  - Between zero to one and one to one, based on velocities of stars in one galaxy (or, galaxy rotation curves). (See reference [18].)
- For some galaxy clusters, recently, the following ratios pertain.
  - Five-plus to one, based on observations correlating with gravitational lensing. (See references [10] and [12].)
  - Eight-minus to one, based on observations correlating with X-ray emissions. (See reference [15].)
- For some galaxy-like objects, recently, the following ratio pertains.
  - One to somewhat more than zero, regarding some dark matter galaxies, based on light emitted by few visible stars. (See reference [17].)

Complementary physics theory suggests the following galaxy evolution scenario for galaxies that would comport early on with zero-plus to one ratios that reference [7] shows and presently with four-minus to one ratios that reference [9] shows. The following thought experiment idealization characterizes the scenario.

We assume that PR006INe modeling pertains (or, that six isomers of the set of, at least, non-zero-charge elementary particles pertain). We focus on the forming and evolving of a galaxy that features ordinary matter.

- Stuff that will become the galaxy is always in somewhat proximity with itself. No collisions between would-be galaxies or between galaxies occur.
- Early on, each isomer expands, essentially independently from the 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 stuff correlating with itself and with one other isomer. Regarding ordinary matter clumps, the one other isomer is a dark matter isomer. Regarding clumps correlating with the ordinary matter, effects correlating with 2γ solutions might mitigate some of the repulsive 4(2)G48 effects.
- An ordinary matter centric galaxy forms, based on 4(6)G4 attraction based on one ordinary matter clump or some ordinary matter clumps. At this stage of formation, results comport with the zero-plus to one ratios that reference [7] shows.
- The galaxy attracts and accrues, via 4(6)G4 attraction, ordinary matter stuff and stuff correlating with the four dark matter isomers for which there is nearby stuff. Results comport with the somewhat less than four to one ratios that reference [9] shows. The following notions might pertain.
  - The ratios are less than four to one because more 4(2)G48 repulsion pertains regarding dark matter isomer stuff repelling dark matter isomer stuff than pertains regarding ordinary matter stuff repelling ordinary matter stuff and dark matter stuff correlating with one isomer.
  - The ratios are not as much less than four to one as they might otherwise be (based on 4(2)G48 repulsion) because of the contribution, which is isomer-independent, of $1R\otimes 2U$ to dark matter.

The following notions also pertain.

- Dark matter centric galaxies can contain ordinary matter stars. Evolution of some of these galaxies parallels the above scenario for some ordinary matter centric galaxies. Some such dark matter centric galaxies comport with the one to somewhat more than zero ratio that reference [17] shows.
- The scenarios we just discussed are not incompatible with ratios of dark matter density to ordinary matter density that people infer for galaxy clusters. (See references [10], [12], and [15].)
- The scenarios we just discussed are not incompatible with the ratio of between zero to one and one to one that reference [18] shows.

3.8 CMB depletion and a possible ratio of dark matter effects to ordinary matter effects

This unit suggests that complementary physics theory explains an observed result, regarding depletion of cosmic microwave background radiation, that traditional physics theory does not explain.

People report the following possible inferred ratio of dark matter effects to ordinary matter effects.

- For absorption of CMB (or, cosmic microwave background radiation) via hyperfine interactions with hydrogen-like atoms.
  - One to one. (See reference [2]. Perhaps note a possible interpretation in reference [1].)

Here, people measured twice as much depletion of CMB as people predicted via traditional physics theory modeling centered on depletion via transitions in ordinary matter hydrogen atoms.

Complementary physics theory suggests the following explanation.

- Solution 2(2)G68 has a span of two.
- Solution 2(2)G68 correlates with that hyperfine transition (and, presumably, with other similar transitions, in multicomponent objects, that are not significant for this discussion).

- Half of the observed effect correlates with hydrogen-atom isomers that correlate with one not ordinary matter isomer of the set of, at least, non-zero-charge elementary particles.
  - To the extent PR006INe modeling pertains to nature and PRnnnINe modeling for nnn of at least 036 does not pertain, the relevant not ordinary matter isomer is a dark matter isomer.
  - To the extent PRnnnINe modeling which nnn of at least 036 is required to explain aspects of nature, the relevant not ordinary matter isomer is a so-called doubly dark matter isomer. The following statements pertain.
    * The number of doubly dark isomers is 30 (or, 36 minus six).
    * None of these 30 isomers interacts with the isomer of 4(6)G4 that interacts with the ordinary matter isomer and the dark matter isomers. None of these 30 isomers interacts with the ordinary matter isomer via 2(1)G2 interactions or via 2(1)G24 interactions. Hence, we suggest the three-word term doubly dark matter.
    * Five of these 30 doubly dark matter isomers interact with the ordinary matter isomer via 2(6)GΓ interactions.
    * One of those five doubly dark matter isomers interacts with the ordinary matter isomer via 2(2)GΓ interactions. 2(2)G68 interactions are 2(2)GΓ interactions.

