Extract 1 from

Some Physics United

With Predictions and Models for Much

Thomas J. Buckholtz

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Research - link

Book - link

ISBN: 1982073934

ISBN13: 978-1982073930

Library of Congress Control Number: 2018900118

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Edition 1

At the time of publication of this edition, ...

- The author received e-mail via the address Thomas.J.Buckholtz@gmail.com.
- The author had a website at http://thomasjbuckholtz.wordpress.com.

ISBN: 1982073934
ISBN13: 978-1982073930
Library of Congress Control Number: 2018900118
CreateSpace Independent Publishing Platform, North Charleston, SC

Printed by CreateSpace Independent Publishing Platform, North Charleston, SC

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Preface

Just one theory for much physics
What a triumph it might be
If indeed it does comport with
Dark matter and gravity

Physics presents opportunities for enhancing the breadth and unity of physics. Opportunities exist to broaden theory to predict new elementary particles and to explain dark matter, dark energy, aspects of the cosmology timeline, and other phenomena. Opportunities exist to unite aspects of the elementary particle Standard Model, special relativity, quantum mechanics, general relativity, atomic physics, and classical physics.

Such opportunities sum to a broad agenda. Attempts to add such breadth and unity seem to have hit impasses. Perhaps it is time to tackle an unsolved problem, via a new approach.

We try to develop a basis for cataloging known elementary particles and predicting other elementary particles. The approach involves math that, while not very deep, seems to have been historically de-emphasized, seems to provide a basis for cataloging and predicting elementary particles, and seems to provide a basis for integrating historically useful physics theories and models.

Aspects, models, and theories that we correlate include elementary particles and their properties, the elementary particle Standard Model, dark matter, dark energy, the cosmology timeline, some astrophysics, special relativity, general relativity, quantum mechanics, some atomic physics, and some classical physics.

We hope that this work provides, at least, precedent and impetus for people to try to tackle such a broad agenda. This work may provide a means to tackle such an agenda. This work may provide progress toward fulfilling that agenda.

- Thomas J. Buckholtz

Portola Valley, California USA
January 2018

To Helen Buckholtz

In memory of Joel and Sylvia J. Buckholtz

With appreciation to each of many people who contributed to my being able to attempt this work

Abstract

We address four physics opportunities. First, predict new elementary particles and forces. Second, explain phenomena such as dark matter. Third, unite physics theories and models. Fourth, point to opportunities for further research.

We use models based on solutions to equations featuring isotropic pairs of isotropic quantum harmonic oscillators.

First, we show solutions that match the known elementary particles. We propose that other solutions correlate with elementary particles that people have yet to detect and with dark energy forces leading to the three known eras - initial acceleration, subsequent deceleration, and current acceleration - pertaining to the rate of expansion of the universe.

Second, we extend solutions to encompass known conservation-law symmetries. We note that extended solutions correlate with known kinematics. We propose that extended solutions describe dark matter, explain ratios of density of dark matter to density of ordinary matter, correlate with dark energy density, and explain other phenomena.

Third, we note that the work unites, extends, and limits aspects of traditional physics. Those aspects include classical physics, special relativity, general relativity, quantum mechanics, the elementary particle Standard Model, and the cosmology timeline. The work provides possible insight regarding foundations of physics topics.

Fourth, we suggest opportunities for people. We suggest opportunities for observational, experimental, and theoretical physics research. We point to possible opportunities to further develop and apply math we use.

Summary

This work predicts new physics phenomena; explains known particle, astrophysics, and cosmology phenomena; embraces various theories of motion; points to possible alternatives to some quantum dynamics theories; and may provide insight regarding some foundation of physics topics. This work points to itself via the term CUSP, which is an acronym for the phrase concepts uniting some physics.

Predicted phenomena include elementary particles and composite particles. Explained phenomena include dark matter, dark matter densities, dark energy forces, and dark energy densities. The CUSP framework embraces Newtonian physics, special relativity, and general relativity. CUSP embraces and points to possibilities for alternatives for each of QED (or, quantum electrodynamics) and QCD (or, quantum chromodynamics).

The CUSP framework features modeling based on solutions to equations that feature isotropic pairs of isotropic quantum harmonic oscillators. People can, without considering motion, list solutions that correlate with all known elementary particles and with the possible elementary particles and forces CUSP predicts.

This summary de-emphasizes some aspects of CUSP that may be useful for explaining known phenomena. Explaining known phenomena does not necessarily require that all predictions CUSP makes comport with nature.

Predicted elementary particles and forces

Predicted elementary particles include six low-mass or zero-mass analogs to quarks, one fractional-charge analog to the W boson, one analog to the Z boson, and three zero-mass particles that belong to a family of four particles that includes photons.

The fractional-charge analog to the W boson would have a charge of one-third the charge of a W boson. The fractional-charge analog would have an antiparticle with a charge that is the negative of the charge of the analog particle. Unlike the W and Z bosons, the analog bosons would not be free-ranging.

