Predictions for elementary particles and explanations for data about dark matter, dark energy, and galaxies

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Abstract

We suggest descriptions for new elementary particles, dark matter, and dark energy. We use those descriptions to explain data regarding dark matter effects, dark energy effects, and galaxy evolution. We use mathematics-based models that feature objects and, originally, de-emphasize motion. The models, descriptions, and explanations add to traditional physics, provide clarity regarding aspects of nature for which people point to possible inadequacies in traditional physics models, and embrace traditional physics models in realms for which people have validated traditional physics models.

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Contents

1 Introduction

This unit introduces our work. This unit discusses context and scope for the work, evolution of the work, and relationships between the work, physics data, and traditional physics theory.

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 one example, describe elementary particles that remain to be found. For another example, describe dark matter. For each of those two examples, resolution does not necessarily depend on considering models pertaining to translational motion.

Traditional physics theory has bases in developing theories of motion without necessarily having descriptions of objects that move. Examples of such theories feature epicycles, elliptical orbits, and the principle of stationary action. Traditional physics theory has bases in adding quantization to classical modeling of the motion of objects. We pursue an approach that catalogs fundamental objects and their properties. The approach features, from its beginning, quantized concepts. The approach does not originally address translational motion.

The approach matches, explains, or predicts phenomena that traditional physics theory approaches do not. For example, we suggest - with some specificity - descriptions of new elementary particles, dark matter, and dark energy forces. The approach suggests formalism that can complement and integrate with traditional physics theory.

1.2 Evolution of our work

This unit discusses the notion that, as of the year 2018, our work seemed to achieve a stable basis of theory centric assumptions and our work began to offer explanations for an increasing scope of observed natural phenomena that people have, starting in 2017 and continuing thereafter, reported.

In 2011, we decided to try to explain eras pertaining to the rate of expansion of the universe.

For years thereafter, we felt that the scope of major assumptions on which we based our work grew somewhat in parallel to the scope of natural phenomena that the work seemed to explain. During this period, we did not consider the evolution of galaxies.

In 2018, the trajectories of the two scopes seemed to decouple. The scope of major assumptions seemed to stop growing. The scope of seemingly explained natural phenomena continued to grow. Newly explained natural phenomena tend to correlate with astrophysics observations - especially, observations correlating with galaxies and dark matter - that people reported during and after 2017.

1.3 Our work, physics data, and traditional physics theory

This unit provides an overview of our work and discusses relationships between our work, physics data, and traditional physics theory.

Generally, our work suggests complements (or, additions) to traditional physics theory. We suggest additions to the list of elementary particles. We suggest descriptions for dark matter and for dark energy forces. We suggest new approximate symmetries and, therewith, new somewhat conservation laws. Some of our suggestions point to possibilities for new interpretations regarding known data.

Generally, our work tends to rely on traditional physics theory concepts regarding objects, internal properties of objects, motion-centric properties, interactions, and kinematics and dynamics theories. Some of our work offers complements to or suggests limits regarding some aspects of traditional physics theory kinematics and dynamics modeling.

Nearby below, we summarize some aspects of and results from our work. We provide perspective for understanding, evaluating, and using our work. We discuss overlaps, similarities, differences, possible synergies, and possible conflicts between our work, physics data, and some aspects of traditional physics theory.

1.3.1 Elementary particles

This unit summarizes - regarding elementary particles - aspects of and relationships between our work, physics data, and traditional physics theory.

People try two approaches to suggesting new elementary particles. People try to explain observed phenomena by suggesting new elementary particles. Perhaps, dark matter has bases in WIMPs or axions. Perhaps, gravity correlates with gravitons. Perhaps, some violation of CP symmetry suggests that nature includes axions. People try to determine patterns that would suggest new particles. Perhaps, supersymmetry pertains and predicts new elementary particles.

Explaining phenomena has succeeded in the past. Explaining protons led to predicting and discovering quarks. Explaining, within the context of gauge theory, the non-zero masses of the W and Z bosons led to predicting and discovering the Higgs boson.

Proposing patterns has succeeded in the past. The proposing, in 1869 by Mendeleev, of organizing principles related to properties of chemical elements led to the periodic table for elements. (Note reference [20].) The table matched all the then-known elements and suggested elements that people subsequently discovered.

Physics might benefit from new candidates for sets of organizing principles for elementary particles. Currently, traditional physics theory sets of candidate principles (such as principles that correlate with supersymmetry) seem to be unverified or to lack specificity regarding properties of particles.

Our work includes a mathematics-based modeling technique that, in effect, outputs the list of known elementary particles, suggests new elementary particles, and suggests organizing principles for an elementary particle analog to the periodic table for chemical elements. The modeling technique does not require making a choice among traditional physics theory kinematics theories.

We think that the set of candidate elementary particles explains some and perhaps most or all of the phenomena that people currently consider when people use known phenomena to point to the possible existence of new elementary particles. Examples of those phenomena include dark matter and baryon asymmetry.

While one mathematics modeling basis outputs the entire set of known and suggested elementary particles, we find it convenient to divide the set into two subsets. We use the two-word phrase basic particles to point to all of the aspects except long-range forces. We use the two-element phrase long-range forces to include bases for phenomena such as electromagnetic fields, gravity, and dark energy forces. We do not separate the notion of boson particles from a broader (than just long-range) concept of forces. For example, sometimes, modeling based on the notion of a strong force provides advantages over modeling based on the notion of gluon basic particles.

We think that people can use the set of elementary particles in the context of traditional physics theory classical physics and in the context of traditional physics theory quantum physics. We think that people can use the set of elementary particles in the contexts of modeling based on each of Newtonian kinematics, special relativity, and general relativity.

Possibly, people will treat outputs from the modeling technique as candidates for basic particles and long-range forces. Possibly, some or all of the candidates represent opportunities for research to detect or infer phenomena and do not necessarily conflict with verified aspects of traditional physics theory.

1.3.2 Dark energy forces and cosmology

This unit summarizes - regarding dark energy forces and cosmology - aspects of and relationships between our work, physics data, and traditional physics theory.

People propose the concept of dark energy pressure to explain observed changes in the rate of expansion of the universe. Traditional physics theory concepts that people use to try to model aspects of the rate of change include the Hubble parameter (or, Hubble constant), equations of state (or, relationships between density and pressure), and general relativity. People suggest possible incompatibilities between observations and traditional physics theory modeling. (See, for example, reference [35].) People suggest phenomenological remedies regarding the modeling. (See, for example, reference [25].) People sometimes use the three-word term dark energy forces in discussions that include notions of dark energy pressure.

Our work regarding spin-two long-range forces points to a candidate unified treatment of gravitational forces and dark energy forces and provides a candidate explanation for three observed eras in the rate of expansion of the universe. The first era correlates with a rate that increases with time and that ends, if we assume that the estimate that reference [25] provides, about 64 thousand years after the big bang. We characterize the dominant force components for this era by the word octupole. The second era correlates with a rate that decreases with time and, if we assume data that references [9], [24], [27], and [28] provide, that ends some billions of years later. We characterize the dominant force component for this era by the word quadrupole. The third era correlates with a rate that increases with time and has lasted some billions of years. We characterize the dominant force component for this era by the word dipole. For each era, dominance refers to interactions between somewhat similar large neighboring objects. Interactions between smaller neighboring objects transit, generally comparatively quickly, to dominance by a monopole force, namely traditional physics theory gravity.

We correlate with the three-word term dark energy forces the spin-two octupole, quadrupole, and dipole long-range forces that we just mentioned.

We think that our work provides a candidate means to close gaps between observations and traditional physics theory. Opportunities exist to characterize (in terms of the rest energies and a few other characteristics, such as rates of rotation, of objects) the strengths of the non-monopole force components of our proposed notion of gravity plus dark energy forces.

1.3.3 Dark matter and galaxies

This unit summarizes - regarding dark matter and galaxies - aspects of and relationships between our work, physics data, and traditional physics theory.

People propose various explanations for observations that, starting in the 1930s, suggest that galaxy clusters do not contain enough ordinary matter to bind observed galaxies into the clusters and that a significant fraction of observed galaxies do not have enough ordinary matter to keep observed stars in their orbits. While people discuss theories that might not require nature to include dark matter, most observations and theoretical work assume that dark matter exists. (People use the term MOND - or, modified Newtonian dynamics - to describe one set of theories that might obviate needs to assume that nature includes dark matter.) People use terms such as WIMPs (or, weakly interacting massive particles), axions, and primordial black holes to name candidate explanations for dark matter. Some of the candidates are not necessarily well-specified. For example, searches for axions span several orders of magnitude of possible axion mass. People suggest that nature might include dark matter photons. People suggest that dark matter might be made from quarks or might experience Yukawa-like potentials. (See, for example, references [36] and [10].)

Our work suggests that nature includes objects that behave like WIMPs but are not elementary particles. These objects would be similar to protons, neutrons, and other hadrons, except that the quark-like components would be fermion elementary particles that have zero charge. These hadron-like particles would interact with gravity, would have no non-zero-charged internal components, and would not interact with light. We know of no reason why these particles would be incompatible with traditional physics theory.

Assuming that the WIMP-similar hadron-like particles exist in nature, a question remains as to the extent to which these particles comprise all dark matter. We think that, today, traditional physics theory would not resolve that question.

People infer a ratio of dark matter density of the universe to ordinary matter density of the universe. That ratio is five-plus to one. (See data that reference [31] provides.) People also infer ratios, for some galaxies and for some galaxy clusters, of dark matter effects to ordinary matter effects.

We think that traditional physics theory does not provide bases for explaining, from fundamental principles, those observed ratios.

Our work explores a possible basis for explaining those observed ratios. For this basis, we posit that nature includes six isomers of a set of elementary particles that includes all known non-zero-charge elementary particles. We introduce symbols of the form PRnISe, for which PR abbreviates the one-element term physics-relevant, n is a non-negative integer, and ISe abbreviates the four-word phrase isomers of the electron. For any relevant value of n, each isomer of PR6ISe-span-one phenomena correlates with not only a set of all known non-zero-charge elementary particles but also with a notion for which we use the two-element term PR1ISe-like photon. In these regards, traditional physics theory correlates with PR1ISe. Complementary physics theory embraces the case of PR1ISe and suggests a case that correlates with PR6ISe. For the case of PR6ISe, one isomer of PR6ISe-span-one phenomena correlates with ordinary matter. Five isomers of PR6ISe-span-one phenomena correlate with dark matter. We assume that the five dark matter isomers of PR6ISe-span-one phenomena correlate with the inference that the density of the universe of dark matter exceeds five times the density of the universe for ordinary matter plus the density of the universe for (ordinary matter) photons. For much of this work, we assume that WIMP-like hadron-like particles account for the difference between the observed ratio of five-plus to one and a ratio of five to one. We think that this work is not incompatible with observations or with established aspects of traditional physics theory.

For the PR6ISe case, a concept that we call span pertains. Each of the six isomers of the PR1ISe-like photon interacts with the non-zero-charge elementary particles that correlate with the isomer of PR6ISe-span-one phenomena that correlates with the PR1ISe-like photon and does not interact with the non-zero-charge elementary particles that correlate with the other five isomers of PR6ISe-span-one phenomena. We say that the span of an isomer of the PR1ISe-like photon is one. For the PR6ISe case, the span of monopole gravity is six. The one isomer of monopole gravity interacts with all six isomers of PR6ISe-span-one phenomena. Our modeling suggests that three isomers of the dipole component of long-range forces pertain. Each isomer has a span of two isomers of PR6ISe-span-one phenomena. For each of the quadrupole and octupole components of long-range forces, six isomers exist and each isomer has a span of one isomer of PR6ISe-span-one phenomena.

For the PR1ISe case, each span is one.

We think that the PR6ISe case explains inferred galaxy-related ratios of dark matter effects to ordinary matter effects.

We propose a galaxy formation and evolution scenario that is compatible with inferred galaxy-related ratios of dark matter effects to ordinary matter effects and that is compatible with our work regarding dark energy forces. (For this discussion of this scenario, we de-emphasize some phenomena such as dark matter galaxies and collisions between galaxies.) Based on this scenario, early in the formation of a galaxy, ordinary matter clumps and forms an early state of the galaxy. The quadrupole long-range force dominates regarding this part of the scenario. Observations that reference [12] reports, regarding galaxies about 10 billion years ago, seem to support this aspect of the scenario. Observations that references [33] and [34] report might support this aspect of the scenario. Starting early in the formation of the galaxy, the dipole long-range force repels one dark matter isomer of PR6ISe-span-one phenomena. Over time, the galaxy attracts (via the monopole gravity force) and accumulates dark matter correlating with the four non-repelled dark matter isomers of PR6ISe-span-one phenomena. Eventually, the ratio of overall dark matter to overall ordinary matter for the galaxy settles at approximately four to one. Observations that reference [16] reports might support this aspect of the scenario.

People might characterize the above galaxy evolution scenario as non-traditional. Much traditional physics theory work regarding galaxy formation assumes that visible galaxies form based on galaxy-scale clumps of dark matter. (See reference [3].) People tend to associate the word halo and the three-word term dark matter halo with dark matter that visible galaxies include. The above scenario suggests that (at least some) galaxies form without much original dark matter. The galaxies would, over time, attract and accumulate dark matter. We suggest that the three-word term ordinary matter halo pertains.

Complementary physics theory PR6ISe modeling treats six isomers - five dark matter isomers and the one ordinary matter isomer - as peers. Complementary physics theory suggests that scenarios, similar to the above scenario, featuring the notion of a dark matter halo pertain to nature. Observations that reference [16] reports might support scenarios that feature dark matter halos.

The following points summarize aspects of this work.

- Traditional physics theory and complementary physics theory offer different scenarios that might comport with data that reference [16] reports. The traditional physics theory scenario correlates with the notion of a dark matter halo. The complementary physics theory scenario correlates with the notion of either an ordinary matter halo or a dark matter halo. Perhaps, the cases of ordinary matter halo and dark matter halo lead to different types of galaxies.
- The complementary physics theory notion of an ordinary matter halo seems to be compatible with observations that references [12], [33], and [34] report. The complementary physics theory notion of a dark matter halo can be compatible with dark matter galaxies that are, in effect, isomers of ordinary matter galaxies that correlate with the types of galaxies for which references [12], [33], and [34] report observations.
- Complementary physics theory suggests the notion of galaxies for which a dark matter halo pertains and the galaxy initially repels ordinary matter. This notion correlates with a dark matter galaxy - with relatively few ordinary matter stars - that reference [32] discusses.

We think that PR6ISe is not incompatible with inferred galaxy cluster related ratios of dark matter effects to ordinary matter effects.

PR6ISe seems to offer an explanation for one piece of data regarding details of the Milky Way galaxy. (Regarding the piece of data, see discussion, in reference [7], regarding data regarding the stellar stream GD-1.)

1.3.4 Dark energy density

This unit summarizes - regarding dark energy density - aspects of and relationships between our work, physics data, and traditional physics theory.

People propose the concept of dark energy density of the universe to explain some observations related to cosmic microwave background radiation (or, CMB). An inferred ratio of density of the universe for dark energy to density of the universe for dark matter plus ordinary matter plus (ordinary matter) photons exceeds two to one. Possibly, the ratio grows from zero to one to its present value based on the age of the universe to which inferences apply.

Traditional physics theory attributes dark energy density to phenomena known as vacuum energy, vacuum fluctuations, or quintessence.

Our work suggests a modeling basis that does not necessarily embrace concepts such as vacuum energy. This aspect of our work seems to avoid some difficulties, such as a possibly large or possibly infinite sum of photon ground-state energies, that people correlate with traditional physics theory. However, this aspect suggests that our work might need to offer a compelling new candidate for a basis for explaining observations that people correlate with the concept of non-zero dark energy density.

Our work suggests that observations (regarding CMB) that people correlate with the three-word term dark energy density might correlate with effects that correlate with existence of an elementary boson that would have zero spin, zero mass, and zero charge. Our models regarding elementary particles suggest the existence of this elementary boson. For the case of PR1ISe modeling, effects correlating with this boson might correlate with non-zero dark energy density.

Our work suggests that observations (regarding CMB) that people correlate with the three-word term dark energy density might correlate with effects whereby a quadrupole component of the spin-one long-range force transmits information pertaining to rotating magnetic (dipole) fields for which the axis of rotation does not match the axis of the (dipole) field.

For the case of PR6ISe modeling, the quadrupole-component effects reflect a coupling between the ordinary matter isomer and dark matter isomers. (In this regard, traditional physics theory correlates with PR1ISe, does not include dark matter isomers, and would not include such a coupling.) For the PR6ISe case, the ratio of inferred density of the universe of dark energy to density of the universe of (generally, but not exactly) dark matter plus ordinary matter would grow, based on the age of the universe, from zero to one to no more than five to one.

For the case of so-called PR36ISe modeling, the quadrupole-component effects reflect a coupling between the ordinary matter isomer and so-called doubly dark matter isomers. (In this regard, traditional physics theory correlates with PR1ISe, does not include doubly dark matter isomers, and would not include such a coupling. Regarding effects of dark energy forces on ordinary matter and dark matter and regarding dark matter and galaxies, results from PR36ISe modeling do not necessarily differ significantly from results from PR6ISe modeling.) Doubly dark isomers would not interact with the ordinary matter isomer or with dark matter isomers via either PR1ISe-like photons or the isomer of gravity that interacts with the ordinary matter isomer. (Each of five sets of six doubly dark isomers would correlate with its own isomer of monopole gravity.) For the PR36ISe case, the ratio of inferred density of the universe of dark energy to density of the universe of (generally, but not exactly) dark matter plus ordinary matter would grow, based on the age of the universe, from zero to one to no more than five to one.

We think that each of the extent to which traditional physics theory describes phenomena underlying inferred non-zero dark energy density and the extent to which our work describes phenomena underlying inferred non-zero dark energy density is an open question.

1.3.5 Depletion of CMB

This unit summarizes - regarding one observation of depletion of cosmic microwave background radiation - aspects of and relationships between our work, physics data, and traditional physics theory.

Results that reference [8] reports about depletion of CMB by absorption by hydrogen atoms might dovetail with the existence of dark matter isomers of hydrogen atoms or with the existence of doubly dark matter isomers of hydrogen atoms. Possibly, our work contributes 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].)

1.3.6 Motion, kinematics conservation laws, QFT, QED, and QCD

This unit summarizes - regarding motion, kinematics conservation laws, QFT (or, quantum field theory), QED (or, quantum electrodynamics), and QCD (or, quantum chromodynamics) - aspects of and relationships between our work, physics data, and traditional physics theory.

Traditional physics theory has roots in theories of motion. Aspects, to which we allude above, of our work generally do not depend on choosing a specific model regarding translational motion.

Traditional physics theory correlates an $SU(2)$ symmetry with conservation of angular momentum and correlates an $SU(2)$ symmetry with conservation of (linear) momentum.

Our work permits adding, to work to which we allude above, traditional physics theory symmetries correlating with conservation of angular momentum and conservation of linear momentum. We can also add symmetries correlating with conservation of energy and (regarding models that correlate with special relativity) boost.

Regarding conservation of angular momentum and conservation of linear momentum, our work permits either of two choices. For one choice, one can add, for each of elementary fermions and elementary bosons, two $SU(2)$ symmetries. This choice provides a path toward much traditional physics theory QFT, QED, and QCD. For the other choice, one can add one $SU(2)$ symmetry for elementary fermions and one $SU(2)$ symmetry for elementary bosons. This (complementary physics theory) choice provides an alternative (to traditional physics theory means) means for modeling aspects of dynamics within multiparticle systems such as protons. Here, kinematics conservation laws pertain for the proton but do not necessarily pertain for individual components of the proton. Modeling correlating with special relativity can pertain for the proton without pertaining to individual components of the proton. Modeling based on potentials can pertain. Modeling does not necessarily feature elementary bosons or virtual particles.

Mathematics-modeling bases for complementary physics theory QFT, QED, and QCD are inherent in the mathematics-modeling bases that underlie aspects of our work that emphasize objects and (up to now in this discussion) de-emphasize motion. The bases include aspects that correlate with traditional physics theory concepts of fields and particles. The bases include aspects that correlate with interaction vertices that are point-like with respect to a temporal coordinate and volume-like with respect to spatial coordinates. The volume-like aspect correlates, for example, with the concept that one can model, for a proton, one quark as being confined by a potential correlating with the other two quarks. Modeling for a proton suggests that boost symmetry (and some alternatives, including no symmetry) - which might pertain for the proton - correlates with modeling that would (had modeling via potentials not, in effect, replaced modeling via virtual elementary bosons) be related to gluons.

Complementary physics theory QFT, QED, and QCD offer some advantages and exhibit some possible disadvantages compared to traditional physics theory QFT, QED, and QCD. Aspects of complementary QED and QCD may be conceptually simpler and more sound mathematically than similar aspects of traditional QED and QCD. Complementary QED modeling and complementary QCD modeling do not necessarily involve the concept of virtual particles. Aspects of complementary QED and QCD may be less developed and less capable of producing - without results from observations or from traditional physics theory - numerical results than are similar to aspects of traditional QED and QCD.

We think that complementary QED and QCD and traditional QED and QCD do not conflict significantly with each other and might provide synergies between each other.

1.3.7 Kinematics and dynamics models

This unit summarizes - regarding kinematics and dynamics models - aspects of and relationships between our work, physics data, and traditional physics theory.

Traditional physics theory provides choices regarding bases for kinematics and dynamics models. One choice features quantum physics modeling and classical physics modeling. Another choice features Newtonian physics, special relativity, general relativity, and other possible bases.

We think that the set of basic particles and long-range forces that our work suggests is compatible with traditional physics theory choices regarding kinematics and dynamics models that we list above, except possibly regarding some modeling that would be based on general relativity. Traditional physics theory seems open to the concept that general relativity may not pertain well for some aspects of nature. For example, reference [15] states, “perhaps general relativity does not describe the universe well on the largest scales.”

Modeling based on general relativity might not be adequately accurate to the extent that some adequately significant phenomena correlate with one span and other adequately significant phenomena correlate with another span. For example, regarding PR6ISe modeling under circumstances in which the quadrupole attractive component of dark energy forces dominates, a dark matter clump that starts on a trajectory similar to the trajectory of a similar ordinary matter clump would not necessarily follow the trajectory that the ordinary matter clump follows. The isomer of the quadrupole attractive component of dark energy forces that correlates with the ordinary matter clump does not equal the isomer of the quadrupole attractive component of dark energy forces that correlates with the dark matter clump. While all six isomers of PR6ISe-span-one phenomena interact via monopole gravity, each one of the six isomers of PR6ISe-span-one phenomena interacts with itself, but not with other isomers of PR6ISe-span-one phenomena, via the quadrupole and octupole components of dark energy forces. Reference [25] points to a possible difficulty regarding modeling based on general relativity. We suggest that this possible difficulty might correlate with octupole aspects of dark energy forces.