3.9 Dark energy density

This unit discusses the notion that dark energy densities might correlate with dark energy stuff, instead of with traditional physics notions such as vacuum energy and vacuum fluctuations.

Traditional physics theory correlates inferred dark energy densities of the universe with phenomena correlating with terms such as vacuum energy, vacuum fluctuations, or quintessence. Complementary physics theory does not necessarily embrace notions such as vacuum energy. (Double-entry modeling may obviate needs to consider notions such as vacuum energy.)

Equation (8) shows an inferred ratio of present density of the universe of dark energy to present density of the universe of dark matter plus ordinary matter plus (ordinary matter) photons. (Reference [16] provides the four items of data.) Here, the symbols Ω_Λ, Ω_c, Ω_b, and Ω_γ correlate with density of, respectively, dark energy, dark matter, ordinary matter, and (ordinary matter) photons. From a standpoint of complementary physics theory, Ω_c includes effects correlating with photons centric to dark matter and with 1R⊗2U hadron-like particles. From a standpoint of each of traditional physics theory and complementary physics theory, equation (8), does not include neutrino density of the universe.

$$\Omega_\Lambda/(\Omega_\mathrm{c}+\Omega_\mathrm{b}+\Omega_\gamma)\approx 2.3 \tag{8}$$

Complementary physics theory suggests that the ratio that equation (8) shows correlates with an actual ratio of five to one regarding the number, 30, of doubly dark matter isomers and the number, six, of ordinary matter isomers and dark matter isomers. We know of no inferences that would not comport with a steady increase, regarding the inferred ratio correlating with equation (8), from approximately zero, with time since somewhat after the big bang. Each of PR036INe modeling and PR216INe modeling suggests an upper bound of five on, in effect, a possible future value for the ratio that correlates with equation (8). The growth correlates with interactions based on phenomena for which table 4 shows a larger number in the column labeled 036 than in the column labeled 006.

Complementary physics theory suggests the modeling case PR216INe and, with that case, a possibility that the universe includes 180 so-called triply dark matter isomers. Here, 180 equals 216 minus 36. Triply dark matter isomers would not interact, via 2G or 4G interactions with any of the ordinary matter, dark matter, or doubly dark matter isomers. Triply dark matter isomers would interact with ordinary matter, dark matter, and doubly dark matter isomers via the 0I boson. (See table 4.)

3.10 Baryon asymmetry

This unit discusses two possible complementary physics theory explanations for baryon asymmetry.

To the extent that the early universe featured roughly the same number of antimatter quarks as matter quarks, something happened to create so-called baryon asymmetry. The two-word term baryon asymmetry correlates with the present lack, compared to matter quarks, of antimatter quarks.

Complementary physics theory suggests two scenarios that might have led to baryon asymmetry. Both scenarios feature roles for W bosons leading to depletion of antimatter leptons. Neither scenario conserves baryon number. Both scenarios conserve lepton number minus baryon number. The following notions pertain.

- In one scenario, 3f0b→1f1b interactions destroy antimatter quarks. This scenario does not depend on the existence of 2T bosons. This scenario does not depend on the existence of 1R (or, arc) elementary fermions.
- In one scenario, the $2T^{\pm}$ boson converts antimatter quarks to matter quarks. This scenario depends on the physics-relevance of 1R (or, arc) elementary fermions. This scenario does not depend of the physics-relevance of 3f0b→1f1b interaction vertices.

3.11 A prediction for the tauon mass

This unit suggests a relationship, which traditional physics seems not to discuss, between the ratio of the tauon mass to the electron mass and a ratio of the strength of electromagnetism and the strength of gravity. This unit discusses the notion that adequately increasing the experimental accuracy of either one of the tauon mass and the gravitation constant leads to prediction regarding the other quantity.

Equation (11) possibly pertains. Here, m denotes mass, τ denotes tauon, e denotes electron, q denotes charge, ε_0 denotes the vacuum permittivity, and G_N denotes the gravitational constant. Equation (11) predicts a tauon mass with a standard deviation of less than one quarter of the standard deviation correlating with the experimental result. (For relevant data, see reference [16].) Possibly, a more accurate experimental determination of either G_N or m_τ could predict a more accurate, than experimental results, value for, respectively, m_τ or G_N.

$$\beta' = m_\tau/m_e \tag{9}$$

$$(4/3) \times \beta^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{10}$$

$$\beta' = \beta \tag{11}$$

$$m_{\tau,\text{ calculated}} \approx (1776.8445 \pm 0.024)\ MeV/c^2 \tag{12}$$

$$m_{\tau,\text{ experimental}} \approx (1776.86 \pm 0.12)\ MeV/c^2 \tag{13}$$

The factor of 4/3 in equation (10) correlates with notions that 2G2 correlates with four so-called channels and 4G4 correlates with three channels. For a 2G2 interaction between two electrons, the strength for each channel is $((q_e)^2/(4\pi\varepsilon_0))/4$ and four channels pertain. For a 4G4 interaction between two electrons, the strength for each channel is $G_N(m_e)^2/3$ and three channels pertain. By extrapolation, for $\Sigma = 10$ and $\Gamma = \Sigma$, ΣGΓ would correlate with zero channels and no interactions.