Before discussing the family of zero-mass bosons that includes the photon, we note that CUSP develops descriptions and predictions regarding elementary particles before CUSP offers options to make a choice to add symmetries correlating with a kinematics model, such as Newtonian physics, special relativity, or general relativity; to make a choice between modeling based on classical physics and modeling based on quantum mechanics; and to make a choice between modeling that is linear in energy and modeling that is quadratic in energy. Regarding stationary electromagnetism, for the earth, we expect CUSP models to allow for at least an r^{-2} monopole force correlating with the charge (if any) of the earth and an r^{-3} magnetic dipole force correlating with the magnetic field of the earth. Here, the notation r^{-n} correlates with Newtonian physics expressions for the radial spatial (or, r) dependence of forces. Possibly, models should accommodate an r^{-4} (or, quadrupole) force, because the axis of rotation for the earth does not align with the axis correlating with the magnetic dipole field of the earth. Similar concepts pertain to stationary electromagnetism correlating with an electron. We expect an r^{-2} force correlating with charge and an r^{-3} force correlating with nominal magnetic dipole moment. Perhaps an r^{-4} interaction correlates with Larmor precession.

Without considering kinematics, CUSP outputs characteristics for interactions mediated by the family of zero-mass bosons that includes photons. CUSP photons have spin one and can intermediate an r^{-4} (or, quadrupole) force, along with the r^{-3} magnetic dipole force and the r^{-2} electrostatic monopole force. CUSP gravitons have spin two and can intermediate each of an r^{-2} (or, monopole) attractive force, r^{-3} (or, dipole) repulsive force, r^{-4} (or, quadrupole) attractive force, and r^{-5} (or, octupole) repulsive force. CUSP predicts a zero-mass force carrier with a spin of three and a zero-mass force carrier with a spin of four.

Predicted composite particles

The CUSP framework points to types of composite particles. One type includes the known composite particles. Each known composite particle includes quarks and gluons. CUSP points to possibilities for composite particles that, internally, include gluons, the low-mass or zero-mass analogs to quarks, and no quarks; composite particles that include quarks and the predicted analogs to the Z and W bosons; and composite particles that include the low-mass or zero-mass analogs to quarks and the predicted analogs to the Z and W bosons.

Kinematics conservation laws and ensembles

The CUSP framework can embrace known kinematics through the addition of symmetries correlating with kinematics conservation laws. People can incorporate into CUSP an $SU(2)$ symmetry that correlates with conservation of angular momentum and an $SU(2)$ symmetry that correlates with conservation of momentum. People can add another symmetry, that, depending on the choice and interpretation of the symmetry, correlates with modeling kinematics correlating with Newtonian motion, special relativity, or general relativity. Regarding special relativity, the symmetry is an $SU(2)$ symmetry and correlates with boost. Because of a feature of CUSP modeling that people might say parallels accounting's double-entry bookkeeping, adding the two conservation law symmetries and the possibly boost symmetry adds another symmetry. The other symmetry is an $SU(7)$ symmetry. In CUSP, this $SU(7)$ symmetry supplants the one-generator Poincare-group symmetry that people correlate with conservation of energy. The $SU(7)$ symmetry correlates with conservation of energy and correlates with the possibilities that nature includes, in essence, 48 so-called ensembles, with each ensemble consisting of a set of free-ranging elementary particles and composite particles.

Each ensemble features its own instance of all known free-ranging elementary particles, all known composite particles, some predicted elementary particles, and all predicted composite particles. Each ensemble includes its own instance of photons and its own instance of Higgs bosons. Particles within each ensemble scarcely interact with the photons associated with other ensembles. Particles within each ensemble do not interact with the Higgs bosons associated with other ensembles.

Dynamics, composite particles, and a possible alternative to QCD

CUSP aspects related to composite particles point to the combining of dynamics symmetries correlating with, for example, quarks and dynamics symmetries correlating with, for example, gluons to form kinematics symmetries appropriate to free-ranging composite particles. The symmetries related to quarks fall short of the symmetries related to free-ranging composite particles. The symmetries related to gluons fall short of the symmetries related to free-ranging composite particles. In QCD, people use free-ranging kinematics symmetries to model quarks and gluons. The CUSP approach that combines the more-limited quark dynamics symmetries and the more-limited gluon dynamics symmetries points to possibilities for an alternative to QCD. The CUSP approach associates uniquely each one of the 48 instances of composite particles with one the 48 kinematics-centric ensembles. Within the CUSP mathematical modeling framework, fermion components of composite particles correlate with six instances and have spans of eight ensembles. Boson components of composite particles correlate with eight instances and have spans of six ensembles.