We think that our work is not incompatible with known observations that people correlate with validating general relativity. Possibly, opportunities exist to determine the extent to which our work extends applications of general relativity to some realms for which people have not verified the applicability of general relativity. For example, our dipole component of dark energy forces might correlate with the traditional physics theory general relativity concept of rotational frame-dragging.

1.3.8 Other topics

This unit summarizes - regarding various topics - aspects of and relationships between our work, physics data, and traditional physics theory.

Regarding our work, people might assume that the following aspects are non-traditional or think that the following aspects are controversial. However, we think that our work shows that these aspects comport with known phenomena, do not contradict known phenomena, do not violate traditional physics theory theories for realms in which people have validated the theories, offer ways to strengthen and further understand some traditional physics theory, and offer parallel theories that are synergistic with traditional physics theory.

- Our work points to a formula that possibly links a ratio of the masses of two elementary particles and a ratio of the strengths of two components of long-range forces. The elementary particles are the tauon and the electron. The forces are electrostatic repulsion between two electrons and gravitational attraction between (the same) two electrons. We think that this numeric relationship comports with measurements and points to a possibility for extending physics theory. The formula suggests a tauon mass and a standard deviation for the tauon mass. Based on 2018 data, four calculated standard deviations fit within one experimental standard deviation of the experimental nominal tauon mass.
- Our work points to (at least approximate) numerical relationships between the ratios of the masses of the Higgs, Z, and W bosons. These relationships might suggest possibilities for extending physics theories related to the weak mixing angle.
- Our work suggests that people might be able to distinguish observationally between the coalescing of two black holes that interact with each other via dark energy force dipole repulsion and the coalescing of two black holes that do not interact with each other via dark energy force dipole repulsion. The work suggests that the number of occurrences of the second type of event is much less than the number of occurrences of the first type of event.
- Our work suggests resolution regarding the possible mismatch between the elementary particle Standard Model notion that all neutrinos have zero mass and interpretations, of data, that people associate with the notion that at least one neutrino flavor (or, generation) has non-zero rest mass. We suggest that spin-four components of long-range forces couple to lepton number (and not to rest mass) and underlie phenomena that people interpret as implying that at least one neutrino has non-zero rest mass. We suggest that all neutrinos have zero rest mass. While this work may prove controversial, we offer the possibility that it resolves an underlying tension regarding traditional physics theory.
- Our work regarding complementary physics theory QED points to a possibility for modeling lepton anomalous magnetic dipole moments via a sum of just three terms. Each term correlates with a component, for which the spin exceeds one, of long-range forces. This work exemplifies remarks above about relative advantages, relative disadvantages, and possible synergies between complementary physics theory QED and traditional physics theory QED.
- We think that possibilities exist for adding, to the elementary particle Standard Model, new elementary particles that our work suggests. Some of the new elementary particles correlate with symmetries that correlate with current Standard Model elementary particles. Examples include two new non-zero-mass spin-one elementary bosons, which would correlate with an $SU(2) \times U(1)$ symmetry similar to the symmetry correlating with the W and Z bosons. So far, our work does not fully explore the feasibility of adding, to the Standard Model, the particles that our work suggests. For example, we do not explore Lagrangian terms for candidate particles. Also, we do not explore the extent of compatibility between the Standard Model and PR6ISe modeling.
- Complementary physics theory suggests possibilities for a new look at aspects of nuclear physics. Our work that suggests new elementary particles suggests one elementary particle that might correlate with repulsive aspects of the residual strong force and one elementary particle that might correlate with the Yukawa potential (or, attractive component of the residual strong force). Modeling that features these two forces could parallel complementary physics modeling, based on potentials and not based on virtual gluons, for quarks in a hadron. We are uncertain as to the extent to which such modeling might provide a basis for new insight about nuclear physics. We are aware of some concern regarding modeling some aspects of nuclear physics based on the notion of virtual pions. (See reference [2].)

2 Methods

This unit summarizes some inspirations that underlie our work and discusses mathematics-based modeling that underlies our research.

2.1 Inspirations

This unit discusses three inspirations that led to our work.

The first two inspirations pertain regarding aspects of the work that are generally not much directly linked to motion (or, kinematics and dynamics). The third inspiration correlates with aspects of dynamics.

One inspiration posits a non-traditional representation for photons.

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 correlates with non-zero longitudinal polarization and a photon rest mass that would be non-zero. However, mathematics allows a way to avoid this perceived possible problem. A second hunch might be that using four oscillators adds no insight. However, using four oscillators leads to a framework for physics theories and, eventually, even to insight about a family of phenomena that includes photons.

One inspiration posits that physics theory does not necessarily have to follow the traditional path of quantizing aspects that correlate with traditional physics theory classical theories of motion.

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 (assuming that one counts eight gluons) 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 somewhat-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 strive to develop 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. Our work then continues from that point.

One inspiration posits a relationship between dynamics and some mathematics for three-dimensional harmonic oscillators.

A partial differential equation correlating with quantum harmonic oscillators includes an operator that correlates with r^{-2} and an operator that correlates with r^2. (See, in table 2, the terms V_{-2} and V_{+2}. Here, r denotes a radial spatial coordinate.) The r^{-2} operator might model aspects correlating with the square of an electrostatic potential or aspects correlating with the square of a gravitational potential. The r^2 operator might model aspects correlating with the square of a strong interaction potential. Other operator aspects can correlate with r^0 and might correlate with aspects of the weak interaction.

We use this observation about relevant mathematics to develop aspects of complementary QCD.

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. (See equation (7).) 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 $(-1 + 1/2) + (n + 1/2) + (0 + 1/2)$.

The following concepts and generalizations pertain.

- The above discussion 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, equation (1) pertains. Each of A_{TA}^{ALG} and A_{SA}^{ALG} correlates with the concept of an isotropic quantum harmonic oscillator. The word isotropic (or, the two-word term equally weighted) also pertains to the pair consisting of A_{TA}^{ALG} and A_{SA}^{ALG}. The one-element term double-entry pertains. For example, increasing a TA-side excitation number by one requires either decreasing a different TA-side excitation by one or increasing one SA-side excitation by one. The two-element term double-entry bookkeeping pertains.

$$0 = A^{ALG} = A_{TA}^{ALG} - A_{SA}^{ALG} \tag{1}$$

- 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 sets of oscillator pairs. For each case, at least one additive property pertains. Examples of additive properties include charge, lepton number, baryon number, and excitations of polarization modes of long-range forces.
  - $U(1)$ pertains for excitations of polarization modes of long-range forces. For example, a $U(1)$ symmetry correlating with the SA1-and-SA2 oscillator pair pertains regarding photons. A $U(1)$ symmetry correlating with the SA3-and-SA4 oscillator pair pertains regarding would-be gravitons.
  - A pair of $U(1)$ symmetries can pertain regarding charge and conservation of charge. The relevant oscillator pairs are TA2-and-TA1 and SA1-and-SA2.
  - Four $U(1)$ symmetries can pertain regarding lepton number, baryon number, somewhat conservation of lepton number, and somewhat conservation of baryon number. Conservation of lepton number minus baryon number pertains. Oscillator pair SA5-and-SA6 correlates with baryon number. Oscillator pair TA6-and-TA5 correlates with somewhat conservation of baryon number. Oscillator pair SA7-and-SA8 correlates with lepton number. Oscillator pair TA8-and-TA7 correlates with somewhat conservation of lepton number.

- The following symmetries can pertain regarding oscillator pairs.
  - $SU(2)$ pertains for the fermion aspect of generations. The relevant oscillator pair is SA3-and-SA4.
  - $SU(2)$ pertains for a somewhat conservation law that pertains, for some interactions, regarding fermion generations. The relevant oscillator pair is TA4-and-TA3.
  - $SU(2)$ pertains for each of the two kinematics conservation laws conservation of linear momentum and conservation of angular momentum.
  - $SU(2) \times U(1)$ pertains for some aspects regarding the weak interaction. The relevant oscillator pair is SA1-and-SA2.

- The following symmetry can pertain regarding the TA0-and-SA0 oscillator pair.
  - $U(1)$ pertains for some binary choices, such as a choice between zerolike mass and 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.

Table 1: Groups and representations

O	Groups	$\widehat{A}_{XA}^{ALG} < 0$		$A_{\_}^{ALG} = 0$		$\widehat{A}_{XA}^{ALG} > 0$	
		Symbol	$\widehat{A}_{XA}^{ALG}$	Symbols	$A_{\_}^{ALG}$	Symbol	$\widehat{A}_{XA}^{ALG}$
2	-	A0−	-1	[blank], $\kappa_{0,-1}$	$\widehat{A}_{XA}^{ALG}=0$	A0+	1
1	$S1G$	χ_{-1}	$-1/2$	-	-	χ_0	$1/2$
2	$U(1)$	-	-	$\pi_{0,-1}$	$\widehat{A}_{XA}^{ALG}=0$	$\pi_{0,@_0}$	1
j	$SU(j)$, $j \geq 2$	$\kappa_{-1,\cdots,-1}$	$-j/2$	-	-	$\kappa_{0,\cdots,0}$	$j/2$
2	$SU(2) \times U(1)$	-	-	-	-	$\kappa'_{0,0}$	1
2	$U(1)$	-	-	$\chi_{(0,0),(-1,-1)}$	$\widehat{A}_{(TA0,SA0)}^{ALG}=0$	-	-

- 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 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.

Table 1 shows groups that our work uses and shows representations that correlate with those groups. The leftmost column shows the relevant number of oscillators. For each row except the last row, the symbol XA can be TA, in which case all of the oscillators are TA-side oscillators, or SA, in which case all of the oscillators are SA-side oscillators. The symbol $S1G$ denotes a group with one generator. The number of generators for $U(1)$ is two. The number of generators for $SU(j)$ is $j^2 - 1$. The symbol π correlates with the concept of permutations. The symbol $\pi_{a,b}$ denotes two possibilities. Regarding the two oscillators, for one possibility, a pertains to the first oscillator and b pertains to the second oscillator. For the other possibility, a pertains to the second oscillator and b pertains to the first oscillator. The symbol χ correlates with the concept of choice. The symbol $\chi_{(0,0),(-1,-1)}$ denotes two choices. For one choice $n_{TA0} = n_{SA0} = 0$. For the other choice $n_{TA0} = n_{SA0} = -1$. The symbol χ_a pertains to one oscillator and correlates with the equation $n_{XA\_} = a$. The symbol κ correlates with the concept of a continuous set of choices. For example, regarding two oscillators XA1 and XA2, equations (2) and (3) describe the continuum of possibilities correlating with $\kappa_{0,-1}$. Here, each of d and e is a complex number. Equation (4) pertains regarding the symbol $\kappa'_{0,0}$. The symbol A0− denotes $\pi_{@_{-1},@_{-1}}$. The symbol A0+ denotes $\pi_{@_0,@_0}$. The symbol $\widehat{A}_{XA}^{ALG}$ denotes the contribution that the relevant oscillators make toward a total A_{XA}^{ALG}. The symbol $\widehat{A}_{(TA0,SA0)}^{ALG}$ denotes the contribution that the TA0-and-SA0 oscillator pair makes toward a total $A_{\_}^{ALG}$. The symbol [blank] - in the first row of table 1 - denotes the concept that, in tables such as table 6, one can interpret a blank cell as correlating with $\kappa_{0,-1}$.

$$d|n_{XA1} = 0,\, n_{XA2} = -1 > \;\; + \;\; e|n_{XA1} = -1,\, n_{XA2} = 0 > \tag{2}$$

$$|d|^2 + |e|^2 = 1 \tag{3}$$

$$\kappa'_{0,0} = \kappa_{0,0} \times \pi_{0,-1} \tag{4}$$

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

$$g_3|g_5,\; g_3|g_7,\; g_5|g_7, \quad g_5 \nmid g_9,\; g_7 \nmid g_9,\; g_7 \nmid g_{11}, \quad g_3|g_{17},\; g_5|g_{17},\; g_7|g_{17} \tag{5}$$

We discuss an aspect regarding harmonic oscillator raising operators.

Our work extends the domain correlating with equation (6) from $n \geq 0$ to $n \geq -1$. Thereby, our work includes equation (7). Here, a^+ denotes a harmonic oscillator raising operator. The integer n correlates, for $n \geq 0$, with the number of excitations.

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

$$a^+|-1>=0|0> \tag{7}$$

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, equation (8), to equation (1). Each of A_{TA}^{PDE} and A_{SA}^{PDE} is a quantum operator.

$$0 = A^{PDE} = A_{TA}^{PDE} - A_{SA}^{PDE} \tag{8}$$

The following perspective pertains.

Equations (9) and (10) 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 theory applications, Ω_{SA} is a constant that correlates with aspects correlating with angular coordinates. Our discussion includes the term Ω_{SA} and, otherwise, tends to de-emphasize 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.

$$\xi_{SA}\Psi(r) = (\xi'_{SA}/2)(-(\eta_{SA})^2{\nabla_r}^2 + (\eta_{SA})^{-2}r^2)\Psi(r) \tag{9}$$

$${\nabla_r}^2 = r^{-(D-1)}(\partial/\partial r)(r^{D-1})(\partial/\partial r) - \Omega_{SA}r^{-2} \tag{10}$$

Including for $D = 1$, each of equation (9), equation (10), and the function Ψ pertains for the domain equation (11) shows.

$$0 < r < \infty \tag{11}$$

We consider solutions of the form that equation (12) shows. (For $\nu_{SA} \geq 0$, this work can pertain for the domain $0 \leq r < \infty$. For $\nu_{SA} < 0$, this work pertains for the domain that equation (11) defines.)

$$\Psi(r) \propto (r/\eta_{SA})^{\nu_{SA}} \exp(-r^2/(2(\eta_{SA})^2)), \text{ with } (\eta_{SA})^2 > 0 \tag{12}$$

Equations (13) and (14) characterize solutions. The parameter η_{SA} does not appear in these equations. Equation (15) correlates with the domains of D and ν_{SA} for which normalization pertains for $\Psi(r)$. For $D + 2\nu_{SA} = 0$, normalization pertains in the limit $(\eta_{SA})^2 \to 0^+$. (Regarding mathematics relevant to normalization for $D+2\nu_{SA} = 0$, the delta function that equation (16) shows pertains. Here, x^2 correlates with r^2 and 4ϵ correlates with $(\eta_{SA})^2$. Reference [19] provides equation (16). The difference in domains, between $-\infty < x < \infty$ and equation (11), is not material here.)

$$\xi_{SA} = (D + 2\nu_{SA})(\xi'_{SA}/2) \tag{13}$$

$$\Omega_{SA} = \nu_{SA}(\nu_{SA} + D - 2) \tag{14}$$

$$D + 2\nu_{SA} \geq 0 \tag{15}$$

$$\delta(x) = \lim{}_{\epsilon\to 0^+}(1/(2\sqrt{\pi\epsilon}))e^{-x^2/(4\epsilon)} \tag{16}$$

Equation (17) introduces three parameters, namely σ, S, and D^*_{SA}. Equation (18) introduces three parameters, namely σ', S', and D^*_{TA}.

$$\Omega_{SA} = \sigma S(S + D^*_{SA} - 2) = \sigma S(S+1), \text{ for } \sigma = \pm 1 \tag{17}$$

$$\Omega_{TA} = \sigma' S'(S' + D^*_{TA} - 2) = \sigma' S'(S'-1), \text{ for } \sigma' = \pm 1 \tag{18}$$

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 equation (17). 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 theory notions of spin divided by $\hbar$. The symbol $\hbar$ denotes the reduced Planck's constant.
    - Solutions for which $\nu_{SA} = -1/2$ can correlate with notions of fields for elementary fermions.
    - Solutions for which $\nu_{SA} = -1$ can correlate with notions of fields for elementary bosons.
    - Solutions for which $\nu_{SA} = -3/2$ can correlate with notions of particles for elementary fermions.
    - TA-side aspects correlate with $D^*_{TA} = 1$ via values of Ω_{TA} that satisfy equation (18). Here, σ' is one of $+1$ and -1. Here, $2S'$ is a nonnegative integer. For some solutions, $D \neq D^*_{TA}$.
    - TA-side PDE solutions are radial with respect to t, the TA-side analog to the SA-side radial coordinate r.
- 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 $\nu_{TA0,SA0} = \nu_{SA1,SA2} = -1$ can correlate with notions of particles for elementary bosons.
- Regarding modeling an object (such as a quark) as being a component of a multicomponent object (such as a proton), an interaction vertex that is volume-like correlates with $(\eta_{SA})^2 > 0$. Here $|\eta_{SA}|$ might correlate with the size of the multicomponent object.
- The case of equation (17) and $\sigma = +1$ is a mathematically straightforward application of equation (14). The case of equation (17) and $\sigma = -1$ correlates with aspects of complementary physics theory modeling. (See discussion related to equation (66).) Similar concepts pertain regarding equation (18) and σ'.

Table 2 provides details leading to equations (13) and (14). We consider equations (9), (10), and (12). 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 (9). The term V_{-2} correlates with the right-most term in equation (10). The four $K_{\_}$ terms correlate with the other term in equation (10). The sum of the two $K_{0\_}$ terms correlates with the factor $D + 2\nu_{SA}$ in equation (13).

The following remarks might be 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 $\hbar^2$.

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

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

Table 3: A catalog of elementary particles

Entities	Spin	Σ	$\sigma=-1$		$\sigma=+1$	
			$m \doteq 0$	$m>0$	$m \doteq 0$	$m>0$
Basic 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)
Long-range forces	≥ 1	≥ 2	-	-	ΣG (NA)	-

3 Results

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

3.1 Elementary particles

This unit shows a table of all known elementary particles and all elementary particles that complementary physics theory predicts. This unit also catalogs interaction vertices for interactions involving only elementary particles.

Table 3 provides a candidate periodic table analog for elementary particles. Here, we separate long-range forces from basic particles. We de-emphasize using this table to display a detailed catalog of long-range forces. (For a catalog of long-range forces, see table 10.) For basic 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 hadrons and atomic nuclei. 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 theory models correlate the relevant particles with zero mass. Traditional physics theory models do or might correlate the relevant elementary fermions with small positive masses or with zero 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. Each cell in which a dash appears might not pertain to nature.

We discuss the basic 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 basic 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 basic particles for which $\sigma = -1$ and $m > 0$. The 0P, or so-called pie, particle might

Table 4: Relationships between some PDE parameters for ΣW, ΣH, ΣI, ΣP, ΣK, and ΣT solutions

D^*_{SA}	ν_{SA}	$D^*_{SA}+2\nu_{SA}$	D	S	Ω	σ	D	$D+2\nu_{SA}$	$2S+1$	$\Sigma\Phi$
3	-1	1	$3-\Omega$	1	2	$+1$	1	-1	3	2W
3	-1	1	$3-\Omega$	0	0	$+1$	3	1	1	0H, 0I
3	-1	1	$3-\Omega$	0	0	-1	3	1	1	0P, 0K
3	-1	1	$3-\Omega$	1	-2	-1	5	3	3	2T

Table 5: Fermion-centric PDE solutions

D^*_{SA}	ν_{SA}	$D^*_{SA}+2\nu_{SA}$	D	S	Ω	σ	D	$D+2\nu_{SA}$	$2S+1$	$\Sigma\Phi$
3	$-1/2$	2	$(5-4\Omega)/2$	$1/2$	$3/4$	$+1$	1	0	2	1C, 1N
3	$-1/2$	2	$(5-4\Omega)/2$	$1/2$	$-3/4$	-1	4	3	2	1Q, 1R
3	$-3/2$	0	$(21-4\Omega)/6$	$1/2$	$3/4$	$+1$	3	0	2	1C, 1N
3	$-3/2$	0	$(21-4\Omega)/6$	$1/2$	$-3/4$	-1	4	1	2	1Q, 1R

correlate with an attractive component of the residual strong force. (See discussion related to equation (67).) The 0P particle might provide an aspect for alternative modeling regarding interactions between hadrons in 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 basic particles for which $\sigma=-1$ and $m \circeq 0$. The 0K, or so-called cake, particle might correlate with a repulsive component of the residual strong force. (See discussion related to equation (67).) The 0K particle might provide an aspect for alternative modeling regarding interactions between hadrons in 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.

The following remarks illustrate roles, leading to table 3, for PDE modeling.

Table 4 summarizes some basic-boson-centric PDE results for field centric solutions. Each solution correlates with $\nu_{SA}=-1$ and with a positive integer D. We feature solutions to equations (13) and (14). While D need not equal three, each Ω_{SA} comports with $D^*_{SA}=3$ and with the requirement that $\Omega_{SA}=\sigma S(S+1)$. For each item that the table lists in the column labeled ΣΦ, the number of possible particles, including antiparticles, equals $2S+1$. For example, 2W correlates, by this count, with three particles - the Z, W^+, and W^- particles. We limit solutions for which $\sigma=+1$ to solutions for which $S\leq 1$. Any solutions for which $\sigma=+1$ and $S\geq 2$ would feature D not being a positive integer. We limit solutions for which $\sigma=-1$ to those for which $S\leq 1$. Solutions for which $\sigma=+1$ and $S\geq 2$ would seem to correlate with some supposedly candidate basic particles that would have negative values of m^2. (See discussion that is related to equation (36) and table 18.) Each one of 2U solutions and ΣG solutions correlates with terms in the operators in equations (9) and (10) and does not appear in table 4.

Table 5 summarizes elementary-fermion-centric PDE solutions. Per discussion related to equation (14), $\nu_{SA}=-1/2$ correlates with fields and $\nu_{SA}=-3/2$ correlates with particles. For each item that table 5 lists in the column labeled ΣΦ, one of the following two sentences pertains. For $\sigma=+1$, $2S+1$ equals the number of elementary particles (including antiparticles) per generation. For $\sigma=-1$, $2S+1$ equals half of the number of elementary particles (including antiparticles) per generation.

The following remarks illustrate roles, leading to table 3, for ALG modeling.