The following notes pertain.

- To the extent that people measure the tauon mass adequately accurately, equation (10) could suggest values of G_N that are more accurate than measured values.
- Equation (10) links the ratio of two elementary particle masses to a ratio of the strengths of two long-range forces.

3.12 Other relationships regarding masses of known elementary particles

This unit discusses ratios of masses of known non-zero mass elementary bosons and ratios of masses of quarks and charged leptons.

We discuss approximate ratios for the squares of masses of the Higgs, Z, and W bosons. The most accurately known of the three masses is the mass of the Z boson. Based on the ratios (of squares of masses) that equation (14) shows, the possibly least accurately suggested mass is that of the W boson. Equation (14) correlates with a number that is within four standard deviations of the nominal mass of the W boson. (For data, see reference [16].) We correlate the numbers in equation (14) with, respectively, $17 = 17$, $9 = 10 - 1$, and $7 = 10 - 1 - 2$. Each of zero, one, two, five, 10, and 17 correlates with a PDE solution for which $D'' = 2$. (See reference [3].)

Tab. 6: Aspects that might correlate with the extent to which neutrinos have non-zero masses

Aspects
• The existence of neutrino oscillations. • Neutrino speeds. • Limits regarding neutrino masses, as inferred from astrophysics data. • Other.

$$(m_{H^0})^2 : (m_Z)^2 : (m_W)^2 :: 17 : 9 : 7 \tag{14}$$

Reference [3] discusses 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 correlates somewhat with generation. The other integer variable correlates somewhat with charge. The seven parameters can be m_e, m_μ (or, the mass of a muon), β , α, and three other numbers. Here, α denotes the fine-structure constant. Each of the three other numbers pertains regarding one generation of quarks. Possibly, for each generation, the number correlates with the extent to which the two relevant masses do not equal the square root of the multiplicative product of the two masses.

3.13 Neutrino oscillations and neutrino masses

This unit discusses the notion that all neutrinos have zero mass, even though people interpret neutrino oscillations and other observed phenomena as suggesting that at least one flavor of neutrino correlates with non-zero mass.

Table 6 lists aspects that might correlate with the extent to which neutrinos have non-zero masses.

We discuss neutrino oscillations.

Traditional physics theory hypothesizes that gravity catalyzes neutrino oscillations. Possibly, this hypothesis correlates with a process of elimination. For traditional physics theory, the possibly relevant elementary bosons correlate with, in complementary physics theory parlance, the Higgs boson, the Z boson, the W boson, gluons, a boson correlating with 2G2 plus 2G24 plus 2G248 (or, photons), and a possible boson correlating with 4G4 (or, gravity). Neutrino interactions with W bosons destroy neutrinos. Neutrinos do not interact with the Higgs boson, gluons, or photons. Possibly, any interactions with Z bosons are not relevant. Gravity (or, 4G4) becomes the only possibility.

Regarding $\Sigma\gamma$ solutions and individual interactions with neutrinos, complementary physics theory suggests the following notions. Some solutions, such as the three 2γ solutions, do not correlate with interactions with neutrinos. Some solutions, such as the 4G48, 6G6, and 8G8 solutions, do not correlate with interactions with any individual elementary particles, including neutrinos. (See table 4.) Some solutions, such as 4G4 and 6G468, correlate with a TA-side $SU(2)$ symmetry that, for modeling correlating with free environments, correlates with conservation of generation. (This $SU(2)$ symmetry parallels a W boson TA-side $SU(2)$ symmetry that correlates with conservation of generation.) Even if neutrinos interact with 4G4, in free environments, conservation of generation pertains for the interactions. Neutrino oscillations do not correlate with interactions with 4G4 in free environments.

Complementary physics theory suggests that, regarding modeling correlating with free environments, neutrino interactions with the following phenomena might catalyze changes of neutrino generation.

- 4G246, 4G2468a, and 4G2468b.
- 8G2468a and 8G2468b.
- Some $\Sigma\gamma'$ solutions, such as 6G24.

Possibly, given the rareness, for each neutrino, of interactions, modeling correlating with free environments suffices regarding neutrino oscillations. Possibly, people do not necessarily need to consider modeling correlating with the notion of confined environments.

Complementary physics theory suggests that neutrino oscillations do not correlate with 4G4 and can correlate with traditional physics theory notions of dark energy forces (such as the complementary physics theory 4G246 long-range force).

We discuss neutrino speeds.

Possibly, measurements of neutrino speeds have yet to contradict the possibility that neutrinos have zero masses.

Complementary physics theory suggests that neutrinos have zerolike rest masses.

We discuss the possibility that astrophysics data have yet to contradict the possibility that neutrinos have zero masses.

Equation (15) provides a traditional physics theory upper limit for the sum, across three generations, of neutrino masses. (See reference [16] and the item "Neutrino Properties" that correlates with reference [6].) In equation (15) (and in equation (16)), the index j correlates with at least one of neutrino generation and neutrino flavor.

$$\sum_{j=1}^{3} m_j \lesssim 0.68 eV/c^2 \tag{15}$$

Reference [16] suggests the lower limit that equation (16) shows. Complementary physics theory suggests that a non-zero result for equation (16) might correlate with aspects of traditional physics theory and not with aspects of nature.

$$\sum_{j=1}^{3} m_j \gtrsim 0.06 eV/c^2 \tag{16}$$

Complementary physics theory suggests interactions (that traditional physics theory does not necessarily embrace), such as with 4G246, 4G2468a, 4G2468b, 8G2468a, and 8G2468, in which neutrinos participate. (Regarding such effects, for PRnnnINe modeling with nnn being at least 036, the size of the effects correlates, in part, with interactions with doubly dark matter.) Possibly, such interactions produce observed astrophysical effects that people interpret, via traditional physics theory, as implying non-zero mass for at least one generation or flavor of neutrino. Possibly, such interpretations are not necessarily optimal.

Possibly, each neutrino correlates with zero rest mass.

3.14 A series of formulas for lengths, including the Planck length

This unit discusses three related formulas that produce lengths and notes possible significance, or lack thereof, for each of the lengths.

We suggest a series of formulas for lengths. Equation (17) correlates with the Schwarzschild radius for an object with mass m. Equation (18) correlates with the Planck length and does not depend on m. Equation (19) includes a factor of m^{-1}. When applied to the mass of 2W bosons, equation (19) correlates with the range of the weak interaction. When applied to the mass of a charged pion, equation (19) correlates somewhat with a range for the strong interaction. Equation (20) shows the ratio between successive formulas. Equation (21) shows, for the electron, the ratio correlating with equation (20).

$$R_4(m) = (G_N)^1 m^1 \hbar^0 c^{-2} 2^1 \tag{17}$$

$$R_2(m) = (G_N)^{1/2} m^0 \hbar^{1/2} c^{-3/2} 2^0 \tag{18}$$

$$R_0(m) = (G_N)^0 m^{-1} \hbar^1 c^{-1} 2^{-1} \tag{19}$$

$$(G_N)^{-1/2} m^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \tag{20}$$

$$(G_N)^{-1/2} (m_e)^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \approx 1.1945 \times 10^{22} \tag{21}$$

Possibly, complementary physics theory points to a minimal size regarding elementary particles. We consider a possible historical parallel. Regarding the ideal gas law and T (the absolute temperature), people might interpret the ideal gas law, in the limit $T \to 0^+$, as correlating with zero-size for atoms.

After the ideal gas law proved useful, people determined that atoms have non-zero size. Our modeling correlates the limit of $|\eta_{SA}| \to 0$ with elementary particles. Possibly, at the scale of the Schwarzschild radius for an elementary particle, new physics pertains.

Possibly, complementary physics theory does not yet point to physics-relevance for the Planck length.

Possibly, complementary physics theory points to $R_0(m_{H^0})$ as being a minimal size relevant for some modeling of aspects of objects that contain more than one elementary fermion. (Here, m_{H^0} denotes the mass of the Higgs boson.)

3.15 Anomalous moments

This unit discusses a complementary physics theory approach to explaining anomalous magnetic dipole moments.

Traditional physics theory provides means, correlating with Feynman diagrams, to calculate a so-called anomalous magnetic dipole moment for each of, at least, the electron and the muon.