Table 6 alludes to all, but does not directly show some of, the ALG solutions that our work suggests have physics-relevance regarding basic particles and long-range forces. In the symbol ΣΦ, the symbol Σ is a non-negative integer and denotes twice the spin S. Here, $\Sigma=1$ correlates with $\hbar/2$ and $S=1$ correlates with $\hbar$. For example, for 1N (which correlates with neutrinos), $S=1/2$ and $\Sigma=1$. Each Φ correlates with a family of solutions. Regarding a specific combination of Σ and Φ, we use, with respect to ΣΦ, the term subfamily. The word boson correlates with solutions for which Σ is a nonnegative even integer. The word fermion correlates with solutions for which Σ is a positive odd integer. Each row in table 6 comports with ALG double-entry bookkeeping. Regarding labeling for some columns, SA0 correlates with the SA0 oscillator, for which n_{SA0} pertains, and SA1,2 correlates with the SA1-and-SA2 pair of oscillators, for which n_{SA1} and n_{SA2} pertain. The expression $\sigma=+1$ correlates with the term free-ranging. Elementary particles for which $\sigma=-1$ exist only in confined environments (such as hadron-like environments or atomic nuclei). For $\sigma=+1$, SA-side aspects correlate with numbers of basic particles

Table 6: Subfamilies

$\Sigma\Phi$	σ	$\vert\!\leftarrow$	$\cdots$	TA	$\cdots$	$\rightarrow\!\vert$	$\vert\!\leftarrow$	$\cdots$	SA	$\cdots$	$\rightarrow\!\vert$
		8,7	6,5	4,3	2,1	0	0	1,2	3,4	5,6	7,8
0H	$+1$					0	0				
0P	-1					0	0				
0I	$+1$					-1	-1				
0K	-1					-1	-1				
1N	$+1$	$\pi_{0,-1}$		$\kappa_{-1,-1}$	$\pi_{0,-1}$	-1	-1	$\pi_{0,-1}$	$\kappa_{-1,-1}$		$\pi^L_{0,-1}$
1C	$+1$	$\pi_{0,-1}$		$\kappa_{0,0}$	$\pi_{0,-1}$	0	0	$\pi_{0,-1}$	$\kappa_{0,0}$		$\pi^L_{0,-1}$
1R	-1		$\pi_{0,-1}$	$\kappa_{-1,-1}$	$\pi_{0,-1}$	-1	-1	$\pi_{0,-1}$	$\kappa_{-1,-1}$	$\pi^L_{0,-1}$	
1Q	-1		$\pi_{0,-1}$	$\kappa_{0,0}$	$\pi_{0,-1}$	0	0	$\pi_{0,-1}$	$\kappa_{0,0}$	$\pi^L_{0,-1}$	
2U	-1		$\dagger U_{TA}$			$\dagger U_{TA}$	$\dagger U_{SA}$		$\dagger U_{SA}$		
2W	$+1$			$\dagger W_{TA}$		$\dagger W_{TA}$	$\dagger W_{SA}$	$\dagger W_{SA}$			
2T	-1				$\dagger T_{TA}$	$\dagger T_{TA}$	$\dagger T_{SA}$		$\dagger T_{SA}$		
2G	$+1$					0	-1	$\pi_{0,@_0}$			
4G	$+1$					0	-1		$\pi_{0,@_0}$		
6G	$+1$					0	-1			$\pi_{0,@_0}$	
$\cdots$G	$+1$					0	-1				$\cdots$
						$^{\dagger U_{TA}}$ $\kappa_{-1,-1,-1}$	$^{\dagger U_{SA}}$ $\kappa_{-1,-1,-1}$				
						$^{\dagger W_{TA}}$ Z: $\kappa_{0,0,0}$	$^{\dagger W_{SA}}$ $(0,@_0,@_0)\uplus(@_0,\kappa'_{0,0})$				
						$^{\dagger T_{TA}}$ $(@_0,@_0,0)\uplus(\kappa'_{0,0},@_0)$	$^{\dagger T_{SA}}$ T^0: $\kappa_{0,0,0}$				

(or long-range force polarization modes) and with interactions in which the basic particles (or long-range force modes) partake. TA-side aspects correlate with notions of conservation laws. For $\sigma = -1$ boson solutions, TA-side aspects correlate with numbers of elementary particles and with interactions in which the particles partake. SA-side aspects tend to correlate with notions of conservation laws. Each symbol of the form $\pi_{a,b}$ correlates with the concept that either one of two choices might pertain. (The symbol $\pi_{...}$ correlates with the concept of permutations.) For one choice, $n_{\_(j-1)} = a$ and $n_{\_j} = b$. Here, the two _ equal each other and equal one of TA and SA. Here, j is an even positive integer. For the other choice, $n_{\_(j-1)} = b$ and $n_{\_j} = a$. Each symbol of the form $\pi_{a,b}$ correlates with a $U(1)$ symmetry. Each symbol of the form $\kappa_{a,\cdots,a}$ correlates with an $SU(j)$ symmetry for which j denotes the number of appearances of the symbol a. The symmetry $^{\dagger U_{TA}}$ $\kappa_{-1,-1,-1}$ correlates with the traditional physics theory strong interaction $SU(3)$ symmetry. (For additional information regarding $^{\dagger U_{TA}}$ $\kappa_{-1,-1,-1}$, see discussion related to table 26.) The item $^{\dagger W_{SA}}$ $(0,@_0,@_0)\uplus(@_0,\kappa'_{0,0})$ correlates with traditional physics theory weak interaction $SU(2)\times U(1)$ symmetry. (The notion that a W$^-$ boson and a positron can be incoming particles for an interaction and a W$^-$ boson and an electron cannot be incoming particles for an interaction correlates with adding the $U(1)$ aspect - to yield $\kappa'_{0,0}$ - to what otherwise is - for the W boson - just $SU(2)$ and $\kappa_{0,0}$. Also, note discussion regarding table 7.) Similar concepts pertain regarding the 2T subfamily and $^{\dagger T_{TA}}$ $(@_0,@_0,0)\uplus(\kappa'_{0,0},@_0)$. For $\sigma = -1$ fermion solutions, TA-side and SA-side aspects correlate with numbers of elementary particles and with interactions in which the particles partake. For boson elementary particles for which $\sigma = +1$, the table shows ground states. Long-range forces correlate with ΣG solutions. For long-range forces, the term boson pertains, the notion of $\sigma = +1$ pertains, and information in the table alludes to ground states. Use of the symbol $\pi^L_{0,-1}$ correlates with the notion that, regarding ordinary matter, nature embraces so-called left-handed matter elementary fermions and so-called right-handed antimatter fermions and does not seem to embrace so-called right-handed matter elementary fermions and so-called left-handed antimatter fermions. For ordinary matter, only one of the two permutations that correlate with $\pi^L_{0,-1}$ pertains. For $\Sigma = 0$, one SA-side oscillator pertains. For $\Sigma = 1$, aside from generation-related (or, SA3 and SA4) oscillators and aside from the handedness-related (or, $\pi^L_{0,-1}$) oscillators, essentially two SA-side oscillators pertain because we do not count the SA1 or SA2 oscillator that correlates with $n_{SA\_} = -1$ in $\pi_{0,-1}$. For $\Sigma = 2$, three SA-side oscillators pertain. Generally speaking, $n_{SA0} = 0$ correlates with an ability to have an isolated quantum interaction with, in effect, the 4G4 solution. Generally speaking, for the 1N, 1C, and 1Q solutions and for $j = 1$ or $j = 2$, $n_{SAj} = 0$ correlates with an ability to have an interaction with a W boson. (Regarding whether the interaction is with the W$^+$ boson or the W$^-$ boson, compare with table 7.) For the 1R solutions, the SA1-and-SA2 oscillator pair correlates with conservation of charge.

Given mathematics correlating with excitations of harmonic oscillators, representations, in table 6,

Table 7: Ground-state solutions for H-family and W-family bosons

Φ	$\Sigma\Phi$	Particle	Symbol	TA4	TA3	TA2	TA1	TA0	SA0	SA1	SA2
H	0H	0H0	H^0					0	0		
W	2W	2W0	Z	0	0			0	0	$@_0$	$@_0$
W	2W	2W1	W^+	0	0			0	$@_0$	0	$@_0$
W	2W	2W2	W^-	0	0			0	$@_0$	$@_0$	0

Table 8: Ground-state solutions for T-family bosons

Φ	$\Sigma\Phi$	Particle	Symbol	TA2	TA1	TA0	SA0	SA1	SA2	SA3	SA4
T	2T	2T0	T	$@_0$	$@_0$	0	0			0	0
T	2T	2T1	T^+	$@_0$	0	$@_0$	0			0	0
T	2T	2T2	T^-	0	$@_0$	$@_0$	0			0	0

for 0I, 0K, and 2U might seem to correlate with no possibilities for excitations. (See equation (7).) Zero possibility for excitations might correlate with a lack of physics-relevance for the solutions. Nature exhibits effects of gluons. Discussion related to tables 26 and 27 shows modeling that correlates with 2U excitations and, thereby, with gluons. Complementary physics theory suggests that 0K correlates with a component of the residual strong force. (See discussion related to equation (67).) Interactions correlating with 0K would take place in confined environments. Paralleling a use for gluons of equation (61), complementary physics theory suggests that 0K particles can excite. For 0I solutions, discussion parallel to that for 0K might pertain. Here, the confined environment might correlate with the universe.

Table 7 shows ground-state solutions relevant for H-family and W-family bosons. The symbol H^0 denotes the Higgs boson. In general, the symbol @ correlates with an excitation number that does not change. Here, the symbol $@_0$ denotes a zero that, for the appropriate particle, does not change. For the W family, a TA-side $SU(2)$ approximate symmetry correlates with the TA4-and-TA3 oscillator pair and with the concept of somewhat conservation of fermion generation. For example, for an adequately isolated interaction vertex in which an electron (or, generation-one charged lepton) becomes a neutrino, the neutrino is a generation-one neutrino. The approximate symmetry and somewhat conservation law do not necessarily pertain when each of two interactions involving different W-family bosons, in effect, entangle with each other.

One interpretation of aspects of table 7 features the notion that TA0 correlates with an $S1G$ symmetry that traditional physics theory correlates with conservation of energy. (See table 12.) For the W family, it is appropriate to interpret the possible TA-side $SU(3)$ symmetry (that table 7 shows) as an approximate $SU(2) \times S1G$ symmetry.

The following remarks illustrate a possible application of ALG modeling.

Table 8 shows a representation of ground-state solutions relevant for T-family bosons. Excitation of a T-family boson correlates mathematically with a one-third probability of exciting each of the oscillators SA0, SA3, and SA4. Of the three oscillators, only the SA0 oscillator correlates with non-zero charge. This modeling suggests that the charge of each T-family boson is one-third the charge of the counterpart W-family boson. This work might extend to the following concepts. For objects for which $\sigma = +1$, the minimum magnitudes of some non-zero quantities are $|q_e|$ for charge, one for lepton number, and one for baryon number. (Here, we consider that a proton or other hadron with no more than three quarks correlates with $\sigma = +1$.) For objects for which $\sigma = -1$, the minimum magnitudes of some non-zero quantities are $|q_e|/3$ for charge and one-third for baryon number. (Non-zero lepton number pertains only to objects for which $\sigma = +1$.) Each of the quantities charge, lepton number, and baryon number is additive with respect to components of a multicomponent object.

The following remarks pertain regarding interaction vertices. These remarks extend discussion related to equation (14) and table 5. These remarks pertain to basic particles and to long-range forces.

Table 9 lists types of interaction vertices that complementary physics theory includes. Here, in the symbol nf, n denotes a number of elementary fermions. In the symbol nb, n denotes a number of elementary bosons. A symbol of the form a↔b denotes two cases, namely a→b and b→a. A symbol of the form a→b denotes the notion that the interaction de-excites each component of a by one unit and excites each component of b by one unit. (Note, for example, that de-excitation of a photon mode does not necessarily produce a ground state.) For each type of interaction vertex, the effective ν is the sum, over incoming field solutions, of the relevant $\nu\_$ and is also the sum, over outgoing field solutions, of the relevant $\nu\_$. (Technically, the previous sentence does not necessarily pertain for 2U

Table 9: Interaction vertices for interactions involving only basic particles and long-range forces

Interaction	Effective ν	Example
0f1b↔2f0b	-1	A Z boson creates a matter-and-antimatter pair of fermions.
1f1b↔1f1b	$-3/2$	An electron and a W^+ boson produce a neutrino.
1f1b↔3f0b	$-3/2$	$1\mathrm{C}^{+1} + 1\mathrm{R}^0 + 1\mathrm{Q}^{-2/3} \rightarrow 1\mathrm{Q}^{+2/3} + 2\mathrm{T}^{-1/3}$.
0f2b↔0f2b	-2	A Higgs boson creates two photons.

solutions and for ΣG solutions. We posit that significant aspects of complementary physics theory can be based on assuming that a $\nu\_$ of minus one correlates with each of 2U solutions and ΣG solutions. Note that, in effect, the value of effective ν correlates with aspects of a product of solutions of the form that equation (12) shows.) Traditional physics theory includes (and table 9 mentions examples of) 1f0b↔1f1b and 0f1b↔0f2b interactions. Complementary physics theory can embrace traditional physics theory 1f0b↔1f1b interactions via the case of 1f1b↔1f1b and the notion that the other boson correlates with 0I phenomena. Complementary physics theory can embrace traditional physics theory 0f1b↔0f2b interactions via the case of 0f2b↔0f2b and the notion that the other boson correlates with 0I phenomena. Complementary physics theory modeling can embrace, at least regarding 0f1b↔0f2b cases in which the 1b in 0f1b correlates with a non-zero-mass zero-charge elementary boson, the notion of an effective ν of minus two. Traditional physics theory includes limits based on fermion statistics and does not necessarily include 1f1b↔3f0b interactions. Table 9 shows an example of a 1f1b↔3f0b interaction that might help catalyze baryon asymmetry. (See discussion related to equation (28).) Here, the superscripts correlate with charge, in units of $|q_e|$ (or, in units of the magnitude of the charge of an electron). Here, each of the three 3f fermions differs from the other two 3f fermions. Traditional physics theory limitations based on fermion statistics do not necessarily pertain. (Also, traditional physics theory might be able to model some complementary physics theory 1f1b→3f0b interactions via the sequence 1f1b↔1f1b followed by 0f1b→2f0b. Here, the outgoing 1b in the first interaction becomes the incoming 1b in the second interaction.)

Traditional physics theory includes the following sequence of vertices. A fermion enters a 1f0b→1f1b vertex. The exiting fermion enters a 1f0b→1f1b vertex. The fermion exiting the second vertex enters a 1f1b→1f0b vertex that de-excites the boson that the first vertex excited. Some aspects of complementary physics theory do not necessarily include the notion of virtual particles and do not necessarily include such a sequence.

3.2 Long-range forces

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

Table 10 provides a candidate periodic table analog for long-range forces. In table 10, each cluster of rows correlates with one value of spin (or, 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 10 shows four-element symbols of the form Σ(s)GΓ. Each Γ is a list of one, two, three, or four unique even integers. The symbol λ denotes such an integer. Values for λ can be two, four, six, and eight. For the SA($\lambda - 1$)-and-SAλ oscillator pair, a spin-related symmetry can be either $n_{SA\mathrm{odd}} = 0$ and $n_{SA\mathrm{even}} = @_0$, which correlates with left-circular polarization, or $n_{SA\mathrm{odd}} = @_0$ and $n_{SA\mathrm{even}} = 0$, which correlates with right-circular polarization. (Here, $n_{SA\mathrm{odd}}$ denotes $n_{SA(\lambda-1)}$ and $n_{SA\mathrm{even}}$ denotes $n_{SA\lambda}$.) For each ΣGΓ, the number of SA-side oscillator pairs that correlate with spin-related symmetry is $-n_{SA0}$. Regarding the Σ in ΣGΓ, Σ denotes both $2S$ and the absolute value of the arithmetic combination across spin-related symmetry SA-side oscillators of $+2S_{\mathrm{oscillator}}$ (or, $+2S_{SA(\lambda-1)}$) for each left-circular spin-related symmetry and $-2S_{\mathrm{oscillator}}$ (or, $-2S_{SA\lambda}$) for each right-circular spin-related symmetry. (Some aspects of this spin-related symmetry application do not correlate with the concept of isotropic. For example, the expression $\pm 2S_{\mathrm{oscillator}}$ gives twice as much weight to the SA3-and-SA4 oscillator pair as the expression $\pm 2S_{\mathrm{oscillator}}$ gives to the SA1-and-SA2 oscillator pair. The spin-related symmetry application computes Σ.) For example, for ΣG24, Σ can be two, as in $|-2+4|$, or six, as in $|+2+4|$. Regarding Σ(1)G2468, for each of $\Sigma = 4$ and $\Sigma = 8$, the table lists two solutions (Σ(1)G2468a and Σ(1)G2468b) because there are two ways (with respect to Γ=2468) to produce the relevant value of Σ. For purposes of table 10, we ignore solutions for which $\Sigma = 0$. The symbol s correlates with span for cases for which n (as in PRnISe) exceeds one. (See table 14.) In table 10, 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

Table 10: A catalog of long-range forces

$\Sigma \in \Gamma$	S	Monopole (SDF $= r^{-2}$)	Dipole (SDF $= r^{-3}$)	Quadrupole (SDF $= r^{-4}$)	Octupole (SDF $= r^{-5}$)
Yes	1	2(1)G2	2(1)G24	2(6)G248	
Yes	2	4(6)G4	4(2)G48	4(1)G246	4(1)G2468a
”	”				4(1)G2468b
Yes	3	6(2)G6		6(6)G468	
Yes	4	8(1)G8			8(1)G2468a
”	”				8(1)G2468b
No	1		2(6)G46	2(6)G468	
”	”		2(2)G68		
No	2		4(6)G26	4(6)G268	
No	3		6(1)G24	6(6)G248	
”	”		6(2)G28		
No	4		8(6)G26	8(1)G246	
No	5		10(2)G28	10(6)G248	
”	”		10(6)G46	10(6)G468	
No	6		12(2)G48	12(1)G246	12(1)G2468
”	”			12(6)G268	
No	7		14(2)G68	14(6)G248	
No	8			16(6)G268	16(1)G2468
No	9			18(6)G468	
No	10				20(1)G2468

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. Regarding values of n, as in r^{-n}, equation (19) pertains. (The symbol $\in$ denotes the four-word phrase is a member of. The symbol $n_{\lambda \in \Gamma}$ denotes the number of integers in Γ.) In table 10, usage of the one-word terms monopole, dipole, quadrupole, and octupole is consistent with usage of those terms in traditional physics theory. Remarks below regarding equation (20) explain an aspect, that seemingly does not pertain to SDF, regarding use of the words monopole, dipole, quadrupole, and octupole. We use the symbol $\Sigma\gamma$ to denote sets of ΣGΓ for which $\Sigma \in \Gamma$. 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.) The first four clusters of rows in table 10 show solutions for which $\Sigma \in \Gamma$. The remaining clusters of rows in table 10 show solutions for which $\Sigma \notin \Gamma$.

$$n = n_{\lambda \in \Gamma} + 1 = -n_{SA0} + 1 \tag{19}$$

We discuss an aspect that correlates with equation (19). Each λ correlates with a square of potential energy for which the potential energy correlates with r^{-1}. The squares multiply, yielding a square of potential energy that correlates with $r^{-2n_{\lambda \in \Gamma}}$. The corresponding potential energy correlates with $r^{-n_{\lambda \in \Gamma}}$. The corresponding force correlates with $r^{-n_{\lambda \in \Gamma}-1}$ (or, $r^{-(n_{\lambda \in \Gamma}+1)}$).

We discuss another aspect that correlates with equation (19). For each G-family Γ, equation (20) states the number of mathematically relevant ΣGΓ solutions. The notion (in table 10) of monopole correlates with $n_{\lambda \in \Gamma} = 1$ and one solution. The notion of dipole correlates with $n_{\lambda \in \Gamma} = 2$ and two solutions. The notion of quadrupole correlates with $n_{\lambda \in \Gamma} = 3$ and four solutions. The notion of octupole correlates with $n_{\lambda \in \Gamma} = 4$ and eight solutions. Our applications to G-family physics de-emphasize G-family solutions for which $\Sigma = 0$.

$$2^{n_{\lambda \in \Gamma}-1} \tag{20}$$

Discussion related to equation (36) and table 18 notes possible relevance - to H-family physics and W-family physics - of G-family solutions for which $\Sigma = 0$. That discussion correlates the one G-family solution for which $n_{\lambda \in \Gamma} = 4$ and $\Sigma = 0$ with the Higgs boson, for which $\Sigma = 0$, and correlates the two G-family solutions for which $n_{\lambda \in \Gamma} = 3$ and $\Sigma = 0$ with the Z and W bosons, for which $\Sigma = 1$. The case of ΣG268 includes, as per equation (20), four solutions - 0G268, 4G268, 12G268, and 16G268. Seemingly, the set of four ΣG268 solutions points to a place for and a lack of a would-be 8G solution for which $n_{\lambda \in \Gamma} = 3$. Given that $n_{\lambda \in \Gamma} = 3$ would pertain, the lack might correlate with spin-one elementary bosons.

Possibly, G-family solutions of the form $\Sigma\mathrm{G}\Gamma'$ - with the three λ in Γ' being six, six, and twelve - pertain. The $0\mathrm{G}\Gamma'$ solution might correlate with U-family physics. Possibly, some 0G solutions correlate with T-family physics. We explore some aspects of these possibilities in discussion related to equation (36) and table 18.

We discuss the 2γ long-range force. Solution 2(1)G2 correlates with an r^{-2} force and with an interaction with charge. Solution 2(1)G24 correlates with an r^{-3} force and with an interaction with nominal magnetic dipole moment. A complementary physics theory separation of notions of a traditional physics theory photon into components is not necessarily inappropriate, in part because (at this stage) modeling does not include translational motion (or, kinematics). The strength of 2(1)G2 does not necessarily correlate with the strength of a magnetic dipole. For example, for a bar magnet or for the earth, nominal magnetic dipole moment does not correlate with a notion of overall charge. Solution 2(6)G248 correlates with interactions that, in effect, measure a lack of alignment between an axis correlating with spin (of an object) and an axis correlating with nominal magnetic dipole moment (of the object). Possibly, 2(6)G248 correlates with aspects of Larmor precession.

We suggest that, assuming a 2(1)G248 interpretation (or, PR1ISe-like interpretation) of 2(6)G248, the complementary physics theory notion of 2γ correlates with the traditional physics theory notion of photon. We denote the traditional physics theory notion of photon via $2(1)\gamma$.

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 theory topic of anomalous magnetic dipole moments. (See discussion related to equation (47).) We anticipate that, for models for much astrophysics that directly pertains to large objects, we can de-emphasize G-family solutions other that $\Sigma\gamma$ solutions. We anticipate that some 2G solutions that are neither 2γ solutions nor $\gamma 2$ solutions correlate with observed effects. For example, we discuss below a model - for depletion of cosmic microwave background radiation (or, CMB) - that features the solution 2(2)G68 and interactions with hydrogen atoms. (See discussion related to equation (25).)

The following notes pertain regarding $\Sigma\mathrm{G}\Gamma$ solutions.

- Modeling for excitations correlates with modeling for excitation for the $\Sigma\mathrm{G}\Sigma$ solution. (For example, models for excitation of each $2\mathrm{G}\Gamma$ parallel models for excitations of 2G2.) This notion correlates with ALG double-entry bookkeeping and with discussion above regarding spin-related symmetry.