Complementary physics theory suggests notions of anomalous electromagnetic moments correlate with $\gamma2$ solutions. Electromagnetic dipole solutions correlate with $\gamma2$ solutions for which SDF is r^{-3}. The following remarks pertain for other than 2G24, which correlates with the traditional physics theory nominal magnetic moment result of $g \approx 2$. (2G24 correlates with 2γ and not with $\gamma2$.) Relevant solutions are 4G26, 6G24, 6G28, and 8G26. Contributions scale as $\alpha^{(\Sigma-2)/2}$, in which α is the fine-structure constant. The 4G26 solution correlates with the traditional physics theory result of $\alpha/(2\pi)$. The following two equations pertain in the context of traditional physics theory. (Reference [16] provides data that equations (22) and (23) show.) In equation (22), the subscript e correlates with the word electron. In equation (23), the subscript μ correlates with the word muon. The symbol a correlates with anomalous magnetic dipole moment. Complementary physics theory suggests that each of 6G24 and 6G28 correlates with contributions of the order α^2. Complementary physics theory is not necessarily incompatible with the difference in signs between equation (22) and equation (23). Possibly, people can extrapolate, based on strengths of 6G24 and 6G28, to predict the order α^2 contribution to the anomalous electromagnetic dipole moment of the tauon.

$$a_e - (\alpha/(2\pi)) \approx -1.76 \times 10^{-6} \tag{22}$$

$$a_\mu - (\alpha/(2\pi)) \approx +4.51 \times 10^{-6} \tag{23}$$

3.16 Lack of magnetic monopoles and of some electric dipole moments

This unit suggests modeling that would comport with nature not including the following - an elementary particle magnetic monopole, a non-zero electric dipole moment for any elementary particle, and a non-zero neutron electric dipole moment.

Table 3 points to no G-family solutions that would correlate with interactions with a magnetic monopole elementary particle or that would correlate with a non-zero electric dipole moment for an elementary particle. Possibly, the lacks of such G-family solutions correlate with nature not including a magnetic monopole elementary particle and with nature not including elementary particles that have non-zero electric dipole moments.

Possibly, for each hadron for which modeling based on PDE techniques pertains and for which all the quarks occupy one state with respect to spatial characteristics, the electric dipole moment is zero. (See discussion, related to table 1, regarding PDE-based modeling that correlates with some aspects of the strong, electromagnetic, and weak interactions.) Complementary physics theory suggests that the neutron and proton are such hadrons.

3.17 Nuclear physics

This unit suggests possibilities for developing complementary physics theory models for atomic nuclei.

Traditional physics theory bases some aspects of modeling, regarding nuclear physics, on notions of a Pauli exclusion force and on notions of a Yukawa potential. Traditional physics theory correlates these effects with notions of a residual strong force. The Pauli exclusion force keeps hadron apart. The Yukawa potential attracts hadrons to each other. Modeling suggests virtual pions as a source for the Yukawa potential.

Complementary physics theory does not necessarily correlate with a Pauli exclusion force or with notions of virtual pions. Possibly, cake (or, 0K) bosons correlate with repulsion between hadrons. Possibly, from a standpoint of modeling, 0K bosons correlate with interactions with colorless or white color charge. Possibly, from a standpoint of modeling, 0K bosons correlate with the identity operator that gluons and the gluon-related $SU(3)$ symmetry lack. Possibly, from a standpoint of modeling, pie (or, 0P) bosons correlate with attraction between hadrons. Possibly, the attraction correlates with PDE-centric expression proportional to $\exp(-tr/(\eta_{TA}\eta_{SA}))$ and with a Yukawa-like $\exp(-r/\eta_{SA})$ potential. (Here, η_{TA} denotes the TA-side analog of the SA-side η_{SA}. The factor η_{TA} has dimensions of time.) Possibly, from a standpoint of modeling, 0K bosons correlate with the identity operator that the non-zero-charge tweak and the related $SU(2)$ component of $SU(2) \times U(1)$ symmetry lack.

4 Discussion

This unit explores synergies between notions that complementary physics theory proposes and aspects of traditional physics theory. The aspects include kinematics and dynamics models and modeling; general relativity and geodesic motion; the elementary particle Standard Model; the Higgs mechanism, entanglement, and tachyon-like behavior; velocities and refraction; supersymmetry; and aspects of cosmology. This unit suggests categories of opportunities for further research and opportunities for further use of techniques we discuss in this manuscript.

4.1 Kinematics conservation laws

This unit introduces, into our work, aspects of motion that correlate with traditional physics theory kinematics conservation laws.

Work above de-emphasizes the concept of motion. (Some exceptions pertain, for example regarding the evolution of galaxies.) Work above de-emphasizes the notion of choosing one or more models of motion.

We introduce some aspects of motion via symmetries that traditional physics correlates with conservation laws related to motion. Traditional physics correlates an S1G symmetry with conservation of energy. The one-element term S1G denotes a symmetry correlating with a group for which one generator pertains. We consider this S1G to be a TA-side symmetry. Traditional physics correlates an $SU(2)$ symmetry with conservation of linear momentum and an $SU(2)$ symmetry with conservation of angular momentum. We consider each of these $SU(2)$ symmetries to be an SA-side symmetry.

The following concepts pertain.

- Models for the kinematics of objects for which $\sigma = +1$ need to include the possibility that all three conservation laws pertain. (Objects for which $\sigma = +1$ can exist as components of (let us call them) larger objects for which $\sigma = +1$. For one example, an electron can exist as part of an atom. For another example, a hadron can exist as part of an atomic nucleus that includes more than one hadron. In such contexts, modeling of the dynamics of the electron or hadron does not necessarily need to embrace all three conservation laws.)

- Models regarding the dynamics of objects for which $\sigma = -1$ do not necessarily need to embrace all three conservation laws. (These objects exist only in the contexts of $\sigma = +1$ larger objects.)

- For a model to embrace conservation of linear momentum and conservation of angular momentum, one, in effect, adds four SA-side oscillators and expresses two instances of $SU(2)$ symmetry. Double-entry bookkeeping suggests adding four TA-side oscillators and, in effect, combining them with the TA0 oscillator to correlate with an $SU(5)$ symmetry.

- Complementary physics theory correlates the TA-side $SU(5)$ symmetry with conservation of energy.

- Notions above suffice for elementary particles for which $\sigma = +1$ and the spin is zero or one-half and suffice for G-family GsatΓ solutions.

- Notions above do not necessarily suffice for elementary particles for which $\sigma = +1$ and the spin is one and do not necessarily suffice for G-family GunsatΓ solutions. In these cases, leftover TA-side symmetries pertain. Complementary physics theory suggests the following notions.

  - Regarding 2W bosons, the leftover TA-side $SU(2)$ symmetry correlates with conservation of fermion generation in, for example, 1f0b→1f1b interactions between leptons and W bosons. Conservation of fermion generation pertains to the extent the fermions model as existing in a free environment. Conservation of generation does not necessarily pertain, for example, to W boson interactions with quarks in hadrons.
  - Regarding the 4G4 solution (or, monopole gravity), the following notions pertain.
    - For modeling pertaining to free environments, 1f1b→1f1b interactions between 4G4 and elementary fermions conserve fermion generation.
    - For modeling pertaining to confined environments, 1f1b→1f1b interactions between 4G4 and elementary fermions do not necessarily conserve fermion generation. (Complementary physics theory suggests that 4G4 does not correlate with interactions with neutrinos.)
    - For modeling pertaining to interactions between 4G4 and $\sigma = +1$ multicomponent objects, gravity interacts with rest mass of the objects and not with properties of components of the objects.
  - Regarding GunsatΓ solutions other than 4G4, the following notion pertains.
    - For the purposes of modeling most phenomena, models can assume that interactions occur with multicomponent objects and interactions do not occur with individual elementary particles.
    - For example, 2(6)G248 interacts with objects for which an axis correlating with non-zero spin does not equal an axis correlating with non-zero nominal magnetic dipole moment.

4.2 Possible complements to traditional physics theory QFT, QED, and QCD

This unit summarizes aspects of possible complementary physics theory complements to traditional physics theory QFT (or, quantum field theory), QED (or, quantum electrodynamics), and QCD (or, quantum chromodynamics).

The following statements summarize aspects of possible complements to traditional physics theory QFT (or, quantum field theory).

- Complementary QFT interaction vertices can correlate with aspects of PDE modeling.
- Complementary QFT interaction vertices do not necessarily correlate only, with respect to spatial space-time coordinates, with points and can correlate objects that exist in confined environments.
- Complementary QFT does not necessarily need to consider notions of virtual particles.
- PDE modeling correlates with aspects of the four traditional physics theory fundamental forces.
- Complementary QFT correlates with the following notions.
  - Modeling correlating with the notion of objects in free environments needs to embrace, for each of those objects, all three traditional physics theory kinematics conservation laws.
  - Modeling correlating with the notion of objects in confined environments does not necessarily need to embrace, for each those objects, all three traditional physics theory kinematics conservation laws.

The following statements summarize aspects of possible complements to traditional physics theory QED (or, quantum electrodynamics).

- Complementary QED can describe anomalous magnetic dipole moments (and other aspects of physics) via sums over finite numbers of terms.
- Complementary QED might point to new approaches to atomic physics. (See reference [3].)

The following statement summarizes aspects of possible complements to traditional physics theory QCD (or, quantum chromodynamics).

- Complementary QCD may describe allowed states for hadron-like particles and for atomic nuclei, based on PDE modeling.

4.3 Kinematics models

This unit describes notions regarding choosing, within a context of complementary physics theory, one or model kinematics models.

Work above de-emphasizes the notion of choosing one or more kinematics models. (The work discusses various dynamics models.)

Kinematics models correlate with the motion of objects for which $\sigma = +1$ and with the notion that free environments pertain.