- In complementary physics theory, excitations can carry more information than do excitations correlating with traditional physics theory. In both types of theory, excitations carry, in effect, information correlating with the interactions that create the excitations. Complementary physics theory G-family excitations can carry information about span. For example, an excitation of 4G correlating with the 4(6)G4 solution includes, in effect, knowledge of the span of six, whereas an excitation of 4G correlating with the 4(1)G246 solution includes, in effect, knowledge of the span of one. (See discussion related to table 10 and discussion related to table 14.) Traditional physics theory correlates with the notion that span is always one.

- A $\Sigma\mathrm{G}\Gamma$ excitation (and the information that correlates with the excitation) contributes to the overall ΣG field. For example, an excitation correlating with the 2G24 solution contributes to the overall 2G (or, electromagnetic) field.

Table 11 summarizes information, including so-called TA-side symmetries, for G-family solutions. (Here, ALG modeling, including the concept of an isotropic pair of isotropic oscillators, pertains.) The symbol A0+ correlates with an oscillator pair for which, for each of the two oscillators, the symbol $@_0$ pertains. (Generally, regarding symbols that table 11 exhibits, see table 1.) For such a pair, no spin-related symmetry pertains.

The following notes pertain.

- 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.

- Complementary physics theory suggests that, for each solution for which the TA-side symmetry is $SU(3)$, the notion of somewhat conservation of fermion generation pertains. (See discussion related to table 7.)

- The upper limit of eight for items in lists Γ correlates with a notion of channels. (See discussion, regarding equation (31), regarding channels.) The upper limit might also correlate with the limit that equation (5) suggests. Here, $SU(9)$ would correlate with aspects of $10\mathrm{G}[\![10]\!]$. (Here, we use $[\![10]\!]$ to denote the integer ten and the notion that $\lambda = [\![10]\!]$.)

Table 11: Information, including TA-side symmetries, for long-range forces

ΣΦΓ	σ	TA-side	$\vert\leftarrow$	$\cdots$	TA	$\rightarrow\vert$	$\vert\leftarrow$	$\cdots$	SA	$\cdots$	$\rightarrow\vert$
		$SU(\_)$ symmetry	6,5	4,3	2,1	0	0	1,2	3,4	5,6	7,8
2G2	+1	None				0	−1	$\pi_{0,@_0}$			
4G4	+1	$SU(3)$			0,0	0	−1	A0+	$\pi_{0,@_0}$		
ΣG24	+1	None				0	−2	$\pi_{0,@_0}$	$\pi_{0,@_0}$		
6G6	+1	$SU(5)$		0,0	0,0	0	−1	A0+	A0+	$\pi_{0,@_0}$	
ΣG26	+1	$SU(3)$			0,0	0	−2	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	
ΣG46	+1	$SU(3)$			0,0	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	$SU(7)$	0,0	0,0	0,0	0	−1	A0+	A0+	A0+	$\pi_{0,@_0}$
ΣG28	+1	$SU(5)$		0,0	0,0	0	−2	$\pi_{0,@_0}$	A0+	A0+	$\pi_{0,@_0}$
ΣG48	+1	$SU(5)$		0,0	0,0	0	−2	A0+	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG68	+1	$SU(5)$		0,0	0,0	0	−2	A0+	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG248	+1	$SU(3)$			0,0	0	−3	$\pi_{0,@_0}$	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$
ΣG268	+1	$SU(3)$			0,0	0	−3	$\pi_{0,@_0}$	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG468	+1	$SU(3)$			0,0	0	−3	A0+	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$
ΣG2468	+1	None				0	−4	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$	$\pi_{0,@_0}$

Table 12: Symmetries correlating with kinematics conservation laws

Conservation law	Traditional physics theory	Complementary physics theory
Conservation of energy	$S1G$	TA-side $SU(5)$
Conservation of linear momentum	$SU(2)$	SA-side $SU(2)$
Conservation of angular momentum	$SU(2)$	SA-side $SU(2)$

We discuss symmetries that traditional physics theory and complementary physics theory correlate with conservation laws related to motion.

Table 12 summarizes symmetries correlating with kinematics conservation laws. Traditional physics theory correlates an $S1G$ symmetry with conservation of energy. The one-element term $S1G$ denotes a symmetry correlating with a group for which one generator pertains. Complementary physics theory considers this $S1G$ symmetry to be a TA-side symmetry. To some extent, complementary physics theory considers that this $S1G$ symmetry correlates with the TA0 oscillator. 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. The relevance of all three conservation laws correlates with modeling that correlates with free environments. (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 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 the four TA-side oscillators with the TA0 oscillator to correlate with an $SU(5)$ symmetry. Complementary physics theory suggests that, for each of the eight added oscillators, $n_{\_} = n_{TA0}$.

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

We discuss G-family interactions with elementary fermions and with multicomponent objects. The following notions pertain. Here, we consider G-family solutions for which $\Sigma \geq 2$.

- 2G2 can interact with an elementary fermion based on the charge of the fermion and can interact with a multicomponent object based on the charge of the multicomponent object.
- We generalize and state that each solution for which the TA-side symmetry is none correlates with interactions with elementary particles and correlates with interactions with multicomponent objects.
  - Here, interactions with elementary particles correlate with a TA-side $SU(5)$ symmetry and with two SA-side $SU(2)$ symmetries.
  - Here, interactions with multicomponent objects correlate with a TA-side $SU(3)$ symmetry and with one SA-side $SU(2)$ symmetry. In effect, the multicomponent object contributes the needed additional SA-side $SU(2)$ symmetry and the needed additional TA-side aspects.
- 4G4 can interact with an elementary fermion based on the (generation and) mass of the fermion and can interact with a multicomponent object based on the rest mass of the multicomponent object.
- We generalize and state that each solution for which the TA-side symmetry is $SU(3)$ correlates with interactions with elementary particles and correlates with interactions with multicomponent objects.
  - Here, interactions with elementary particles correlate with a TA-side $SU(7)$ symmetry and with two SA-side $SU(2)$ symmetries.
  - Here, interactions with multicomponent objects correlate with a TA-side $SU(5)$ symmetry and with one SA-side $SU(2)$ symmetry. In effect, the multicomponent object contributes the needed additional SA-side $SU(2)$ symmetry.
- We note the limit of $SU(7)$, which correlates with equation (5).
- Complementary physics theory suggests that each solution for which the TA-side symmetry is $SU(5)$ does not correlate with interactions with elementary particles and does correlate with interactions with multicomponent objects.
- Complementary physics theory suggests that each solution for which the TA-side symmetry is $SU(7)$ does not correlate with interactions with elementary particles and does not correlate with interactions with multicomponent objects, except to the extent that interactions with multicomponent objects lead to no significant externally observable effects on the multicomponent objects. (An example of an interaction that leads to no significant externally observable effects would be an interaction that does not change externally observable energy, momentum, angular momentum, and composition of a multicomponent object but does change an internal state of the multicomponent object. People might correlate such a change with a change in the entropy of the multicomponent object.)

We discuss G-family solutions for which conservation of energy pertains regarding interactions with elementary fermions. (Note the summarizing, in table 14, of some results.)

Only one spin - spin one-half - pertains for elementary fermions. We focus on known ordinary matter elementary fermions and, thereby, make the assumption that all relevant elementary fermions correlate with left-handedness. This assumption implies that aspects correlating with $\lambda = 6$ (or, with baryon handedness) do not vary throughout this discussion and that aspects correlating with $\lambda = 8$ (or, with lepton handedness) do not vary throughout this discussion. We focus on 1f1b aspects of 1f1b$\rightarrow \cdots$ interactions in which 1f elementary fermions correlate with $\sigma = +1$.

The list of relevant ΣGΓ solutions consists of the 2G2, 4G4, ΣG24, ΣG26, ΣG46, ΣG246, ΣG248, ΣG268, 2G468, 10G468, 18G468, and ΣG2468 solutions. This list does not include solutions for which $\Sigma = 0$. The list does not include 4G48, 6G6, and 8G8, because these solutions do not correlate with expressions 1f1b for which the fermion is an elementary particle. The list does not include 6G468, which would couple with baryon handedness and, therefore, correlate only with 1f1b interactions with elementary fermions for which $\sigma = -1$.

The magnitudes of interaction strengths correlating with solutions 2G24 and 2G248 scale per the magnitude of electromagnetic dipole moment (or, magnitude of nominal dipole magnetic moment). (For neutrinos, electromagnetic dipole moments are zerolike.) The magnitude correlating with 2G2 scales with the magnitude of the electromagnetic monopole moment (or, charge), which (for elementary fermions) correlates with the magnitude of the electromagnetic dipole moment.

For each elementary fermion that has a non-zero nominal magnetic dipole moment, the magnetic field (which correlates with 2G24) is not spherically symmetric. For each other ΣG24_, we posit that spherical symmetry does not correlate with a non-zero property (of an elementary fermion) correlating with the ΣG24_ solution.

The magnitudes of interaction strengths correlating with solutions 4G4, 4G246, 4G2468a, and 4G2468b scale with rest energy. (See discussion regarding table 13.)

Each of the $\gamma 2$ solutions - 6G24, 4G26, 8G26, 6G28, and 10G28 - includes an element λ in Γ for which $\lambda = 2$. The magnitudes of interaction strengths correlate with charge. In particular, neutrinos do not interact with forces correlating with these solutions. The Γ for the 6G24 solution includes $\lambda = 4$. The interaction strength varies as a function correlating with rest energy.

The magnitudes of strengths correlating with the 8G2468a solution and the 8G2468b solution correlate with left-handedness, which is constant across all relevant elementary fermions, including neutrinos. Also, the magnitude of spin is constant across all elementary fermions.

The remaining solutions are the 2G46, 10G46, ($\Sigma \geq 8$)G246, 6G248, ($\Sigma \geq 10$)G248, 4G268, 12G268, 2G468, ($\Sigma \geq 10$)G468, and ($\Sigma \geq 12$)G2468 solutions. For each of these solutions, at least one of the following three sentences pertains. The solution correlates with notions of anomalous moments, with each moment not being with respect to electromagnetism. The solution correlates with notions of anomalous moments that are not dipole anomalous moments. The solution does not correlate with interactions with individual elementary fermions. (Regarding the first of the three sentences, $2 \notin \Gamma$ pertains. Regarding the second of the three sentences the word quadrupole pertains or the word octupole pertains.)

We discuss the magnitudes of strengths, regarding interactions with multicomponent objects, of long-range forces correlating with some G-family solutions.

Table 13 summarizes scaling properties, for $\Sigma\gamma$ solutions, regarding strengths of interactions. Assuming that 2G2 correlates with charge, that 2G24 correlates with nominal magnetic dipole moment, that 4G4 correlates with rest energy, that 6G6 correlates with baryon number, and that 8G8 correlates with lepton number, the following two rules (which we posit pertain regarding $\Sigma\gamma$ solutions) imply aspects that the table shows. (Here, each rule correlates with one of the next two sentences.) If a solution $\Sigma \mathrm{G}\Gamma_1$ differs from a solution $\Sigma \mathrm{G}\Gamma_2$ only because $8 \notin \Gamma_1$ and $8 \in \Gamma_2$ and if the list Γ_1 contains at least one member, then the strength correlating with $\Sigma \mathrm{G}\Gamma_2$ correlates with rotation around an axis and with the strength, correlating with $\Sigma \mathrm{G}\Gamma_1$, of interactions correlating with a non-rotating object. If, mathematically, a solution $0\mathrm{G}\Gamma_1$ exists and if Γ_2 differs from Γ_1 only because $\Sigma \notin \Gamma_1$ and $\Sigma \in \Gamma_2$, the strength of $\Sigma \mathrm{G}\Gamma_2$ scales with the property correlating with the $\Sigma \mathrm{G}\Sigma$ solution. (This rule pertains even if Γ_1 is a list with no members. This rule implies that each of 4G2468a and 4G2468b correlates with rest energy. The previous rule then implies that 4G246 correlates with rest energy.) In table 13, the three-word phrase axis of rotation correlates with rotation around an axis. The notion of cross-product correlates with a non-alignment of an axis correlating with the property and the axis correlating with rotation. For the case of the earth, 2G24, and 2G248, the non-alignment is between the axis correlating with the nominal magnetic field and the axis correlating with rotation. One of 4G2468a and 4G2468b correlates with precession correlating with one of an axis of minimal moment of rotational inertia (with respect to a non-zero quadrupole distribution of rest energy that correlates with 4G246) and an axis of maximal moment of rotational inertia (with respect to a non-zero quadrupole distribution of rest energy that correlates with 4G246). The other of 4G2468a and 4G2468b correlates with the other axis. The two-letter abbreviation NR abbreviates the two-word term not relevant. For the case 6G468 and regarding ΣG46, allowed values of Σ are two and ten. The allowed values of Σ do not include six.

3.3 Spans for objects and long-range forces

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

For each of each basic particle, each hadron-like particle, and each long-range force, the one-word term span denotes the number of isomers of a set of, at least, non-zero-charge elementary particles with which an isomer of the particle or force interacts. The set includes all non-zero-charge elementary particles and the traditional physics theory photon, which we denote by $2(1)\gamma$ or by $2(1)\mathrm{G}2 \oplus 2(1)\mathrm{G}24 \oplus 2(1)\mathrm{G}248$. (Note that table 10 lists 2(6)G248 and does not list 2(1)G248.)

Table 14 summarizes information regarding spans (or equivalently, numbers of isomers) for basic

Table 13: Scaling properties, for $\Sigma\gamma$ solutions, regarding strengths of interactions

Solution	Strength scales with the property (which is not related to rotation) ...	Strength scales with rotation correlating with ...
2G2	Charge	NR
2G24	Nominal magnetic dipole moment	NR
2G248	Nominal magnetic dipole moment	A cross-product
4G4	Rest energy	NR
4G48	Rest energy	The axis of rotation
4G246	Rest energy and non-zero moment	NR
4G2468a	Rest energy and non-zero moment	A cross-product
4G2468b	Rest energy and non-zero moment	A cross-product
6G6	Baryon number	NR
6G468	?	?
8G8	Lepton number	NR
8G2468a	Lepton number	A cross-product
8G2468b	Lepton number	A cross-product

particles, for hadron-like particles, and for some long-range force solutions and summarizes information regarding types of objects with which boson basic particles and some long-range forces interact. In the symbol PRnISe, the two letters PR denote the one-element term physics-relevant and the three letters ISe denote the four-word phrase isomers of the electron. The table separates, based on a complementary physics theory view, elementary particle Standard Model aspects from aspects that the elementary particle Standard Model does not embrace. The magnitude of charge for the $\mathrm{T}^{\pm}$ boson is one-third the magnitude of the charge for each of the $\mathrm{W}^{\pm}$ boson and the electron. The symbol $1\mathrm{Q}\otimes2\mathrm{U}$ correlates with known and possible hadrons. The symbol $1\mathrm{R}\otimes2\mathrm{U}$ correlates with possible hadron-like particles. Regarding the G-family, the table includes just the $\Sigma\gamma$ solutions. Regarding the PR6ISe case, the span for 2G68 is two. Table 14 shows the extent to which each of the elementary bosons and some of the long-range forces interacts directly with each of at least some elementary fermions and with each of at least some multicomponent objects. The symbol Y denotes that interactions occur. The symbol † denotes that somewhat conservation of fermion generation pertains for 1f1b→1f1b interaction vertices. The symbol N denotes that interactions do not occur. Complementary physics theory suggests the possibility that neither the 0H boson nor the 0I boson interacts directly with multicomponent objects. Complementary physics theory suggests that G-family solutions for which the TA-side symmetry is $SU(5)$ do not correlate with direct interactions with elementary fermions. (See discussion related to table 12.) Complementary physics theory suggests that the G-family solution for which the TA-side symmetry is $SU(7)$ does not correlate with interactions with elementary fermions and does not correlate with interactions with multicomponent objects, except for interactions that change only the internal entropy of multicomponent objects. For elementary bosons for which $\sigma = -1$, table 14 shows each non-one span in parentheses. Each of these non-one span numbers results from mathematics. The effective span depends on the span correlating with the object (such as a hadron-like object) in which the elementary boson exists.

Equation (21) provides an expression correlating with PR6ISe. Here, a span s (as in $\Sigma(\mathrm{s})\Phi\Gamma$) correlates with information in the PR6ISe column of table 14. (Technically, equation (21) includes - also - the G-family solutions that table 14 omits. Technically, equation (21) includes the notion that an empty Γ list - or, $\Gamma = \emptyset$ - can pertain. In the equation, $\{\_\}$ correlates with the four-element phrase the set of _.) The expression $\{\Sigma(1)\Phi\Gamma\}$ to correlates with the two-element phrase PR6ISe-span-one phenomena. Without loss of generality, one can assume that, throughout equation (21), $j = 0$ correlates with ordinary matter or with an ability to interact directly with ordinary matter. One might correlate the two-word term ordinary matter with the expression $\{\Sigma(1)\Phi\Gamma\}_0$. Dark matter includes $\cup_{j=1}^{5}\{\Sigma(1)\Phi\Gamma\}_j$ and $1\mathrm{R}\otimes2\mathrm{U}$ (which is part of $\{\Sigma(6)\Phi\Gamma\}_0$).

$$(\cup_{j=0}^{5}\{\Sigma(1)\Phi\Gamma\}_j) \cup (\cup_{j=0}^{2}\{\Sigma(2)\Phi\Gamma\}_j) \cup (\cup_{j=0}^{0}\{\Sigma(6)\Phi\Gamma\}_j) \tag{21}$$

PR6ISe modeling assumes, in effect, that span-six aspects of 2G apply parallelly to span-six aspects of 4G.

We explore the possibility that span-six aspects (such as aspects correlating with 2(6)G248) of 2G apply orthogonally to span-six aspects (namely aspects correlating with 4(6)G4) of 4G. We call this case PR36ISe. The number of isomers of PR6ISe-span-one solutions is 36. (See the PR6ISe column in table 14.) Roughly speaking, there are six isomers of PR6ISe. Each of the six isomers of PR6ISe has its own

Table 14: Particles and solutions that correlate with one isomer and particles and solutions that might correlate with more than one isomer; plus, the extent to which elementary bosons and some long-range forces interact with elementary fermions and with multicomponent objects

Entities - Particle sets and solution sets (hadron-like particles, basic particles, and some long-range forces)		Span (or, s)		Direct interactions with	
Standard Model	Possible	PR1ISe	PR6ISe	Elementary fermions	Multicomponent objects
1C ($\sigma = +1$)	-	1	1	-	-
1N ($\sigma = +1$)	-	1	6	-	-
1Q ($\sigma = -1$)	-	1	1	-	-
-	1R ($\sigma = -1$)	1	6	-	-
2U ($\sigma = -1$)	-	1	(6)	Y†	N
2W: Z ($\sigma = +1$)		1	6	Y†	N
	2T: 2T^0 ($\sigma = -1$)	1	(6)	Y†	N
2W: W$^\pm$ ($\sigma = +1$)	2T: 2T$^\pm$ ($\sigma = -1$)	1	1	Y†	N
1Q$\otimes$2U ($\sigma = +1$)	-	1	1	-	-
-	1R$\otimes$2U ($\sigma = +1$)	1	6	-	-
0H ($\sigma = +1$)	-	1	1	Y	N
-	0P ($\sigma = -1$)	1	1	N	Y
-	0I ($\sigma = +1$)	1	1	Y	N
-	0K ($\sigma = -1$)	1	1	N	Y
2G2 ($\sigma = +1$)	-	1	1	Y	Y
2G24 ($\sigma = +1$)	-	1	1	Y	Y
2G248 ($\sigma = +1$)	-	1	6	Y†	Y
-	4G4 ($\sigma = +1$)	1	6	Y†	Y
-	4G48 ($\sigma = +1$)	1	2	N	Y
-	4G246 ($\sigma = +1$)	1	1	Y	Y
-	4G2468a ($\sigma = +1$)	1	1	Y	Y
-	4G2468b ($\sigma = +1$)	1	1	Y	Y
-	6G6 ($\sigma = +1$)	1	1	N	Y
-	6G468 ($\sigma = +1$)	1	1	Y	Y
-	8G8 ($\sigma = +1$)	1	1	N	$\approx$N
-	8G2468a ($\sigma = +1$)	1	1	Y	Y
-	8G2468b ($\sigma = +1$)	1	1	Y	Y

(The symbol † denotes that somewhat conservation of fermion generation pertains.)

isomer of 4(6)G4 (or, gravity). One isomer of PR6ISe includes the one ordinary matter and five dark matter isomers. Technically, equations (22) and (23) pertain. (Contrast these equations with equation (21).) Solutions 2(2)GΓ and 2(6)GΓ appear in equation (22) and do not appear in equation (23). Without loss of generality, one can assume that, in equation (22), Ξ_0 correlates with ordinary matter plus dark matter. We correlate the three-word term doubly dark matter with the 30 new (compared to the PR6ISe case) isomers of PR6ISe-span-one solutions. The two-word term doubly dark correlates with the notion of not interacting with ordinary matter via interactions correlating with the 2G2 and 2G24 components of 2γ and not interacting with ordinary matter via interactions correlating with 4γ.

$$(\cup_{k=0}^{5}\Xi_k) \cup (\cup_{k=0}^{2}\{2(2)\mathrm{G}\Gamma\}_k) \cup (\cup_{k=0}^{0}\{2(6)\mathrm{G}\Gamma\}_k) \tag{22}$$

$$\Xi = (\cup_{j=0}^{5}\{\Sigma(1)\Phi\Gamma\}_j) \cup (\cup_{j=0}^{2}\{\Sigma'(2)\Phi\Gamma\}_j) \cup (\cup_{j=0}^{0}\{\Sigma'(6)\Phi\Gamma\}_j), \text{ with } \Sigma'(\_)\Phi \neq 2(\_)\mathrm{G} \tag{23}$$

The discussion above de-emphasizes the possibility that the PR36ISe span for 1N might be 36 and the possibility that the PR36ISe span for 1R⊗2U might be 36. To the extent than span-36 aspects pertain, equation (24) replaces equation (22). In equation (24), we use the symbol Φ' (instead of the symbol Φ) to correlate with the possibility of span-36 for 1R⊗2U hadron-like particles, which are not elementary particles.

$$(\cup_{k=0}^{0}\{\Sigma(36)\Phi'\}_k) \cup (\cup_{k=0}^{5}\Xi_k) \cup (\cup_{k=0}^{2}\{2(2)\mathrm{G}\Gamma\}_k) \cup (\cup_{k=0}^{0}\{2(6)\mathrm{G}\Gamma\}_k) \tag{24}$$

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

The 2(2)G68 solution does not belong to the set of 2γ solutions and does not belong to the set of $\gamma 2$ solutions. The 2(2)G68 solution does not correlate with interactions with individual elementary particles. Table 13 correlates $\lambda = 6$ with baryons and $\lambda = 8$ with leptons. We posit that 2(2)G68 correlates with some electromagnetic (or, $\Sigma = 2$) interactions with atoms and other objects that include both baryons and leptons.

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

Unlike for the cases of electromagnetic interactions that correlate with 2(1)G2 and 2(1)G24, 2G produced by ordinary matter objects interacts with dark matter objects (for the case in which PR06ISe pertains to nature) or doubly dark matter objects (for the case in which PR36ISe 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 dark matter objects (for the case in which PR06ISe pertains to nature) or doubly dark matter objects (for the case in which PR36ISe pertains to nature) interacts with ordinary matter via 2(2)G68.

3.4 Comparative features of models based on one, six, and 36 isomers of charge

This unit compares features of traditional physics theory, PR1ISe modeling, PR6ISe modeling, and PR36ISe modeling.

Table 15 discusses cumulative features of various types of modeling. Generally, each row augments the rows above that row. The two-word term traditional physics in the first column of the first row abbreviates the three-word term traditional physics theory. Regarding PR1ISe, new elementary particles include new basic particles and new long-range forces. We think that PR6ISe provides useful insight about nature. Regarding ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter, PR36ISe offers an alternative (to PR6ISe) explanation of dark energy density. (See discussion related to equation (26).) Otherwise, regarding bases for aspects that table 15 lists, PR36ISe is similar to PR6ISe.

3.5 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 16 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 [9], [24], [27], and [28]. These observations correlate with the eras that correlate with deceleration and recent acceleration. For each of various redshifts that those references mention and

Table 15: Cumulative features of various types of modeling

Modeling	New descriptions and new explanations	New subtleties
Traditional physics	• (Baseline)	
PR1ISe	• New elementary particles • Dark energy forces • Dark energy density • Some dark matter	
PR6ISe or PR36ISe	• More dark matter • Ratios of dark matter effects to ordinary matter effects • Ratios of dark energy density of the universe to density of the universe of ordinary matter plus dark matter	• Spans • Dark energy forces

Table 16: 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 PR1ISe models

regarding estimating relevant times after the big bang, possibly see reference [13].) Early acceleration pertains (except possibly before or during the possible inflationary epoch) for some time after the big bang. (That era might last for roughly about 64 thousand years. See remarks nearby below that cite reference [25].) 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 parallels to 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 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 16 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 16 lists, the two-word term net attractive correlates with a notion of essentially always attractive (though sometimes not significantly attractive).

Regarding the early acceleration era, notions that reference [25] discusses might correlate with effects of the net repulsion that complementary physics theory correlates with 4(1)G2468a and 4(1)G2468b. Reference [25] notes possibilities for a component of dark energy that had effect during times correlating with $z \geq 3000$. Here, z denotes redshift. Use of reference [13] suggests that this redshift correlates with about 64 thousand years after the big bang.

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.

Possibly, a better term than the six-word term rate of expansion of the universe would feature the rates of moving apart of observed very large astrophysical objects.

3.6 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, regarding galaxies, 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 [12].)
- For some galaxies, recently, the following ratios pertain.
  - Somewhat less than four to one, based on observations correlating with gravitational lensing. (See reference [16].)
  - Between zero to one and one to one, based on velocities of stars in each of two galaxies (or, galaxy rotation curves). (See references [33] and [34].)
- 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 a relatively few visible stars. (See reference [32].)

We discuss aspects pertaining to the amounts of ordinary matter and dark matter in galaxies. For now, we assume that nature comports with at least one of PR6ISe modeling and PR36ISe modeling. For now, we de-emphasize some phenomena such as $1R \otimes 2U$ hadron-like particles and collisions between galaxies.

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), filaments (which correlate with effects of early universe baryon acoustic oscillations), and statistical variations in densities of stuff. 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.

Traditional physics theory considers the notion that galaxies form based on clumps of dark matter. Traditional physics theory uses the term dark matter halo. Traditional physics theory includes various conjectures about the nature of dark matter and therefore, is not necessarily completely specific about the nature of or dynamics within halos.

We explore modeling that people might correlate with the three-word term ordinary matter halo.

Complementary physics theory suggests the following galaxy evolution scenario that would comport early on with zero-plus to one ratios that reference [12] shows and presently with approximately four to one ratios that reference [16] shows. The following thought experiment idealization characterizes the scenario. We assume that PR6ISe modeling pertains. We focus on the forming and evolving of a galaxy that features ordinary matter. 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.

- Early on, each isomer of PR6ISe-span-one phenomena expands, essentially independently from the other isomers of PR6ISe-span-one phenomena, based on repulsion correlating with 4(1)G2468a and 4(1)G2468b.
- Then, each isomer of PR6ISe-span-one phenomena starts to clump, essentially independently from the other isomers of PR6ISe-span-one phenomena, based on attraction correlating with 4(1)G246.
- With respect to clumps correlating with any one isomer of PR6ISe-span-one phenomena, 4(2)G48 repels one other isomer of PR6ISe-span-one phenomena and repels some stuff correlating with itself. Regarding ordinary matter clumps, the one other isomer of PR6ISe-span-one phenomena is a dark matter isomer of PR6ISe-span-one phenomena.

- 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 [12] shows.
- The galaxy attracts and accrues, via 4(6)G4 attraction, ordinary matter stuff and stuff correlating with the four dark matter isomers of PR6ISe-span-one phenomena for which there is nearby stuff. Results comport with the approximately four to one ratios that reference [16] shows. The following notions might pertain.
  - Some ratios are not big as they might otherwise be partly because each one of the four relevant dark matter isomers of PR6ISe-span-one phenomena repels, via 4(2)G48, one relevant dark matter isomer of PR6ISe-span-one phenomena.
  - Some ratios are not as small as they might otherwise be (based on 4(2)G48 repulsion) because of the contribution, which is independent of PR6ISe-span-one phenomena, of 1R$\otimes$2U to dark matter.

The following notions also pertain.

- Other data might correlate with the notion that at least some ordinary matter intense galaxies (or ordinary matter intense galaxy-like objects) form without original dark matter halos. One might correlate this evolution with the three-word phrase stars before halos. Reference [6] might provide such data. (See, for example, figure 7 in reference [6]. 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 might suggest that at least some galaxies accrue, over time, dark matter, with the original fractions of dark matter being small. Use of reference [13] suggests that redshifts of at least seven pertain to times ending about 770 million years after the big bang.
- The scenario that we just discussed is not incompatible with the ratios of between zero to one and one to one that references [33] and [34] show.
- We do not estimate a range regarding the extent to which gravity (correlating with the 4G4 solution) might attract, early in the galaxy formation scenario, clumps of dark matter.

We explore modeling that people might correlate with the three-word term dark matter halo.

Complementary physics theory treats as peers six isomers of PR6ISe-span-one phenomena. One of those isomers correlates with ordinary matter. Each of five of those isomers correlates with dark matter. Complementary physics theory suggests that nature embraces galaxy formation and evolution scenarios that are similar to the one we correlate with the three-word term ordinary matter halo, but that differ because the one isomer correlating with the halo is a dark matter isomer and not the ordinary matter isomer. Because observations of stars and galaxies tend to have bases in ordinary matter isomer 2γ phenomena (or, readily observable electromagnetism), we distinguish two cases. (The previous sentence de-emphasizes some observations - regarding collisions between black holes or neutron stars - that have bases in 4γ phenomena.) For one case, the dark matter isomer that correlates with the halo does not repel - via 4G48 - ordinary matter. We correlate this case with the seven-word term dark matter halo plus much ordinary matter. For one case, the dark matter isomer that correlates with the halo repels - via 4G48 - ordinary matter. We correlate this case with the seven-word term dark matter halo plus little ordinary matter.

Complementary physics theory correlates the notion of the approximately four to one ratios that reference [16] shows with the case of ordinary matter halo and with the case of dark matter halo plus much ordinary matter. For each of these two cases, five isomers contribute significantly and one of those isomers correlates with ordinary matter.

The following notions pertain.

- Regarding the case of dark matter halo plus little ordinary matter, the evolution of some galaxies parallels the above scenario for some ordinary matter halo galaxies. Some such so-called dark matter galaxies comport with the one to somewhat more than zero ratio that reference [32] shows.
- Regarding the case of dark matter halo plus little ordinary matter, people lack means to detect, via 2γ phenomena, early stage galaxies. Presumably, some of these galaxies are, in effect, dark matter halo analogs to the ordinary matter halo galaxies to which references [33] and [34] allude.

- Regarding high redshift data correlating with figure 7 in reference [6], presumably observations do not include significant fractions of dark matter halo galaxies because of a lack of ordinary matter centric $2(1)\gamma$ emissions from the galaxies.

Discussion above is not incompatible with the notion that visible stars do not include much dark matter.

Discussion above is not incompatible with the notion that (most) black holes originally form based on single isomers. Complementary physics theory suggests that people might be able to distinguish observationally between the coalescing of two black holes that interact with each other via 4G48 repulsion and the coalescing of two black holes that do not interact with each other via 4G48 repulsion.

Neither traditional physics theory nor PR1ISe modeling includes the notion of dark matter isomers. We think that it would be, at best, difficult to explain - based on for example $1\mathrm{R}\otimes 2\mathrm{U}$ dark matter - ratios, that observations suggest, of dark matter effects to ordinary matter effects.

We discuss relatively small-scale effects, within galaxies, that might correlate with dark matter.

People look for possible local effects, within the Milky Way galaxy, that might correlate with dark matter.

For one example, data regarding the stellar stream GD-1 suggest effects of an object of 10^6 to 10^8 solar masses. (See reference [7].) 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 [11].)

- Complementary physics theory offers the possibility that the object is an originally dark matter centric clump of stuff (that might include at least one dark matter black hole).

For other examples, people report inhomogeneities regarding Milky Way dark matter. (See references [11] and [22].) Researchers note that simulations suggest that such dark matter may have velocities similar to velocities of nearby ordinary matter stars. Complementary physics theory suggests that these notions are not incompatible with complementary physics theory notions that dark matter stars, which would be similar to ordinary matter stars, exist.

People report, regarding galaxy clusters, inferred ratios of dark matter effects to ordinary matter effects.

- For some galaxy clusters, recently, the following ratios pertain.
  - Five-plus to one, based on observations correlating with gravitational lensing. (See references [18] and [26].)
  - Eight-minus to one, based on observations correlating with X-ray emissions. (See reference [29].)

We suggest that complementary physics theory is not necessarily incompatible with these galaxy cluster centric ratios.

Complementary physics theory is not necessarily incompatible with the traditional physics theory notion that ordinary matter centric baryon acoustic oscillations contributed to the formation of dark matter filaments.

Regarding models for which n (as in PRnISe) exceeds one, each of the five dark matter isomers of PR6ISe-span-one phenomena has its own baryon-like particles and its own PR1ISe-like photon physics. Complementary physics theory suggests, for models for which n (as in PRnISe) exceeds one and based on aspects of traditional physics theory, that dark matter baryon-like acoustic oscillations occurred in the early universe. Complementary physics theory suggests that dark matter baryon-like acoustic oscillations contributed (along with ordinary matter baryon acoustic oscillations) to the formation of current dark matter filaments.

Complementary physics theory suggests that people might want to consider the notion of ordinary matter filaments and the notion of filaments correlating with ordinary matter plus dark matter.

3.7 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 seem to 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 [8]. Perhaps note a possible interpretation in reference [5].)

Here, people measured twice as much depletion of CMB as people predicted via traditional physics theory modeling that was 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. 2(2)G68 interactions are 2(2)GΓ interactions. Equation (25) pertains.

$$\text{2G68} \notin 2\gamma,\ \text{2G68} \notin \gamma 2 \tag{25}$$

- 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 dark matter isomer of PR6ISe-span-one phenomena or with one doubly dark matter isomer of PR6ISe-span-one phenomena.

3.8 Dark energy density

This unit discusses the notion that dark energy densities might correlate with aspects related to aye (or, 0I) bosons, with dark matter, or with dark energy stuff and not necessarily with traditional physics theory notions such as vacuum energy and vacuum fluctuations.

Equation (26) 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 [31] 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 each of traditional physics theory and complementary physics theory, equation (26), does not include neutrino density of the universe. From a standpoint of complementary physics theory, Ω_c includes effects correlating with 1R⊗2U hadron-like particles and, for models for which n (as in PRnISe) exceeds one, includes PR1ISe-like photons centric to dark matter. We know of no inferences that would not comport with a steady increase, regarding the inferred ratio correlating with equation (26), from approximately zero, with time since somewhat after the big bang.

$$\Omega_\Lambda/(\Omega_\mathrm{c} + \Omega_\mathrm{b} + \Omega_\gamma) \approx 2.3 \tag{26}$$

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.)

Interactions with aye (or, 0I) bosons might lead to effects similar to effects that traditional physics theory correlates with vacuum energy or vacuum fluctuations. (See discussion related to equation (68).) To the extent that effects correlating with aye bosons suffice, the effects might suffice regarding each of PR1ISe, PR6ISe, and PR36ISe modeling. Assuming that such interactions might not adequately explain non-zero dark energy density, we discuss possibilities for other complementary physics theory aspects that might explain non-zero dark energy density.

For PR6ISe modeling, complementary physics theory includes the notion of 2(6)G248, whereas traditional physics theory correlates with the notion of 2(1)G248. We suggest that the difference, in complementary physics theory, between 2(6)G248 and 2(1)G248 might correlate with nature's producing effects, regarding CMB, that people correlate, via traditional physics theory, with non-zero dark energy density. The difference correlates with interactions between ordinary matter and dark matter. Modeling suggests an upper bound of five regarding, in effect, a possible future value for the ratio that correlates with equation (26).

For PR36ISe modeling, differences between 2(>1)GΓ and 2(1)GΓ correlate with interactions between ordinary matter plus dark matter and doubly dark matter. For example, half of the effect that reference [8] reports correlates with 2G68 interactions correlating with one doubly dark matter isomer of hydrogen atoms. Also, any span-36 phenomena would correlate with interactions between ordinary matter plus dark matter and doubly dark matter. (See equation (24).) In effect, dark energy density correlates with a notion of dark energy stuff. Modeling suggests an upper bound of five regarding, in effect, a possible future value for the ratio that correlates with equation (26).

3.9 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 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. Neither scenario conserves baryon number. Both scenarios conserve lepton number minus baryon number. The following notions pertain.

- In one scenario, the $2\mathrm{T}^{\pm}$ boson converts antimatter quarks to matter quarks. This scenario depends on the physics-relevance of 1R elementary fermions. Equation (27) shows an example of a 1f1b→1f1b interaction. (Per remarks above, interactions of the form 1f0b→1f1b correlate with 1f1b→1f1b.) Here, the superscripts correlate with charge, in units of $|q_e|$. The subscripts correlate with lepton number minus baryon number, followed by lepton number, followed by baryon number. Equation (28) shows an example of a 3f0b→1f1b interaction. Here, each of the three elementary particles that correlates with 3f differs from the other two elementary particles.

$$1\mathrm{Q}^{+1/3}_{+1/3;0,-1/3} \rightarrow 1\mathrm{R}^{0}_{+1/3;0,-1/3} + 2\mathrm{T}^{+1/3} \tag{27}$$

$$1\mathrm{C}^{+1}_{-1;-1,0} + 1\mathrm{R}^{0}_{+1/3;0,-1/3} + 1\mathrm{Q}^{-2/3}_{+1/3;0,-1/3} \rightarrow 1\mathrm{Q}^{+2/3}_{-1/3;0,+1/3} + 2\mathrm{T}^{-1/3} \tag{28}$$

- In one scenario, 3f0b→1f1b interactions destroy antimatter quarks. This scenario does not depend on the existence of 2T (or, tweak) elementary bosons. This scenario does not depend on the existence of 1R (or, arc) elementary fermions. Equation (29) shows an example of a 3f0b→1f1b interaction. Aspects of traditional physics theory might suggest that the three quarks differ from each other by generation.

$$3\ 1\mathrm{Q}^{-2/3}_{+1/3;0,-1/3} \rightarrow 1\mathrm{C}^{-1}_{+1;+1,0} + 2\mathrm{W}^{-1} \tag{29}$$

3.10 A prediction for the tauon mass

This unit suggests a relationship, which traditional physics theory seems not to discuss, between the ratio of the tauon mass to the electron mass and a ratio of a 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 gravitational constant leads to a prediction regarding the other quantity.

Equation (32) 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 (32) 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 [31].)

$$\beta' = m_\tau / m_e \tag{30}$$

$$(4/3) \times \beta^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{31}$$

$$\beta' = \beta \tag{32}$$

$$m_{\tau,\ \text{calculated}} \approx (1776.8445 \pm 0.024)\ MeV/c^2 \tag{33}$$

$$m_{\tau,\ \text{experimental}} \approx (1776.86 \pm 0.12)\ MeV/c^2 \tag{34}$$

The factor of 4/3 in equation (31) 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.

The following notes pertain.

Table 17: Aspects that might correlate with the extent to which neutrinos have non-zero masses

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

- To the extent that equation (32) correlates with nature, a more accurate experimental determination of G_N or m_τ could predict a more accurate (than experimental results) value for, respectively, m_τ or G_N.
- Equation (32) links the ratio of two elementary particle masses to a ratio of the strengths of two long-range forces.
- For each $\Sigma \geq 2$ solution that table 11 lists, the number of channels equals the number of blank SA-side cells in an extended version of table 11 that includes the oscillator pair SA9-and-SA10 and embraces the notion that blank (or, $\kappa_{0,-1}$) pertains for each added cell.
- For $\Sigma = 10$ and $\Gamma = \Sigma = \llbracket 10 \rrbracket$, ΣGΓ would correlate with zero channels and no interactions.

3.11 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 17 lists aspects that might correlate with the extent to which neutrinos have non-zero masses.

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

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

Traditional physics theory hypothesizes that gravity catalyzes neutrino oscillations. This hypothesis might correlate with a process of elimination. Traditional physics theory suggests that each known elementary boson does not catalyze neutrino oscillations. The only traditional physics theory catalyst for neutrino oscillations would be gravity. (We note that complementary physics theory suggests that the 4G4 component of 4γ does not correlate with neutrino oscillations. See table 14.)

Equation (35) provides a traditional physics theory lower limit for the sum, across three generations, of neutrino masses. (See reference [31].)

$$\sum_{j=1}^{3} m_j \gtrsim 0.06eV/c^2 \tag{35}$$

The traditional physics theory elementary particle Standard Models suggests that each one of the three neutrinos has zero mass.

Complementary physics theory suggests that each one of the three neutrinos has zero mass. (See table 3.) Neutrinos have non-zero lepton number and would interact with phenomena correlating with (at least) solutions 8G2468a and 8G2468b. (See tables 13 and 14.) Possibly, traditional physics theory interprets effects, which actually correlate with 8G2468a and 8G2468b (or other non-4γ) interactions, as producing results that equation (35) shows. Moreover, solutions 8G2468a and 8G2468b do not correlate with the $SU(2)$ symmetry that correlates with somewhat conservation of fermion generation. (See table 14.)

Complementary physics theory suggests that each neutrino correlates with zero rest mass.

Table 18: Relationships between some parameters, for $D'' = 2$

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

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 (36) shows, the possibly least accurately suggested mass is that of the W boson. Equation (36) correlates with a number that is within four standard deviations of the nominal mass of the W boson. (For data, see reference [31].) Complementary physics theory correlates the numbers in equation (36) with, respectively, the expressions $17 = 17$, $9 = 10 - 1 - 0$, and $7 = 10 - 1 - 2$. Each of zero, one, two, 10, and 17 correlates with the value of $D + 2\nu$ for a PDE solution for which $D'' = 2$. (See table 18.) In the right side of each of the three expressions, the positive number correlates with the TA0-and-SA0 oscillator pair. In the right side of the last two of the three expressions, the nonpositive numbers correlate with the TA2-and-TA1 oscillator pair and the SA1-and-SA2 oscillator pair.

$$(m_{H^0})^2 : (m_Z)^2 : (m_W)^2 :: 17 : 9 : 7 \tag{36}$$

Table 18 summarizes mathematical results that correlate with $D'' = 2$. (Compare with tables 4 and 5.) Here, we correlate with D'' the symbols S'', Ω'', and σ''. Each of S'', Ω'', and σ'' does not necessarily correlate with uses of S, Ω, or σ in models regarding elementary particles. For $\Omega'' = 0$, the table uses the letters NR to denote that the sign of σ'' is not relevant.

The following correlations might pertain - the 0G2468 solution, $S'' = 4$ for the TA0-and-SA0 oscillator pair, and the Higgs boson; the 0G246 solution, $S'' = 3$ for the TA0-and-SA0 oscillator pair, and the Z boson; and the 0G268 solution, $S'' = 3$ for the TA0-and-SA0 oscillator pair, and the W boson.

This discussion suggests two aspects of modeling that might correlate with the non-existence of non-zero-mass elementary bosons for which the spin is more than one and for which $\sigma = +1$. One aspect is the notion that, for $S'' < 3$, the $D + 2\nu$ that correlates with the oscillator pair TA0-and-SA0 is no greater than five and therefore, given the applicability of at least four other oscillator pairs, some candidate elementary bosons would correlate with negative squares of masses. The other aspect is the lack of 0GΓ solutions for which S'' would be less than three.

Regarding masses for T-family bosons, discussion related to equations (72) and (73) pertains.

We discuss a formula that approximately fits the masses of the six quarks and three charged leptons. (See equation (37).) The formula includes two integer variables and seven parameters. One integer variable, M'', correlates somewhat with generation. 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 $d'(2)$. Here, α denotes the fine-structure constant. (See equation (38).) Here, $d'(k)$ pertains regarding generation-$(k + 1)$ quarks. For each generation, the number might correlate with the extent to which the two relevant quark masses do not equal the square root of the multiplicative product of the two quark masses.