Kinematics models can correlate with classical physics or with quantum physics. Kinematics models can correlate with Newtonian physics modified to limit the speed of free-environment transmission of effects to the speed of light, with special relativity, or with general relativity. Kinematics models can be linear in energy or quadratic in energy. The Dirac equation is linear in energy. The Klein-Gordon equation is quadratic in energy.

The following points pertain.

- Presumably, complementary physics theory is compatible with all choices of kinematics models.
- Special relativity features boost symmetry. In the context of complementary physics theory, boost symmetry correlates with an additional SA-side $SU(2)$ symmetry. The double-entry bookkeeping aspect of complementary physics theory can accommodate boost symmetry by adding a TA-side pair of oscillators that correlates with any one of no symmetry, $U(1)$ symmetry, or $SU(2)$ symmetry. Possibly, the TA-side addition correlates with modeling and does not correlate with observable phenomena.

4.4 Dynamics models for hadron-like particles

This unit discusses an approach, compatible with complementary physics theory, for modeling the dynamics, in hadrons, of quarks and gluons.

Regarding dynamics in hadrons, for each of quarks and gluons, traditional physics theory QCD modeling correlates with symmetries that correlate with special relativity. Modeling correlates a subset of those symmetries with kinematics for each of quarks and gluons.

Complementary physics theory suggests possibilities for modeling of dynamics within hadron-like particles such that the following notions pertain. (See reference [3].)

- Elementary fermions (or, 1Q and/or 1R particles) correlate with a symmetry that correlates, for the hadron-like particles, with one of conservation of linear momentum and conservation of angular momentum.
- Gluons (or, 2U particles) correlate with a symmetry that correlates, for hadron-like particles, with the other one of conservation of linear momentum and conservation of angular momentum.
- To the extent that modeling for hadron-like particles includes boost symmetry, gluons correlate with a symmetry that correlates with boost symmetry for hadron-like particles.

This complementary physics theory modeling correlates with the notion that neither one of quarks and gluons behaves like an elementary particle for which $\sigma = +1$.

4.5 General relativity and geodesic motion

This unit discusses the concept that, for some models, geodesic motion correlates with modeling but not with space-time. This unit suggests possible opportunities for research regarding various aspects of large-scale physics.

For PR036INe models and PR216INe models, the general relativity concept of geodesic motion can pertain within PR006INe subsets but not necessarily for the entirety of modeling. For example, the sun can deflect, via 4G4, the 2G2 and 2G24 components of a photon emitted by ordinary matter, but the sun would not deflect, via 4G4, the 2G2 and 2G24 components of a photon emitted by doubly dark matter.

Our work suggests nominal long-range forces correlating with $\Sigma \geq 6$ (or, $S \geq 3$). However, possibly, under all circumstances, nominal long-range forces for which $\Sigma = 4$ or $\Sigma = 2$ are more significant than nominal long-range forces for which $\Sigma \geq 6$.

Possibly, concepts such as those we just mentioned point to opportunities for observational and theoretical research regarding each of the following topics and regarding relationships between each of the following topics - the domain of applicability of the Einstein field equations; the notion that (within those equations) the cosmological constant is a constant; the notion and applicability of the concept of a Hubble parameter; notions regarding geodesic motion; and the strengths of forces correlating with the 4G48, 4G246, 4G2468a, and 4G2468b solutions.

4.6 The elementary particle Standard Model

This unit discusses aspects regarding possibilities for integrating, into the elementary particle Standard Model, elementary particles and long-range forces that complementary physics theory suggests that nature embraces.

Reference [3] suggests that, to the extent that satisfying symmetries such as $SU(3) \times SU(2) \times U(1)$ boson symmetries suffices, people might be able to add, to the Standard Model, elementary particles and long-range forces that our work suggests.

4.7 The Higgs mechanism, entanglement, and tachyon-like behavior

This unit provides possible complementary physics theory perspective regarding the traditional physics theory notions of a Higgs mechanism, entanglement, and tachyon-like behavior.

Possibly, to the extent one models the universe as being a confined environment the following statements pertain.

- The cake (or, 0K) boson correlates with the Higgs mechanism and/or Higgs field.
- Theory does not completely disentangle any object from a notion of the universe minus that object.
- These notions correlate with a large-scale notion of tachyon-like behavior.

4.8 Velocities and refraction

This unit describes notions, within a context of complementary physics theory, regarding velocity and refraction.

Work above de-emphasizes the notion of explicitly modeling velocities of objects.