Table 19 shows experimental rest energies and calculated rest energies for 1C and 1Q elementary fermions. Rest energy denotes rest mass times c^2. The table shows rest energies in units of GeV. (Regarding data from experiments, see reference [31].) For each particle other than the top quark, reference [31] provides one estimate. For the top quark, reference [31] provides three estimates. For each quark, table 19 shows a data range that runs from one standard deviation below the minimum

Table 19: Approximate rest energies (in GeV) for 1C and 1Q particles

		M'	3	2	1
		Charge	$-1 \cdot \lvert q_e \rvert$	$+(2/3) \cdot \lvert q_e \rvert$	$-(1/3) \cdot \lvert q_e \rvert$
M''	Legend				
0	name		electron	up	down
0	data		$(0.511 \text{ to } 0.511) \times 10^{-3}$	$(1.8 \text{ to } 2.7) \times 10^{-3}$	$(4.4 \text{ to } 5.2) \times 10^{-3}$
0	calc *		0.511×10^{-3}	2.2×10^{-3}	4.8×10^{-3}
1	name			charm	strange
1	data			$(1.24 \text{ to } 1.30) \times 10^{0}$	$(0.092 \text{ to } 0.104) \times 10^{0}$
1	calc *			1.263×10^{0}	0.0938×10^{0}
2	name		muon	top	bottom
2	data		$(0.106 \text{ to } 0.106) \times 10^{0}$	$(1.56 \text{ to } 1.74) \times 10^{2}$	$(4.15 \text{ to } 4.22) \times 10^{0}$
2	calc *		0.106×10^{0}	1.72×10^{2}	4.18×10^{0}
3	name		tauon		
3	data		$(1.777 \text{ to } 1.777) \times 10^{-3}$		
3	calc *		1.777×10^{-3}		

* Calculation

nominal value that reference [31] shows to one standard deviation above the maximum nominal value that reference [31] 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. Our calculations use equation (37). In that equation, the factor 3/2 correlates with the average of $M' = 2$ and $M' = 1$. (Note the appearance of $M' = 3/2$ in equation (42). The concepts of $M' = 3/2$ and $m(M'', 3/2)$ are useful mathematically, though not necessarily directly physics-relevant.) Regarding equations (43), (44), and (45), we choose values that fit data. Regarding each charged lepton, our calculations fit data to more significant figures than the numbers in the table show. Regarding the tauon, our actual calculation correlates with a mass that may be more accurate, and more accurately specified, than the mass correlating with reference [31] data. (See equations (33) and (34).)

$$m(M'', M') = m_e \times (\beta^{1/3})^{M'' + (j^{''}_{M''}) d''} \times (\alpha^{-1/4})^{(1-\delta(|M'|,3)) \cdot ((3/2) \cdot (1+M'') + (j^{'}_{M'}) d'(M''))} \tag{37}$$

$$\alpha = ((q_e)^2 / (4\pi\varepsilon_0)) / (\hbar c) \tag{38}$$

$$j^{''}_{M''} = 0, +1, -1, 0 \text{ for, respectively, } M'' = 0, 1, 2, 3 \tag{39}$$

$$d'' = (2 - (\log(m_\mu / m_e) / \log(\beta^{1/3}))) \approx 3.840679 \times 10^{-2} \tag{40}$$

$$1 - \delta(|M'|, 3) \text{ equals } 0, \text{ for } |M'| = 3, \text{ and equals } 1, \text{ otherwise} \tag{41}$$

$$j^{'}_{M'} = 0, -1, 0, +1 \text{ for, respectively, } |M'| = 3, 2, 3/2, 1 \tag{42}$$

$$d'(0) \sim 0.318 \tag{43}$$

$$d'(1) \sim -1.057 \tag{44}$$

$$d'(2) \sim -1.5091 \tag{45}$$

$$m(2, 3) \approx 8.59341 MeV/c^2 \tag{46}$$

Table 20: Ranges of $d'(M'')$ that fit the data ranges that table 19 shows for quark masses

Symbol	Minimum (approximate)	Nominal (table 19)	Maximum (approximate)
$d'(0)$	0.251	0.318	0.386
$d'(1)$	-1.072	-1.057	-1.042
$d'(2)$	-1.5158	-1.5091	-1.5024

Table 20 shows ranges of $d'(M'')$ that fit the data ranges that table 19 shows for quark masses. (See equations (43), (44), and (45).) To the extent that people measure quark masses more accurately, people might find relationships between $d'(0)$, $d'(1)$, and $d'(2)$, and thereby reduce the number of parameters to less than seven.

The charge q_e correlates with β, via equation (31). The charge q_e appears in α, via equation (38). Possibly, based on equations (36) and (37) and based on modeling for the G-family, complementary physics theory entangles concepts related to mass and concepts related to charge more deeply than does traditional physics theory.

3.13 Anomalous moments

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

Equations (47), (48), and (49) show results of experiments regarding anomalous magnetic dipole moments. (See reference [31].) The subscripts e, μ, and τ denote, respectively, electron, muon, and tauon. The symbol a correlates with anomalous magnetic dipole moment. The symbol α denotes the fine-structure constant.

$$a_e - (\alpha/(2\pi)) \approx -1.76 \times 10^{-6} \tag{47}$$

$$a_\mu - (\alpha/(2\pi)) \approx +4.51 \times 10^{-6} \tag{48}$$

$$-0.052 < a_\tau < +0.013 \tag{49}$$

Traditional physics theory provides means, correlating with Feynman diagrams, to calculate an anomalous magnetic dipole moment for each of, at least, the electron and the muon. Equation (50) shows a result correlating with a first-order Standard Model (or, traditional physics theory) calculation. (See reference [14].)

$$a_{\tau,\mathrm{SM}} \approx +1.177 \times 10^{-3} \tag{50}$$

Complementary physics theory suggests that notions of anomalous electromagnetic moments correlate with $\gamma 2$ solutions. Electromagnetic dipole solutions correlate with $\gamma 2$ solutions for which SDF is r^{-3}. The following remarks pertain for other than the 2G24 solution, which correlates with the traditional physics theory nominal magnetic moment result of $g \approx 2$. (2G24 correlates with 2γ and not with $\gamma 2$.) The relevant solutions might be 4G26, 6G24, 6G28, 8G26, and 10G28. However, 6G28 and 10G28 do not interact with individual elementary fermions. These solutions might correlate with, for example, the Lamb shift. Regarding anomalous electromagnetic dipole moments, we assume that 4G26, 6G24, and 8G26 pertain.

Complementary physics theory suggests that contributions to a scale as $\alpha^{(\Sigma-2)/2}$. The 4G26 solution might correlate with the traditional physics theory result of $\alpha/(2\pi)$. The 6G24 might correlate with contributions of the order α^2. Possibly, people can extrapolate, based on observed strengths of 6G24, to predict the order α^2 contribution to a_τ.

We assume that, for a charged lepton cl, equation (51) pertains. Here, t_{cl} is the property that the first column of table 21 identifies.

$$a_{\mathrm{cl}} - (\alpha/(2\pi)) \approx a_{6\mathrm{G}24,1} + a_{6\mathrm{G}24,\mathrm{t}} t_{\mathrm{cl}} \tag{51}$$

Table 21 shows approximate possible values for $a_{6\mathrm{G}24,1}$ and $a_{6\mathrm{G}24,\mathrm{t}}$, based on fitting data that equations (47) and (48) show and using various candidates for t_{cl}. We de-emphasize the notion that 8G26 might also contribute to an actual value.

Table 21: Possible approximations regarding the 6G28 and 6G24 contributions to $a_{\mathrm{cl}} - (\alpha/(2\pi))$ for charged leptons

Assumption regarding t_{cl}	$a_{6\mathrm{G}24,1}$	$a_{6\mathrm{G}24,\mathrm{t}}$
m	-1.79×10^{-6}	5.96×10^{-8}
m^2	-1.76×10^{-6}	5.62×10^{-10}
M''	-1.76×10^{-6}	3.13×10^{-6}
$(M'')^2$	-1.76×10^{-6}	1.57×10^{-6}
generation	-8.03×10^{-6}	6.27×10^{-6}
$(\text{generation})^2$	-3.85×10^{-6}	2.09×10^{-6}
$\log(m/m_e)$	-1.76×10^{-6}	1.18×10^{-6}
$(\log(m/m_e))^2$	-1.76×10^{-6}	2.21×10^{-7}

Table 22: Possible approximations for $a_\tau - (\alpha/(2\pi))$

Assumption regarding first order behavior for $a_{\mathrm{cl}} - (\alpha/(2\pi))$. The term is linear in a lepton's:	First order suggestion for $a_\tau - (\alpha/(2\pi))$	Prediction for a_τ	Approximate comparison $(a_\tau - a_{\tau,\mathrm{SM}})/a_{\tau,\mathrm{SM}}$	Fit
m	$+1.04 \times 10^2 \times 10^{-6}$	$+1.266 \times 10^{-3}$	$+75 \times 10^{-3}$	-
m^2	$+1.77 \times 10^3 \times 10^{-6}$	$+2.933 \times 10^{-3}$	$+1500 \times 10^{-3}$	-
M''	$+7.65 \times 10^{-6}$	$+1.169 \times 10^{-3}$	-6.9×10^{-3}	!
$(M'')^2$	$+12.35 \times 10^{-6}$	$+1.174 \times 10^{-3}$	-2.9×10^{-3}	!
generation	$+10.8 \times 10^{-6}$	$+1.172 \times 10^{-3}$	-4.3×10^{-3}	!
$(\text{generation})^2$	$+15.0 \times 10^{-6}$	$+1.176 \times 10^{-3}$	-0.7×10^{-3}	!!
$\log(m/m_e)$	$+7.83 \times 10^{-6}$	$+1.169 \times 10^{-3}$	-6.8×10^{-3}	!
$(\log(m/m_e))^2$	$+12.9 \times 10^{-6}$	$+1.174 \times 10^{-3}$	-2.5×10^{-3}	!

Table 22 provides, based on table 21 and equation (51), some possible suggestions for $a_\tau - (\alpha/(2\pi))$. The comparison is with respect to a Standard Model first order calculation. (See equation (50).) Possibly, per the notion that the interaction strength does not necessarily correlate linearly or quadratically with a traditional physics theory property and per the quadratic behavior with respect to $|q_e|$ in the expression $\alpha^{(\Sigma-2)/2}$, we might expect that appropriate results might correlate with the square of generation or with the square of a function of $\log(m)$. (See work that includes equation (37).)

Each of the results that table 22 shows comports with experimental results. Possibly, except for the row regarding m and the row regarding m^2, each row in table 22 might comport with the calculation based on the Standard Model. Possibly, the $(\text{generation})^2$-centric result that table 22 shows comports best, of the results the table suggests, with the calculation based on the Standard Model. The $(\text{generation})^2$-centric result differs from the result equation (50) shows by about 0.7 parts in 1000.

Based on the notion that contributions to a scale as $\alpha^{(\Sigma-2)/2}$ and on results that table 21 shows, it seems unlikely that $a_{6\mathrm{G}24,1}$ correlates with 8G26. However, it is possible that the strength of interactions correlating with 4G26 differs from the traditional physics theory result that correlates with $\alpha/(2\pi)$ and that $a_{6\mathrm{G}24,1}$ correlates with such a difference.

4 Discussion

This unit describes steps for developing or understanding our work, discusses some physics topics, describes possible synergies between notions that complementary physics theory proposes and some aspects of traditional physics theory, and discusses some concepts regarding masses or perceived masses of elementary particles.

4.1 Steps for developing or understanding our work

This unit provides a list of steps for developing some aspects of our work or for gaining understanding of some aspects of our work.

The following steps and concepts provide an entry into our work.

1. Posit a list of forces that would explain much regarding observed phenomena.
    - The strong, weak, and electromagnetic interactions correlate, in traditional quantum physics, with spin-one boson elementary particles. To some extent, the strong interaction correlates with a potential that the expression r^1 characterizes. In particular, on the scale that people observe the strong interaction, a potential proportional to r (or, distance) correlates with asymptotic freedom. An attractive force characterized by r^0 correlates with that potential. Our work shows that, to some extent, the weak interaction correlates with an r^0 potential and possibly a negligible, with respect to translational motion, force. In each of our work and traditional physics theory, electrostatics correlates with an r^{-1} potential and an r^{-2} force that can be attractive or repulsive.
    - The gravitational and dark energy interactions might correlate with spin-two bosons. To some extent, the gravitational interaction correlates with an r^{-1} potential and an attractive r^{-2} force. The following interactions might pertain regarding dark energy forces. An r^{-4} potential and a repulsive r^{-5} force might provide for an initial era of growing rate of expansion of the universe. An r^{-3} potential and an attractive r^{-4} force might provide for the subsequent several-billion-year era of slowing rate of expansion of the universe. An r^{-2} potential and a repulsive r^{-3} force might provide for the recent multi-billion-year era of growing rate of expansion of the universe.
    - Traditional physics theory correlates the word monopole with r^{-2} forces, the word dipole with r^{-3} forces, the word quadrupole with r^{-4} forces, and the word octupole with r^{-5} forces. Our work provides a mathematical basis (which traditional physics theory does not invoke) that supports using those four correlations. Especially because people might not associate r^{-}–force-law expressions with some kinematics models (such as general relativity), people might prefer using words of the form _pole to using expressions of the form r^{-}–. Nevertheless, we use the words and expressions interchangeably and we tend to emphasize using the expressions.
    - The following concepts pertain.
        - For two objects that move apart from each other, an r^{-n} force between the two objects eventually dominates an $r^{-(n+1)}$ force.
        - For a scenario involving objects moving away from each other, pairs of smaller neighboring objects might undergo transitions from dominance by an r^{-n} force to dominance by an $r^{-(n+1)}$ force sooner than would pairs of larger objects.
        - For a pair of neighboring similar astrophysical objects that are not very large objects, the currently dominant force is r^{-2} gravitational attraction.
2. Posit that such a list of forces should be an output from a method that outputs matches to all known elementary particles and outputs suggestions for new elementary particles.
3. Develop a mathematics-based method that outputs matches to all known elementary particles and outputs suggestions for new elementary particles.
4. Realize that the method points to possibly relevant new elementary particles, to possibly relevant new symmetries, and other possibly relevant insight.
    - New zero-charge fermion elementary particles exist and, when bound together by gluons (or, the strong interaction), provide a basis for hadron-like particles that have some characteristics similar to characteristics that people associate with hypothetical WIMPs (or, weakly interacting massive particles, which might be a component of dark matter).
    - A new non-zero-charge boson elementary particle might have played a role in producing baryon asymmetry (or, the relative lack of antimatter during much of the history of the universe).
    - A symmetry correlating with conservation of charge pertains.
    - A symmetry correlating with three generations for fermion elementary particles pertains.

- Approximate symmetries pertain and correlate with somewhat conservation of fermion generation, somewhat conservation of lepton number, somewhat conservation of baryon number, and conservation of lepton number minus baryon number.
- The method suggests that neutrino masses might be zero (as per aspects of the elementary particle Standard Model) and that some suggested forces (which are related to dark energy forces) underlie each of the following (which people interpret as implying that at least one flavor of neutrino has non-zero mass) - neutrino oscillations and some astrophysics data.
- The method can embrace symmetries that provide proxies for conservation of angular momentum, conservation of linear momentum, and conservation of energy.

5. Posit that the ratio of five-plus to one for dark matter density of the universe to ordinary matter density of the universe has an explanation in a description of dark matter that is consistent with the mathematics-based method.
   - The explanation suggests that the universe includes six (PR6ISe-span-one phenomena) isomers of a set (of phenomena) that includes all charged elementary particles and the PR1ISe-like aspects of the photon.
   - One isomer of PR6ISe-span-one phenomena correlates with ordinary matter (and familiar photons).
   - Five isomers of PR6ISe-span-one phenomena correlate with dark matter. (These isomers of PR6ISe-span-one phenomena include particles that people might call dark matter photons.)
   - The somewhat-WIMP-like hadron-like particles provide some (and, perhaps most or all) of the remaining dark matter.
6. Identify, in our mathematics-based modeling, a ratio - of generators for symmetry-related (mathematics) groups - that is six and that correlates with the six isomers of PR6ISe-span-one phenomena.
   - One PR6ISe isomer of r^{-2}-force gravity spans all six isomers of PR6ISe-span-one phenomena.
   - For each of the dark energy forces, the number of isomers is either six (and the span of each isomer correlates with one isomer of PR6ISe-span-one phenomena) or three (and the span of each isomer correlates with two isomers of PR6ISe-span-one phenomena).
7. Develop a scenario for the formation of at least some galaxies, based on observed ratios of dark matter effects to ordinary matter effects, our description of dark matter, and results regarding the spans of gravity and dark energy forces.
8. Realize that the description of dark matter and the concept of spans might underlie explanations for various observed ratios of dark matter effects to ordinary matter effects and might underlie explanations of some phenomena observed regarding the Milky Way galaxy.
9. Realize that reuse of the galaxy formation scenario might explain aspects of dark matter galaxies.
10. Realize that the work to which we allude above pertains (at least generally) without making choices regarding kinematics or dynamics models.
    - The work dovetails generally with classical physics techniques and with quantum physics techniques.
    - The work dovetails generally with Newtonian physics, special relativity, and general relativity in regimes for which people have validated general relativity. (Notions correlating with span point to possible needs to reconsider some traditional physics theory aspects regarding dark energy forces and general relativity.)
11. Realize that techniques leading to the mathematics-based model might correlate with complements to quantum field theory (or, QFT), quantum electrodynamics (or, QED), and quantum chromodynamics (or, QCD).
    - Complementary QFT avoids infinite sums of photon ground-state energies and avoids some concerns about modeling a possibly unbounded universe. Some aspects of complementary QFT do not necessarily include the concept of virtual particles. Complementary QFT interaction vertices are point-like with respect to a temporal coordinate and can (unlike traditional physics theory QFT vertices) be volume-like with respect to spatial coordinates.

- Complementary QED provides a three-term sum for the anomalous magnetic dipole moments of charged leptons.
- Complementary QCD provides a possible explanation for the electric dipole moment of the neutron and the electric dipole moment of the proton being zerolike (or, zero or at most very small).

12. Realize that a lack, in some aspects of complementary QFT, of concepts paralleling vacuum energy or paralleling vacuum fluctuations may point toward desirability to consider new explanations for non-zero dark energy density of the universe.
13. Realize that each of PR1ISe modeling, PR6ISe modeling, and PR36ISe modeling points to a possible explanation for non-zero dark energy density of the universe.

4.2 Some physics topics

This unit notes possibilities for detecting dark matter and doubly dark matter; discusses some physics phenomena, including electric dipole moments and baryon acoustic oscillations; and discusses aspects of modeling.

4.2.1 Directly detecting dark matter and doubly dark matter

This unit discusses aspects of extant approaches for directly detecting dark matter and possible new approaches for directly detecting dark matter or doubly dark matter.

We are aware of various efforts to directly detect dark matter. Some efforts look for WIMPs. We are uncertain as to the extent to which these efforts might be able to detect 1R$\otimes$2U hadron-like particles. Some efforts look for axions. We are uncertain as to the extent to which these efforts might attribute axion sightings to effects that correlate with the difference between 2(6)G248 and 2(1)G248.

Complementary physics theory suggests new possibilities for directly detecting dark matter or doubly dark matter. To the extent that PR6ISe pertains to nature and PR36ISe does not pertain to nature, the following discussion pertains to detecting dark matter; to the extent that PR36ISe pertains to nature, the following discussion pertains to detecting doubly dark matter. The basis for one possibility is the difference between 2(6)G248 and 2(1)G248. Here, a detector might feature a rotating (or, precessing) magnetic dipole moment, with the axis of rotation perhaps being orthogonal (and certainly not being parallel) to the axis correlating with the magnetic dipole. Independent of that possible means for detection, people might try to infer 2(6)G248 phenomena correlating with precessing dark matter magnetic fields (or - for the PR36ISe case - 2(6)G248 phenomena correlating with precessing doubly dark matter magnetic fields). A basis for another possibility is the difference between 2(2)G68 and 2(1)G68. Complementary physics theory suggests that 2G68 correlates with, at least, some atomic transitions.

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

This unit discusses three related formulas that produce lengths.

We suggest a series of formulas for lengths. Equation (52) correlates with the Schwarzschild radius for an object of mass m. Equation (53) correlates with the Planck length and does not depend on m. Equation (54) includes a factor of m^{-1}. When applied to the mass of 2W bosons, equation (54) correlates somewhat with the range of the weak interaction. When applied to the mass of a charged pion, equation (54) correlates somewhat with a range for the strong interaction. Equation (55) shows the ratio between successive formulas. Equation (56) shows, for the electron, the ratio correlating with equation (55).

$$R_4(m) = (G_N)^1 m^1 \hbar^0 c^{-2} 2^1 \tag{52}$$

$$R_2(m) = (G_N)^{1/2} m^0 \hbar^{1/2} c^{-3/2} 2^0 \tag{53}$$

$$R_0(m) = (G_N)^0 m^{-1} \hbar^1 c^{-1} 2^{-1} \tag{54}$$

$$(G_N)^{-1/2} m^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \tag{55}$$

$$(G_N)^{-1/2} (m_e)^{-1} \hbar^{1/2} c^{1/2} 2^{-1} \approx 1.1945\times 10^{22} \tag{56}$$

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.)

4.2.3 Lack of magnetic monopoles and a possible lack of some electric dipole moments

This unit suggests modeling that would comport with the notion that nature does not include 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 10 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 a point-like 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, people might want to consider the notion that the 2G2 solution correlates with an electromagnetic (not magnetic) monopole moment.

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 2, 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 might be such hadrons. Some research suggests that some pentaquarks might not be such hadrons. (See interpretation, in reference [30], of reference [1].)

4.2.4 Some approximate symmetries

This unit discusses somewhat conservation of generation, somewhat conservation of lepton number, and somewhat conservation of baryon number.

We discuss somewhat conservation of generation.

Known 1f1b→1f1b interactions between W bosons and leptons conserve lepton generation. The exiting fermion correlates with the same generation that correlates with the entering fermion. TA-side modeling for elementary fermions points to an $SU(2)$ symmetry that complementary physics theory correlates with a possibility for conservation of fermion generation. TA-side modeling for some elementary bosons, including the W boson, points to an $SU(2)$ symmetry that complementary physics theory correlates with a possibility for somewhat conservation of generation. (See table 7.) This symmetry correlates with the non-TA0 components of $SU(3)$ TA-side symmetries, such as the TA-side symmetries that table 11 shows.) Complementary physics theory posits that conservation of generation pertains to the extent that an overall interaction models as involving only one weak interaction boson. For quarks in hadrons, traditional physics theory correlates with the notion that interactions that involve multiple weak interaction bosons do not necessarily conserve generation and do not necessarily conserve CP (or, charge conjugation and parity). Paralleling traditional physics use of the two-word term approximate symmetry regarding CP, complementary physics theory uses the two-word term somewhat conservation regarding generation.

Complementary physics theory suggests that some elementary boson phenomena correlate with somewhat conservation of generation and that some elementary boson phenomena do not correlate with somewhat conservation of generation. (See table 14.)

We discuss somewhat conservation of baryon number and somewhat conservation of lepton number.

Each of conservation of baryon number and conservation of lepton number pertains, in complementary physics theory, to the extent that one ignores interactions mediated by the $2\mathrm{T}^{\pm}$ boson and interactions correlating with 1f1b↔3f0b vertices. For all interactions, complementary physics theory correlates with conservation of lepton number minus baryon number. We use the two-word term somewhat conservation regarding each of lepton number and baryon number.

4.2.5 CPT-related symmetries

This unit discusses some complementary physics theory symmetries and some aspects of traditional physics theory CPT-related symmetries.