We assert, without discussing some details, the following notions regarding modeling elementary particles for which $\sigma = +1$ and regarding modeling long-range forces. Possibly, one needs, in essence, to consider a specific set of space-time coordinates in order to express a notion of velocity and a quantity for velocity. Possibly, one does not necessarily need to select a kinematics model. The expression $\overrightarrow{v}$ denotes an observed or observable velocity of an object. Here, we consider that the word object can include traditional physics theory notions, such as that of photons, pertaining to long-range forces. The construct $< \_ >$ correlates with a classical physics construct of observed value or with the expected value of a quantum operator. The expression v^2 denotes $< \overrightarrow{v} \cdot \overrightarrow{v} >$. We use the notion that excitations pertaining to G-family phenomena correlate with the notion that $n_{SA0} = -1$ pertains.

- Some complementary physics theory modeling can feature the notion that $n_{SA0} = -v^2/c^2$.
- The traditional physics theory one-word term refraction can pertain.
- Based on double-entry bookkeeping, the following notions pertain.
  - For a charged lepton (or, 1C elementary particle), double-entry bookkeeping, in effect, converts the $n_{SA\_}$ values for the oscillator pair that correlates with conservation of linear momentum from zero and zero to zero and $+v^2/c^2$. The trajectory of the electron bends.
  - For a long-range force (or, ΣGΓ solution), double-entry bookkeeping, in effect, converts the $n_{SA\_}$ values for the oscillator pair that correlates with conservation of linear momentum from zero and zero to zero and $-(1 - v^2/c^2)$. The trajectory bends.
  - Possibly, for 0I, 0H, and 2W elementary bosons, lifetimes are sufficiently short that modeling regarding refraction is not necessarily useful.
  - For a neutrino (or, 1N elementary particle), one of the TA4-and-TA3 oscillators retains its excitation value of $n_{TA\_} = -1$. For the other of the two oscillators, $n_{TA\_} = -v^2/c^2$ pertains. Conservation of generation does not pertain. Neutrino oscillations occur. Refraction does not necessarily occur.

Aspects of the above discussion suggest the possibility that neutrino trajectories do not necessarily refract with respect to spatial space-time coordinates. Possibly, people can correlate neutrino oscillations with a notion of refraction with respect to temporal aspects.

4.9 Supersymmetry

This unit notes that complementary physics theory seems not to be compatible with supersymmetry.

Possibly, tables 2 and 3 are not compatible with supersymmetry.

4.10 Arrow of time

This unit notes that complementary physics theory may provide perspective regarding the topic of arrow of time.

Reference [3] suggests a $\Psi(t_0, r_0)$ that correlates with the TA0-and-SA0 oscillator pair and has similarities to equation (4). Reference [3] shows that such a $\Psi(t_0, r_0)$ normalizes for exactly one of incoming radial momentum or outgoing radial momentum. We might expect that people would choose, for modeling a boson that enters an interaction vertex, normalization for incoming radial momentum. We might expect that people would choose, for modeling a boson that exits an interaction vertex, normalization for outgoing radial momentum. Possibly, the lack of dual normalization provides insight regarding the topic of arrow of time.

4.11 The cosmology timeline

This unit lists topics, regarding aspects of the cosmology timeline, for which our work suggests insights.

Work that we discuss above makes suggestions about the following aspects of the traditional physics theory cosmology timeline.

- The production of baryon asymmetry.
- A possible inflationary epoch.
- Eras regarding the rate of expansion of the universe.
- Clumping that forms various objects, such as stars, galaxies, and galaxy clusters.
- Galaxy formation and evolution.

Possibly, our work also suggests the following notions.

- Early in the evolution of the universe, quarks, arcs, and gluons formed hadron-like seas. The seas might have undergone phase changes, with the last changes featuring at least one transition from seas to hadron-like particles.
- To the extent the universe underwent a so-called inflationary epoch, the epoch might have correlated with such changes regarding sea states and/or with the formation of baryon asymmetry.
- Scenarios regarding clumping suggest that early black holes contained stuff correlating with essentially just one isomer. Later phenomena, perhaps most notably collisions between black holes, might produce black holes that contain significant amounts of stuff correlating with each of more than one isomer.
- Significant aspects of quasars, black hole jets, and blazars might correlate with effects of the 4G48 repulsive long-range force.
- Complementary physics theory is not incompatible with possible large-scale flatness for the universe.

4.12 Concluding remarks

This unit discusses possible opportunities based on our work.

Possibly, our work provides impetus for people to tackle broad agendas that the work suggests. Possibly, our work provides means to fulfill aspects such agendas. Possibly, our work fulfills aspects of such agendas.

Possibly, opportunities exist to develop more sophisticated theory and modeling than the theory and modeling we present. Hopefully, such a new level of work would provide more insight than we provide.

Possibly, our work suggests - directly or indirectly - opportunities for observational research, experimental research, development of precision measuring techniques and data analysis techniques, numerical simulations, and theoretical research regarding elementary particle physics, nuclear physics, atomic physics, astrophysics, and cosmology.

Possibly, our work suggests applied mathematics techniques that have uses other than uses we make.

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