Table 23 summarizes complementary physics theory concepts regarding so-called TSP, APM, and SSP transformations. The table pertains for ALG models. TSP abbreviates the phrase temporal side parity. APM abbreviates the phrase antiparticle or anti-mode. SSP abbreviates the phrase spatial side parity.

Traditional physics theory includes notions of C (or, charge-reversal) transformation and approximate symmetry, P (or, parity-reversal) transformation and approximate symmetry, and T (or, time-reversal)

Table 23: TSP, APM, and SSP transformations (regarding ALG models)

Swap (for each odd j' and with $j'' = j' + 1$)	Swap	Swap pertains for the transformation		
		TSP	APM	SSP
$n_{TAj''}$ and $n_{TAj'}$	-	Yes	Yes	No
-	n_{TA0} and n_{SA0}	No	No	No
$n_{SAj'}$ and $n_{SAj''}$	-	No	Yes	Yes

Table 24: Traditional physics theory T, C, and P transformations, in a context of complementary physics theory ALG models

Swap (for each odd j' and with $j'' = j' + 1$)	Swap	Swap pertains for the transformation			Transformation and swap pertain for gluons and color charge		
		T	C	P	T	C	P
$n_{TAj''}$ and $n_{TAj'}$	-	Yes	Yes	No	No	No	No
-	n_{TA0} and n_{SA0}	No	No	No	No	No	No
$n_{SAj'}$ and $n_{SAj''}$	-	No	Yes	Yes	No	No	No

transformation and approximate symmetry. In traditional physics theory, invariance under CPT transformation pertains.

Table 24 might correlate with traditional physics theory notions of T, C, and P approximate symmetries. Similarities exist between TSP transformation and T (or, time reversal) transformation, between APM transformation and C (or, charge-reversal) transformation, and between SSP transformation and P (or, parity-reversal) transformation. A significant difference between TSP symmetry and T symmetry and a significant difference between APM symmetry and C symmetry might pertain and correlate with gluons and color charge.

4.2.6 Channels and G-family interactions

This unit discusses aspects regarding G-family interactions and channels.

The notion of channels pertains to, for example, the relative strengths of electromagnetism and gravity. (See discussion related to equation (32).)

Regarding table 11 and the G-family, complementary physics theory suggests that each channel can correlate with a unique blank (or, $\kappa_{0,-1}$) SA-side oscillator pair in the range from SA3-and-SA4 through SA9-and-SA10. For this purpose, isotropic weighting pertains regarding oscillator pairs.

We discuss possible aspects of modeling for a 1f1b→1f0b interaction. The following notions pertain.

The incoming state de-excites by transferring one unit of 1b excitation to one of the channels. For that channel, equation (57) pertains.

$$\kappa_{0,-1} \rightarrow \kappa_{0,0} \tag{57}$$

The new SA-side $SU(2)$ symmetry adds an extra kinematics-conservation-like symmetry that cannot last. (See table 12.) The interaction includes converting the $\kappa_{0,0}$ symmetry to something, pertaining to the outgoing state, like a $\pi_{@_0,@_0}$ symmetry.

The above modeling is not incompatible with various complementary physics theory concepts, including the equal strengths of channels and the linear scaling, by number of channels, of interaction strengths.

4.2.7 Objects, properties of objects, forces, motion, and kinematics models

This unit discusses aspects that correlate with traditional physics theory kinematics conservation laws.

Much traditional physics theory discusses models for objects, internal properties (such as spin and charge) of objects, motion-centric properties (such as linear momentum) of objects, and interactions (or, forces) that affect internal properties of objects or motion of objects. Aspects (that we discuss above) specific to our work rely on data that people collect and interpret in the context of traditional physics theory concepts related to objects, properties, forces, and motion.

Work (that we discuss above) tends to rely on traditional physics theory concepts regarding objects, internal properties, motion-centric properties, interactions, and kinematics and dynamics theories. We suggest additions to the list of elementary particles and additions to the sets of approximate symmetries and somewhat conservation laws. Work (that we discuss above) tends to de-emphasize possibilities that complementary physics theory might add insight regarding other aspects that traditional physics theory considers.

Work (that we discuss above) de-emphasizes the concept of motion. (Some exceptions pertain. One exception correlates with the evolution of galaxies. One exception correlates with the rotation of objects.) Work (that we discuss above) de-emphasizes the notion of choosing one or more models of motion.

We introduce, into complementary physics theory, some aspects of motion via symmetries that traditional physics theory correlates with conservation laws related to motion. (See discussion related to table 12.)

Kinematics models can correlate with classical physics or with quantum physics. Kinematics models can correlate with Newtonian physics modified to limit the speed, of the 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.

- Complementary physics theory might be 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 an SA-side pair of oscillators that correlates with any one of no symmetry, $U(1)$ symmetry, or $SU(2)$ symmetry. We use the two-element phrase boost-related symmetry to correlate with those three possibilities. Possibly, the SA-side addition correlates with modeling and does not correlate with observable phenomena.
- Regarding the G-family, beyond modeling that includes models for channels, one might correlate the oscillator pairs SA11-and-SA12, SA13-and-SA14, and SA15-and-SA16 with conservation of angular momentum symmetry, conservation of linear momentum symmetry, and boost-related symmetry. (See discussion regarding equation (57).) Doing so might correlate with relevance for an $SU(17)$ symmetry. (Note remarks regarding equation (5).)
- Possibly, within a context correlating with the symmetries that equation (58) shows, modeling for all known physics correlates with a notion of confined environment and a notion that we might characterize by $\sigma_{17} = -1$. (Compare with $\sigma = -1$ in, for example, table 6. Regarding the possibility correlating with a TA-side $SU(7)$ symmetry, see table 25 and, perhaps, also note that one might, in table 6, move information regarding the TA8-and-TA7 oscillator pair to the TA6-and-TA5 oscillator pair.)

$$\text{TA-side: } SU(7) \text{ or } SU(17), \ \text{SA-side: } SU(17) \tag{58}$$

4.2.8 Aspects of dynamics modeling regarding multicomponent particles

This unit illustrates the notion that modeling for components of a multicomponent object does not necessarily need to correlate, for each component, with conservation of angular momentum and conservation of linear momentum and illustrates the notion that elementary bosons can contribute any one of three symmetries regarding boost-related symmetry.

For models for a binary star system, conservation of momentum might pertain regarding the system and does not pertain regarding each star.

We explore dynamics modeling for components of hadron-like particles.

Table 25 reinterprets aspects of table 6. Each row in table 25 correlates with solutions that correlate with phenomena related to dynamics within hadron-like particles. For example, known hadron-like particles correlate with 1Q⊗2U; have internal interactions mediated by 2U elementary particles, 2W elementary particles, and 2G long-range forces; can emit 1C and 1N particles; and so forth. (The table does not list the 0P and 0K solutions, which complementary physics theory suggests pertain to interactions between hadron-like particles but not necessarily to dynamics within hadron-like particles. See discussion regarding table 3.) Regarding table 25, each pairing of a boson solution with a fermion solution exhibits each of CP3, CA3, and a choice between B3, B2, and B0. CP3 correlates with $SU(2)$:±1 and with, for the

Table 25: Properties and interactions, with respect to hadron-like particles, for elementary particles and unimpeded long-range forces

$\Sigma\Phi$	σ	$\vert\leftarrow$	$\cdots$	TA	$\cdots$	$\rightarrow\vert$	$\vert\leftarrow$	$\cdots$	SA	$\cdots$	$\rightarrow\vert$
or		8,7	6,5	4,3	2,1	0	0	1,2	3,4	5,6	7,8
$\Sigma\Phi\Gamma$											
0H	$+1$			CP3	CC2	0	B0	B2	B3	*	
0I	$+1$			B3	B2	B0	0	CC2	CP3	*	
1N	$+1$		CBN2	CA3	ECT2s	-1	-1	ECS2	G3	CLN2	
1C	$+1$		CBN2	CA3	ECT2s	0	0	ECS2	G3	CLN2	
1R	-1		CBN2	CA3	ECT2	-1	-1	ECS2	G3	CLN2	
1Q	-1		CBN2	CA3	ECT2	0	0	ECS2	G3	CLN2	
2U	-1			B3	B2	B0	-1	CC2	CG3	*	
2W	$+1$			CP3		0	B0	B2	B3	*	
2T	-1			B3	B2	B0	0		CP3	*	
$\Sigma G\Gamma$	$+1$			CP3	CC2	0	B0	B2	B3	*	

hadron-like particle, one of conservation of angular momentum and conservation of momentum. (Here, the number after the colon denotes a contribution to the relevant $\widehat{A}^{ALG}_{XA}$. See table 1.) Regarding symbols of the form ±, plus pertains to the extent that either $n_{TA0} = 0$ or $n_{SA0} = 0$ and minus pertains to the extent that either $n_{TA0} = -1$ or $n_{SA0} = -1$. (There are no cases of mismatches between n_{TA0} and n_{SA0}.) CPA correlates with $SU(2)$:±1 and with, for the hadron-like particle, the other one of conservation of angular momentum and conservation of momentum. CC2 correlates with $U(1)$:0 and with conservation of charge. The choice between B3, B2, and B0 correlates with a choice of modeling for the kinematics of a hadron-like particle. B3 correlates with $SU(2) : \pm1$, with boost symmetry, and with modeling (for the hadron-like particle) correlating with special relativity. B2 correlates with $U(1)$:0. Each of a TA-side B0 and an SA-side B0 correlates with $n_{TA0} = n_{SA0}$; with $\chi_{(0,0),(-1,-1)}$ and, with respect to the elementary boson, with $\widehat{A}^{ALG}_{(TA0,SA0)}$=0; and, for the hadron-like particle, with $\kappa_{0,-1}$ (or, no symmetry). (See table 1.) In table 25, each entry in the TA4-and-TA3 column and each entry in the SA3-and-SA4 column correlates with $SU(2)$. In table 25, each entry in the TA2-and-TA1 column and each entry in the SA1-and-SA2 column correlates with $U(1)$. The symbol * correlates with a boson channel. (See discussion related to equation (31) and discussion related to equation (57).) CBN2 correlates with $U(1)$:0 and with somewhat conservation of baryon number. CLN2 correlates with $U(1)$:0 and with somewhat conservation of lepton number. Conservation of lepton number minus baryon number correlates with a combination of CBN2 and CLN2. CA3 correlates with $SU(2)$:±1 and with somewhat conservation of generation. G3 correlates with $SU(2)$:±1 and with generation. Each of ECT2s, ECT2, and ECS2 correlates with $U(1)$:0. The pair ECT2s and ECS2 correlates with conservation of charge. The pair ECT2 and ECS2 correlates with conservation of charge. For each row in table 25, the combination of conservation of momentum and conservation of angular momentum (or, the combination of CP3 and CA3) does not pertain.

Table 25 correlates with the notion that, if such could exist in nature, a free-ranging 1Q or 1R particle would correlate, at least with respect to traditional physics theory, with some (at least virtual) bosons. Complementary physics theory modeling regarding such a 1Q or 1R particle does not include both emitting an elementary boson and absorbing the same elementary boson or a successor to the same elementary boson. (See remarks related to table 9.) In complementary physics theory, the notion of free environment does not pertain for individual elementary fermions for which $\sigma = -1$.

Complementary physics theory suggests that a hadron-like particle must include at least two (non-virtual) fermions for which $\sigma = -1$. (The notion of virtual correlates with traditional physics theory. Aspects of complementary physics theory do not necessarily include the notion of virtual fermions.) In addition, per the example regarding 1Q⊗2U hadron-like particles, there is no requirement for n_{SA0} for the elementary fermions to match n_{SA0} for the elementary bosons.

4.2.9 Models for neutrino oscillations and for refraction of long-range forces

This unit discusses aspects of complementary physics theory modeling regarding neutrino oscillations and regarding the refraction of long-range forces.

Each of equations (59) and (60) offers a possible basis for generalizing kinematics work (that we discuss above) based on using the range $-1 < n_{P0} < 0$. (Uses of the expression $n_{P0} < -1$ pertain for spin-related symmetry applications, for some modeling regarding gluons, and not necessarily for other

Table 26: 2U solutions

Solution	TA6	TA5	TA0	SA0	SA3	SA4
2U60	-2	-1	0	-1	-1	-1
2U56	0	-2	-1	-1	-1	-1
2U05	-1	0	-2	-1	-1	-1
2U50	-1	-2	0	-1	-1	-1
2U06	0	-1	-2	-1	-1	-1
2U65	-2	0	-1	-1	-1	-1

purposes. Regarding the spin-related symmetry applications, see table 11. Regarding the gluon-related modeling, see table 26.) Here, E denotes energy, $\overrightarrow{P}$ denotes momentum, $\overrightarrow{v}$ denotes velocity, $<$ _ $>$ denotes the expected value of _, $P^2 = < \overrightarrow{P} \cdot \overrightarrow{P} >$, and $v^2 = < \overrightarrow{v} \cdot \overrightarrow{v} >$. Here, double-entry bookkeeping pertains to models for which at least one of the TA-side set of harmonic oscillators and the SA-side set of harmonic oscillators is not necessarily isotropic.

$$n_{P0} = -c^2 P^2 / E^2 \tag{59}$$

$$n_{P0} = -v^2 / c^2 \tag{60}$$

For neutrinos (or, 1N solutions), assuming that equation (60) pertains and that $0 < v^2 < c^2$ pertains leads to denaturing conservation of generation. This modeling might correlate with neutrino oscillations. Possibly, this concept provides perspective that traditional physics theory does not provide.

For long-range forces, assuming that equation (60) pertains and that $0 < v^2 < c^2$ regarding a $\Sigma\gamma$ solution leads to denaturing at least one of conservation of linear momentum and conservation of angular momentum. This modeling might correlate with refraction. We are uncertain as to the extent to which such work would provide perspective that traditional physics theory does not provide.

Possibly other applications of double-entry bookkeeping lead to modeling pertaining to, for example, the binding together of two objects (such as stars) to form another object (such as a binary star system).

For ALG modeling regarding kinematics, conservation of energy, angular momentum, and momentum might need to pertain for a multicomponent object and would not necessarily pertain for the component objects. Regarding traditional physics theory classical physics modeling, we are uncertain as to the extent to which such work would add perspective that traditional physics theory does not provide. Regarding traditional physics theory quantum physics modeling, we think that such work correlates with possibilities for complementary physics theory modeling in which elementary fermions contribute one of the $SU(2)$ symmetries and do not correlate with a second kinematics $SU(2)$ symmetry and in which elementary bosons (including long-range forces) contribute one of the $SU(2)$ symmetries and do not correlate with a second kinematics $SU(2)$ symmetry. (See discussion related to table 12.) This notion points to complementary physics theory quantum modeling that does not feature virtual particles.

4.2.10 U-family interactions and the strong interaction $SU(3)$ symmetry

This unit discusses aspects regarding modeling gluons and modeling U-family interactions.

The 2U solutions correlate with gluons. Here, we provide details correlating with the ${}^{\dagger U_{TA}}\ \kappa_{-1,-1,-1}$ symmetry that table 6 shows.

Table 26 shows details regarding 2U solutions. The expression $\kappa_{-1,-1,-1}$ correlates with $A_{TA}^{ALG} = -3/2$. Each of the six TA-side $\pi_{0,-1,-2}$ permutations pertains. Each permutation correlates with $A_{TA}^{ALG} = -3/2$. Table 26 suggests notation for gluon-related solutions. The set of three permutations for which 0, -1, and -2 appear in cyclic order correlates with interactions with one of matter elementary fermions for which $\sigma = -1$ and antimatter elementary fermions for which $\sigma = -1$. The set of the other three permutations correlates with the other choice between antimatter elementary fermions for which $\sigma = -1$ and matter elementary fermions for which $\sigma = -1$. Regarding matter elementary fermions for which $\sigma = -1$, each of oscillators TA6, TA5, and TA0 correlates with a color charge. Relative to a traditional physics theory standard representation for gluons, one of TA6 and TA5 correlates with the color red, the other of TA6 and TA5 correlates with the color blue, and TA0 correlates with the color green.

Traditional physics theory correlates gluons with zero-mass and with phenomena that complementary physics theory correlates with 2U solutions. We consider 2U phenomena regarding dynamics inside hadron-like particles. In such a frame of reference, complementary physics theory modeling based on

Table 27: 2U erase or paint ground states

Ground state	TA6	TA5	TA0	SA0	SA3	SA4
2U0 = 2U60⊕2U50	−1	−1	0	0	−1	−1
2U6 = 2U56⊕2U06	0	−1	−1	0	−1	−1
2U5 = 2U05⊕2U65	−1	0	−1	0	−1	−1

equations (61) and (62) pertains. Here, the notation $a \leftarrow b$ correlates with the three-element phrase *a* becomes *b* (or, with the notion that *b* replaces *a*). Here, the symbol → denotes, in the mathematical sense of a limit, the two-word phrase goes to.

$$(n_{SA0} = -1) \leftarrow (n_{SA0} = -v^2/c^2 \to 0^-) \tag{61}$$

$$(n_{TA\_''} = -2) \leftarrow (n_{TA\_''} = (-1 - v^2/c^2) \to (-1)^-) \tag{62}$$

Equations (61) and (62) correlate with boson behavior for gluons. In effect, modeling of excitations and de-excitations correlates with a ground state that correlates with equation (63) and with, for the appropriate $n_{TA\_'}$, equation (64). (See tables 26 and 27.) Excitation correlates with erasing a color charge (from, for example, a quark) and de-excitation correlates with painting a color charge (on, for example, a quark). (See discussion related to table 26.)

$$n_{SA0} = 0 \tag{63}$$

$$n_{TA\_'} = 0 \tag{64}$$

Table 27 shows results of applying, to items in table 26, aspects correlating with equations (63) and (64). Table 27 shows three erase or paint ground states.

A gluon correlates with a weighted sum of two or three erase-and-paint pairs. For each pair, the erase part correlates with, in effect, an ability to erase, from the $\sigma = -1$ elementary fermion that absorbs the gluon, a color. The paint part correlates with, in effect, an ability to paint, on to the $\sigma = -1$ elementary fermion that absorbs the gluon, a color. The value $n_{TA\_} = 0$ denotes an ability for a gluon to erase or paint the color charge correlating with the TA_ oscillator. Equation (65) shows a traditional physics theory representation for one of the eight gluons. (Out of the eight gluons, this is the only one that involves three erase-and-paint pairs. Each of the other seven gluons involves two erase-and-paint pairs.) Regarding table 27, we make the following correlations. (Alternatively, without loss of generality or results, one might reverse the roles of TA6 and TA5.) The symbol r correlates with painting the color red and with a painting application of 2U6. The symbol $\bar{r}$ correlates with erasing the color red and with an erasing application of 2U6. The symbol b correlates with painting the color blue and with a painting application of 2U5. The symbol $\bar{b}$ correlates with erasing the color blue and with an erasing application of 2U5. The symbol g correlates with painting the color green and with a painting application of 2U0. The symbol $\bar{g}$ correlates with erasing the color green and with an erasing application of 2U0.

$$(r\bar{r} + b\bar{b} - 2g\bar{g})/(6)^{1/2} \tag{65}$$

Traditional physics theory correlates an $SU(3)$ symmetry with gluons. Complementary physics theory embraces the same $SU(3)$ symmetry per discussion nearby above. A $\kappa_{-1,-1}$ symmetry that correlates, in table 6, with the oscillator pair SA3-and-SA4 reappears in table 27. This $\kappa_{-1,-1}$ symmetry correlates with conservation of fermion generation for interactions mediated by gluons.

4.2.11 Possible modeling for fissionable or bound-state multicomponent objects

This unit discusses aspects of complementary physics theory modeling regarding multicomponent objects.

For PDE modeling regarding a multicomponent object, the following concepts might pertain. A_{SA}^{PDE} correlates with $(mc^2)^2 + f_{SA}$. A_{TA}^{PDE} correlates with $E^2 + f_{TA}$. Here, each of f_{SA} and f_{TA} is nonnegative. For some applications, $f_{SA} > 0$ correlates with a fissionable system and possibilities for decay. Note that, if $f_{TA} = 0$, E^2 exceeds $(mc^2)^2$. For example, $f_{SA} > 0$ might correlate with models for beta decay via the weak interaction. For some applications, $f_{TA} > 0$ correlates with bound states. Note that, if $f_{SA} = 0$, E^2 is less than $(mc^2)^2$. For example, $f_{TA} > 0$ might correlate with models for the structure of atomic nuclei. We are uncertain as to the extent to which such modeling for multicomponent objects would provide perspective that traditional physics theory does not provide.

4.2.12 Aspects regarding applications for which $\sigma = -1$

This unit discusses mathematics regarding PDE modeling that correlates with the notions that Ω_{TA} is nonpositive, $\sigma' = -1$, Ω_{SA} is nonpositive, and $\sigma = -1$.

Complementary physics theory includes PDE modeling for which equation (66) pertains regarding the TA0-and-SA0 oscillator pair. (See, for example, equation (67).) These applications correlate with the notion that, for equation (8) and appropriate assumptions, one can move, in equation (8), the originally nonnegative Ω_{TA}/t^2 term from correlating with A_{TA}^{PDE} to become a nonpositive Ω_{SA}/r^2 term correlating with A_{SA}^{PDE} and one can move the originally nonnegative Ω_{SA}/r^2 term from correlating with A_{SA}^{PDE} to become a nonpositive Ω_{TA}/t^2 term correlating with A_{TA}^{PDE}. After the moves, Ω_{TA} is nonpositive, $\sigma' = -1$, Ω_{SA} is nonpositive, and $\sigma = -1$. The assumptions can include that $t = r$ and that $|\eta_{TA}| = |\eta_{SA}|$.

$$t^2/(2\eta_{TA}) + r^2/(2\eta_{SA}) = tr/(|\eta_{TA}| \cdot |\eta_{SA}|) \tag{66}$$

4.3 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).

We assume a definition of QFT that is not limited to correlating with special relativity. (See, for example, reference [17].)

The following statements summarize aspects of possible complements to traditional physics theory QFT.

- Complementary QFT interaction vertices can correlate with aspects of PDE modeling.
- Complementary QFT interaction vertices do not necessarily correlate only, with respect to spatial coordinates, with points. Vertices can correlate with objects that model as existing within a region having non-zero spatial extent.
- 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 of those objects, all three traditional physics theory kinematics conservation laws and does not necessarily need to embrace the notion of interaction vertices.

The following statements summarize aspects of possible complements to traditional physics theory QED.

- Complementary QED can describe anomalous magnetic dipole moments (and other aspects of physics) via sums over finite numbers of terms. (See discussion related to equation (47).)
- Complementary QED might point to new approaches to atomic physics.
  - A possible approach has bases in the notion that the $\Omega_{SA} r^{-2}$ term in equation (10) might correlate, at least somewhat, with the square of the potential that impacts an electron and in the notion that, in equation (9), the limit $(\xi'_{SA}/2)(\eta_{SA})^{-2} \rightarrow 0$ can pertain while $(\xi'_{SA}/2)(\eta_{SA})^2$ remains a non-zero constant. This work might lead to insight regarding allowed states. This work might not correlate well with abilities to compute energies for states. Herein, we de-emphasize this work.

The following statement summarizes aspects of possible complements to traditional physics theory QCD.

- Complementary QCD may describe allowed states for hadron-like particles and for atomic nuclei, based on PDE modeling. (Regarding internal states for hadron-like particles, see discussion related to table 28. Regarding internal states for atomic nuclei, see discussion related to equation (67).)

Table 28: SA-side kinematics symmetries for complementary physics theory modeling of hadron-like particles (that contain no more than three quarks and arcs) and components of those hadron-like particles

Symmetry	Correlation for hadron-like particles	Elementary particles
$SU(2)$	With one of conservation of linear momentum and conservation of angular momentum	Elementary fermions (or, 1Q and 1R particles)
$SU(2)$	With the other one of conservation of linear momentum and conservation of angular momentum	Gluons (or, 2U particles)
$SU(2)$	(To the extent that modeling for the hadron-like particles includes boost symmetry,) with boost symmetry	Gluons (or, 2U particles)

4.4 Dynamics models for hadrons, nuclear physics, and temporal aspects of transitions

This unit discusses possible aspects of complementary physics theory modeling regarding hadron-like particles, nuclear physics, and temporal aspects of quantum transitions.

4.4.1 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. This unit also calls attention to possible differences between modeling for the dynamics of hadron-like particles that contain no more than three quarks and modeling for the dynamics of hadron-like particles that contain more than three quarks.

We discuss the notion that each hadron-like particle that includes no more than three quarks (or, 1Q particles) and arcs (or, 1R particles) does not include both quarks and arcs. Discussion related to table 8 suggests that a hadron-like particle has a charge for which the magnitude is either zero or a non-zero integer multiple of $|q_e|$ and a baryon number that is either zero or a non-zero integer multiple of one. For a hadron-like particle that includes no more than three quarks and arcs, the restrictions to integer charge and integer baryon number preclude the presence of both quarks and arcs. A tetraquark might contain a matter-and-antimatter pair of quarks and a matter-and-antimatter pair of arcs.

Regarding dynamics in hadrons that contain no more than three quarks, for each of quarks and gluons, traditional physics theory QCD modeling correlates with symmetries, for each of quarks and gluons, that correlate with special relativity. Complementary physics theory suggests possibilities for modeling that correlates one subset of those symmetries with dynamics for quarks and another subset of those symmetries with dynamics for gluons.

Table 28 shows notions that complementary physics theory suggests for modeling aspects of dynamics of hadron-like particles (that contain no more than three quarks and arcs). For example, modeling for one of conservation of linear momentum for a hadron-like particle and conservation of angular momentum for the hadron-like particle correlates with aspects of modeling the elementary fermions that exist within the hadron-like particle. Modeling for the other one of conservation of linear momentum for the hadron-like particle and conservation of angular momentum for the hadron-like particle can correlate either with aspects of modeling the elementary bosons that exist within the hadron-like particle or (for PDE modeling) with the potential that binds the elementary fermions into the hadron-like particle.

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

Reference [30] suggests that some of the dynamics within at least some pentaquarks correlates with the dynamics for a system composed of a meson-like particle (that features a matter quark and an antimatter quark) and a baryon-like particle (that features three matter quarks). Aspects that complementary physics theory correlates with the pie elementary particle and with the cake elementary particle might play roles in such dynamics. Possibly, modeling can consider that, if they exist, some hexaquarks have parallels to atomic nuclei.

4.4.2 Dynamics models for 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 hadrons apart from each other. 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. Cake (or, 0K) bosons might correlate with repulsion between hadrons. Possibly, from a standpoint of modeling, 0K bosons correlate with interactions with colorless color charge or white color charge. Possibly, from a standpoint of modeling, 0K bosons correlate with the identity operator that the relevant (traditional physics theory and complementary physics theory) gluon-related $SU(3)$ symmetry lacks. From a standpoint of modeling, pie (or, 0P) bosons might correlate with attraction between hadrons. Possibly, the attraction correlates with a PDE-centric expression proportional to the term that equation (67) shows and with a Yukawa-like $\exp(-r/|\eta_{SA}|)$ potential. (Here, t denotes the TA-side analog of the SA-side r and $|\eta_{TA}|$ denotes the TA-side analog of the SA-side $|\eta_{SA}|$. The factor $|\eta_{TA}|$ has dimensions of time.) Possibly, from a standpoint of modeling, 0P bosons correlate with the identity operator that the $SU(2)$ component of a relevant weak interaction $SU(2) \times U(1)$ symmetry lacks.

$$\exp(-tr/(|\eta_{TA}| \cdot |\eta_{SA}|)) \tag{67}$$

4.4.3 Dynamics models for quantum transitions

This unit discusses the possibility that aspects of complementary physics theory pertain to temporal aspects of quantum transitions.

People discuss the extent to which quantum transitions correlate with non-zero time intervals. (See, for example, reference [4].) People may have observed quantum transitions that take non-zero time. (See reference [21].)

Possibly, complementary physics theory can model such aspects of transitions via non-point-like temporal vertices. Modeling that features non-point-like temporal vertices might parallel modeling that features volume-like spatial vertices (or spatial potentials) and might be based on $SU(5)$ aspects of conservation of energy. Modeling that features non-point-like temporal vertices might parallel temporal aspects of equation (67). (See, also, discussion regarding equation (66).)

4.5 General relativity and large-scale physics

This unit suggests limits regarding the applicability of modeling based on general relativity and suggests possible opportunities for research regarding modeling various aspects of large-scale physics.

While general relativity comports with various phenomena, people discuss possible problems regarding the applicability of general relativity to large-scale physics. For example, reference [15] states, "... perhaps general relativity does not describe the universe well on the largest scales." Also, people express other concerns regarding modeling pertaining to large-scale physics. For example, reference [25] alludes to possible concerns correlating with the Hubble constant (or, a Hubble parameter).

Complementary physics theory offers possible insight and resolution regarding such concerns.

Complementary physics theory suggests that general relativity might not suffice to the extent that modeling correlates significantly with one isomer of 4G4 and correlates significantly with two or more isomers (of PR6ISe-span-one phenomena) of a long-range force $\Sigma G\Gamma$ other than 4G4. For example, for PR6ISe modeling, during the first era of accelerating rate of expansion of the universe, the six isomers of the set of 4(1)G2468a and 4(1)G2468b forces dominate, with each isomer of force correlating with a unique one of six isomers of non-zero-charge (or, PR6ISe-span-one) elementary fermions. Effects correlating with any one of the six isomers of PR6ISe-span-one phenomena do not necessarily correlate significantly with the motion of objects correlating with any of the other six isomers of PR6ISe-span-one phenomena.

Complementary physics theory offers the following possible opportunities, tests, and challenges regarding general relativity.

- The extent to which general relativity correlates with effects of components, other than 4G4, of 4γ might be an open question. For example, for PR1ISe models, to what extent do effects that correlate with 4G48 correlate with the general relativity concept of rotational frame-dragging (or, the Lense-Thirring effect)?

- The span of 4(2)G48 is less than the span of 4(6)G4. This mismatch regarding spans suggests that PR6ISe and PR36ISe models based solely on general relativity might not accurately portray aspects regarding the presently accelerating rate of expansion of the universe. This mismatch might provide a basis for improving on traditional physics theory modeling.

- The spans of 4(1)G2468a, 4(1)G2468b, and 4(1)G246 are less than the span of 4(6)G4. This mismatch regarding spans suggests that PR6ISe and PR36ISe models based solely on general relativity might not accurately portray aspects regarding large-scale effects in eras that precede the present era of accelerating rate of expansion of the universe. This mismatch might provide a basis for improving on traditional physics theory modeling.
- Six isomers of 4(6)G4 pertain for PR36ISe models. General relativity might pertain somewhat for each PR6ISe isomer and might not pertain across PR6ISe isomers.
- Effects of non-4G4 components of 4γ can be significant for aspects of galaxy evolution.

Our work suggests nominal long-range forces correlating with $\Sigma \geq 6$ (or, $S \geq 3$). (Here, the word nominal contrasts with the word anomalous.) However, under almost all circumstances, nominal long-range forces for which $\Sigma = 4$ or $\Sigma = 2$ might be 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 general relativity; the notion and applicability of the concept of a Hubble parameter; notions regarding geodesic motion; and the spans and the strengths of forces correlating with the 4G48, 4G246, 4G2468a, and 4G2468b solutions.

4.6 The elementary particle Standard Model

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

At least 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, basic particles and long-range forces that complementary physics theory 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, at least to the extent that one models the universe as being a confined environment, the following statements pertain.

- The aye (or, 0I) boson correlates with the Higgs mechanism 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.

Complementary physics theory QFT suggests interaction vertices that correlate with the nine-element term point-like with respect to temporal aspects of interaction vertices and with the nine-element term volume-like with respect to spatial aspects of interaction vertices. Possibly, people would interpret these vertices and other aspects of complementary physics theory as correlating with tachyon-like behavior.

4.8 Supersymmetry and string theory

This unit notes that complementary physics theory is not necessarily compatible with supersymmetry and that aspects of complementary physics theory might help people explore the relevance of string theory to elementary particle physics.

Possibly, tables 3 and 10 are not, in themselves, compatible with supersymmetry. Speculatively, people might explore the notion of layering supersymmetry over results that tables 3 and 10 show. However, given aspects of complementary physics theory, supersymmetry might not be necessary to explain known phenomena.

String theory correlates with notions of space-time frothiness on the scale of the Planck length (or, $R_2(m)$). (See equation (53).) Complementary physics theory suggests that there might be no need to appeal to such frothiness in order to limit sums of boson ground state energies. Possibly, leaving aside some mathematical aspects of complementary physics theory, complementary physics theory does not necessarily require that elementary particles have zero size. The Planck length might correlate with a size for elementary particles that have non-zero spin. (See equation (53).) The Schwarzschild radius might correlate with a size for elementary particles that have zero spin. (See equation (52).) Speculatively, the disparity between these two sizes might lead to means to explore making string theory more relevant to elementary particle physics that it has proven to be.

4.9 Relative strengths of electromagnetism and gravity

This unit suggests concepts that may correlate with a traditional physics theory notion that the strength of gravity is much less than the strength of electromagnetism.

For this discussion, we assume that we can work within aspects of complementary physics theory that de-emphasize translational motion. Below, the symbol 1f correlates with a non-zero-charge non-zero-mass elementary fermion that pertains throughout the discussion. We confine our attention to 1f1b→1f1b interactions such that the exiting elementary fermion is the same as the entering elementary fermion. The elementary fermion correlates (as do all elementary fermions) with $S = 1/2$ (or, $\Sigma = 1$). Regarding modeling, we assume that no translational motion pertains. Hence, no kinematic angular momentum pertains. We assume that conservation of angular momentum pertains. Below, in a symbol of the form 1f1b($\Sigma =$ _), the expression $\Sigma =$ _ pertains for the boson.

The expression that equation (68) shows can correlate with interactions in which the incoming boson correlates with 2G2. The interaction flips the spin orientation of the elementary fermion. The exiting 1b correlates with zero spin. The spin-zero boson might be a 0I boson, which has no mass and no charge. The expression 1f1b($\Sigma = 2$)→1f1b($\Sigma = 4$) can also pertain.

$$\mathrm{1f1b}(\Sigma = 2) \rightarrow \mathrm{1f1b}(\Sigma = 0) \tag{68}$$

Regarding 4G4, the expression 1f1b($\Sigma = 4$)→1f1b($\Sigma = 0$) does not correlate, within our thought experiment, with interactions. Conservation of angular momentum cannot pertain. The expression 1f1b($\Sigma = 4$)→1f1b($\Sigma = 2$) can pertain. The expression 1f1b($\Sigma = 4$)→1f1b($\Sigma = 6$) can pertain.

The expression 1f1b($\Sigma = 2$)→1f1b($\Sigma = 0$) can pertain for each of the following cases - 1b($\Sigma = 2$) correlates with 2G, 1b($\Sigma = 2$) correlates with 2W, and 1b($\Sigma = 2$) correlates with 2U. This notion might correlate with traditional physics theory notions that correlate with relationships between the strengths of the electromagnetic, weak, and strong interactions.

Possibly the notion that 1f1b($\Sigma = 4$)→1f1b($\Sigma = 0$) does not pertain for 4G4 correlates with traditional physics theory notions that the strength of gravity is much less than the strength of electromagnetism.

4.10 Arrow of time and entropy

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

We discuss aspects regarding arrow of time.

Equation (67) suggests a $\Psi(t, r)$ that correlates with the TA0-and-SA0 oscillator pair. (See equation (12).) The domains $t \geq 0$ and $r \geq 0$ pertain for $\Psi(t, r)$. Without loss of generality, we posit that $\eta_{TA} > 0$ pertains regarding after an interaction, $\eta_{TA} > 0$ does not pertain regarding before an interaction, $\eta_{TA} < 0$ pertains regarding before an interaction, and $\eta_{TA} < 0$ does not pertain regarding after an interaction. We posit that that $\eta_{SA} > 0$ pertains regarding elementary particles that exit an interaction, $\eta_{SA} > 0$ does not pertain regarding elementary particles that enter an interaction, $\eta_{SA} < 0$ pertains regarding elementary particles that enter an interaction, and $\eta_{SA} < 0$ does not pertain regarding elementary particles that exit an interaction. Of the four possibilities - $\eta_{TA} > 0$ and $\eta_{SA} > 0$, $\eta_{TA} < 0$ and $\eta_{SA} < 0$, $\eta_{TA} > 0$ and $\eta_{SA} < 0$, and $\eta_{TA} < 0$ and $\eta_{SA} > 0$, mathematically, Ψ normalizes for only the first two possibilities. To the extent that this modeling correlates with the topic of arrow of time, the lack of dual normalization regarding each of the case of incoming and the case of outgoing might provide insight.

The complementary physics theory notion that modeling of conservation of energy correlates with an $SU(5)$ symmetry (and not necessarily with a traditional physics theory notion of $S1G$ symmetry) might provide insight regarding the topic of arrow of time. Complementary physics theory tends to correlate $SU(\_)$ symmetries with origins (with respect to coordinates) and with radial coordinates.

We discuss aspects regarding entropy.

Speculatively, interactions correlating with the 8G8 solution catalyze, in some situations, increases in entropy. (See discussions related to tables 12 and 14.)

4.11 Numbers of dimensions

This unit speculates regarding one aspect of the topic of numbers of dimensions.

Complementary physics theory suggests that, at least in some sense, a number - three - of spatial dimensions correlates with $D^*_{SA} = 3$ and a number - one - of temporal dimensions correlates with $D^*_{TA} = 1$.

For a hypothetical five spatial dimensions and $D^*_{SA} = 5$, for an elementary fermion, the particle might correlate with $\nu_{SA} = -5/2$ and modeling might suggest relevance for two fields. One field could correlate with $\nu_{SA} = -1/2$. One field could correlate with $\nu_{SA} = -3/2$. The notion of two fields might correlate with a lack of physics relevance.

4.12 One notion regarding possible universes beyond our universe

This unit speculates about one notion regarding possible universes beyond our universe.

The ratio of the number of generators of $SU(17)$ to the number of generators of $SU(7)$ is six (or, 288/48). Regarding discussion regarding equation (58), this factor of six might correlate with a $\pi_{r,b,g}$ symmetry correlating with red, blue, and green color charges and with oscillators TA6, TA5, and TA0. (See table 26.)

Possibly, in the context of $\sigma_{17} = -1$, the factor of six correlates with a $U(1)$ symmetry (for which the number of generators is two) and an $SU(2)$ symmetry (for which the number of generators is three). (See discussion related to equation (58).) Speculatively, one or more of the following notions might pertain.

- Our universe is one of either two or six universes in a so-called larger-scale universe that includes, respectively, two or six objects of the scale of our universe.
- A big bang for the larger-scale universe created, in effect, our universe and an anti-universe.
- A traditional physics theory somewhat analog of a possible T-symmetry-related conservation of energy pertains across the creation of this our-universe and anti-universe pair.

4.13 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.
- Eras regarding the rate of expansion of the universe.
- Dark matter baryon-like acoustic oscillations, plus effects of those acoustic oscillations that lead to at least some aspects of dark matter filaments.
- Clumping that forms various objects, such as stars and galaxies.
- 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 that the universe underwent an inflationary epoch, the epoch might have correlated with such changes regarding sea states, with the formation of baryon asymmetry, or (at least to some extent) with 4G2468a and 4G2468b repulsion.
- Scenarios regarding clumping suggest that early black holes contained stuff correlating with essentially just one isomer of PR6ISe-span-one phenomena. 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 of PR6ISe-span-one phenomena.
- Significant aspects of quasars, black hole jets, and blazars might correlate with effects of the 4G48 repulsive long-range force.

- Significant aspects of black hole or neutron star collisions might correlate with effects of the 4G48 repulsive long-range force. Collisions for which the colliding objects correlate with one isomer of 4G48 might produce observable effects that differ from observable effects correlating with collisions for which the colliding objects do not share an isomer of 4G48.
- Complementary physics theory is not incompatible with possible large-scale flatness for the universe.

4.14 Other discussion regarding elementary particle masses or perceived masses

This unit explores concepts related to elementary particle masses and to masses, as perceived via traditional physics theory, related to elementary particles. Aspects include perceived masses of neutrinos, masses of arc elementary particles, masses of charged leptons, masses of quarks, and masses of tweak bosons.

We explore the possibility that complementary physics theory can estimate the traditional physics theory non-zero lower bound for the sum of the masses of the three neutrinos. (See equation (35).)

For $\gamma 2$ solutions, interaction strengths may scale in proportion to $\alpha^{\Sigma/2}$ (See discussion related to equation (50).) The strength correlating with an 8GΓ solution might be approximately α^2 times the strength correlating with the corresponding 4GΓ. The expression $\alpha^2 m_e$ evaluates to $0.027 eV/c^2$ and might correlate mathematically with each of the three neutrinos. The correlation is not directly physics-relevant because 8G8 does not interact with individual neutrinos. Possibly, the notion of $\alpha^2 m_e$ carries over to aspects correlating with 8G2468a and 8G2468b, which do interact with neutrinos. Possibly, for three neutrinos, these results are not necessarily incompatible with the traditional physics theory estimate that equation (35) shows.

We note concepts regarding the masses of neutrinos and arcs (or, 1R particles). Possibly, people can benefit from considering that, for neutrinos and arcs, analogs to table 19 and equation (37) pertain. The analogs would be based on replacing, in equation (37), m_e with $m_v = 0$; replacing, in table 19, the unit of charge $|q_e|$ with $q_\nu = 0$; noting that, in table 19, each calc item would show a mass of zero; assuming, in table 19, that each data item shows a mass of zero; and, in table 19, changing the names of the particles. Here, the subscript $_\nu$ denotes neutrino.

We explore concepts related to the lack of equality in equation (69). (See table 19 and equation (37). Note that, respectively, for the electron, muon, and tauon, the values of M'' are zero, two, and three.) Doing so might lead to insight about the term $(j^{''}_{M''})d''$ in equation (37). We determine a quantity ω_e that has units of mass; that might correlate mathematically, but not physically, with 8G8 strength related to all three charged leptons; and that satisfies equation (70). (8G8 does not interact with individual elementary fermions and might not interact significantly with multicomponent objects.) The result $\omega_e \approx 0.3486\, MeV/c^2$ pertains. This result is somewhat less than the mass of the electron. This result does not necessarily comport with work just above regarding $\alpha^2 m_e$. As yet, we do not find the exploration of ω_e to be physics-relevant.

$$m_\mu^2/m_e^2 < (m_\tau^2/m_\mu^2)^2 \tag{69}$$

$$(m_\mu^2 - \omega_e^2)/(m_e^2 - \omega_e^2) = ((m_\tau^2 - \omega_e^2)/(m_\mu^2 - \omega_e^2))^2 \tag{70}$$

We explore a similar concept regarding quarks and 6G6. Equation (71) pertains. (See equation (37).) The result $\omega_q \approx 3.02\, MeV/c^2$ pertains. This result might be somewhat less than the geometric mean of the experimental masses of the up and down quarks. (See table 19. Regarding equation (71), the notion of $m(M'', 3/2)$ correlates with the factor of 3/2 that appears in equation (37) and with the notion that $j^{'}_{3/2} = 0$.)

$$((m(1,3/2))^2 + \omega_q^2)/((m(0,3/2))^2 + \omega_q^2) = ((m(2,3/2))^2 + \omega_q^2)/((m(1,3/2))^2 + \omega_q^2) \tag{71}$$

We are uncertain as to possible significance for the notion that each of ω_e and ω_q is somewhat similar to the masses of the respectively relevant generation-one elementary fermions.

We explore possibilities regarding masses for T-family bosons.

Work above correlates with the notion that the charge of the $\mathrm{T}^\pm$ boson is one-third the charge of the W boson. (See discussion related to table 8.) Aspects regarding charge are additive and correlate with $U(1)$ and $\pi_{0,-1}$ symmetry. None of linear, $U(1)$, and $\pi_{0,-1}$ pertains regarding mass. Presumably, none of linear, $U(1)$, and $\pi_{0,-1}$ pertains regarding squares of mass.

Speculatively, the $0\mathrm{G}\Gamma'$ solution correlates with U-family physics. (See remarks related to equation (20).) 2U particles (or, gluons) have zero mass. Zero mass correlates with $S'' = 0$. (See, in table 18, the column labeled $D + 2\nu$.) Possibly, we can, in effect, extrapolate from $S'' = 0$ for U-family physics and $S'' = 3$ for W-family physics to $S'' = 7$ for T-family physics. The equation $S'' = 7$ would correlate with allowed values of λ of two, four, six, eight, 10, 12, and 14 and provides the first possibility (beyond the limit $\lambda \leq 8$) to have G-family-like solutions for which $\Sigma = 0$. For $S'' = 7$, $D + 2\nu = 50$. Complementary physics theory suggests that equations (72) and (73) might pertain regarding the masses of T-family bosons. (Here, we allow for the possibilities of adding or subtracting the integers - correlating with $S'' = 0$, $S'' = 1$, and $S'' = 2$ - correlating with the oscillator pairs TA2-and-TA1 and SA1-and-SA2.) Based on data from reference [31] regarding the Higgs boson, the rest energies of the T-family bosons might be between ~ 208 GeV and ~ 221 GeV.

$$47/17 \leq (m_{T^\pm})^2/(m_{H^0})^2 \leq 53/17 \tag{72}$$

$$49/17 \leq (m_{T^0})^2/(m_{H^0})^2 \leq 51/17 \tag{73}$$

5 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 of 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 that we make.

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