Spans for components of gravity

Based on symmetries, the CUSP framework points to a number of ensembles that each component of gravity spans. There are eight instances of the r^{-2} (or, monopole) component of gravity. Each instance spans (or, intermediates interactions between and within) six ensembles. There are 24 instances of the r^{-3} (or, dipole) component of gravity. Each instance spans (or, intermediates interactions between and within) two ensembles. There are 48 instances of the r^{-4} (or, quadrupole) component of gravity. Each instance spans (or, intermediates within) one ensemble. There are 48 instances of the r^{-5} (or, octupole) component of gravity. Each instance spans (or, intermediates within) one ensemble.

Dark matter and dark matter densities

CUSP models point to an explanation for dark matter and an explanation for the dark matter density of the universe. Inferences about dark matter within galaxy clusters seem to be not inconsistent with density ratios of about five to one, dark matter to ordinary matter. CUSP suggests that this ratio correlates with the ratio of number of dark matter ensembles to number of ordinary matter ensembles. Inferences about dark matter correlate with density of the universe ratios of about or somewhat more than five to one, dark matter to ordinary matter. CUSP suggests that, to the extent the actual ratio is $5 + x$ to one, people can consider adding a component correlating with $x/6$ to the otherwise inferred density of ordinary matter. People calculate ordinary matter density of the universe by summing densities for baryonic matter, photons, and neutrinos. CUSP suggests that a fourth component, correlating with $x/6$, might correlate with ordinary matter composite particles other than composite particles made exclusively from quarks and gluons. (Some of these composite particles would not interact with light.) This explanation suggests that, in ordinary matter galaxies, dark matter halos can include one or both of other-ensemble material and ordinary-ensemble composite particles.

Galaxy formation, galaxy evolution, and dark matter densities

CUSP suggests mechanisms underlying the formation and evolution of galaxies. A CUSP-based scenario seems to dovetail with data published during the period 2015 to 2017. Early on, an ordinary matter galaxy can be essentially all ordinary matter. Over time, the galaxy attracts and accumulates other-ensemble dark matter, leading to about 79 percent of the galaxy being dark matter. The scenario features mechanisms that correlate with the monopole and dipole components of gravity and with electromagnetism. The scenario is not incompatible with notions that more than 83 percent of a galaxy cluster may be dark matter and that about five-sixths of the galaxies in a cluster may be dark matter galaxies. This explanation is not incompatible with the existence of ordinary matter stars in dark matter galaxies. This explanation is not incompatible with collisions between essentially single-ensemble galaxies creating mixed-ensemble galaxies and/or deformed or irregular galaxies. To the extent traditional theories of galaxy formation might suggest that concepts above would correlate with galaxies not being adequately spatially large, the repulsive force of the dipole component of gravity might contribute to adequate dispersal of stuff.

Dark energy forces and dark energy densities

CUSP differentiates between dark energy forces and dark energy densities.

The three non-monopole aspects of gravity provide for dark energy forces. These forces lead to phenomena people correlate with the term rate of expansion of the universe. Regarding interactions between the largest objects that people can directly infer, repulsion based on the r^{-5} component of gravity led to the initial few billion years of accelerating expansion, attraction based on the r^{-4} component of gravity led to the subsequent few billion years of decelerating expansion, and repulsion based on the r^{-3} component of gravity led to the recent few billion years of accelerating expansion.

Dark energy density correlates with instances of the combination of gravity plus six ensembles, with none of these ensembles being the ordinary matter ensemble or the dark matter ensembles. These instances of gravity do not interact with ordinary matter or dark matter. The instance of gravity that interacts with ordinary matter and dark matter does not interact with ensembles that correlate with dark energy densities. Other interactions, not correlating with light or gravity, provide indirectly for abilities to infer the presence of dark energy stuff. One candidate for interactions between ordinary matter or dark matter and dark energy stuff features transfers, between entities, of the zero-mass or low-mass analogs to quarks.

CUSP explains why inferred densities of dark energy stuff need not equal the predicted actual density of seven times the density of ordinary matter plus dark matter.

Envisioning dark matter and dark energy stuff

Each of the 48 ensembles is identical, regarding elementary particles and composite particles, to each other ensemble. (Some practical differences, such as differences correlating with baryon asymmetry, may exist.) Presumably, a galaxy that features stuff other than ordinary matter stuff could include physics-savvy beings who could infer, from their perspective, dark matter densities and dark energy densities. Relationships between ensembles are reciprocal. Two different ensembles are exactly one of each other's dark matter or each other's dark energy. People can, by looking at ordinary matter they see, envision much about what people consider to be dark matter and much about what people consider to be dark energy stuff.

Anomalous magnetic moments and a possible alternative to QED

CUSP aspects, that for example embrace magnetic dipole moments and predict multipole aspects of gravity, include solutions that correlate with anomalous multipole moments. Some of these solutions may provide a straightforward way to model anomalous magnetic dipole moments and other electromagnetic anomalous multipole moments. One application estimates an anomalous magnetic dipole moment for the tauon that is similar to an estimate people make via the Standard Model. CUSP may point to possibilities for an alternative to QED.

Other elementary particle phenomena

CUSP describes mechanisms that catalyze neutrino oscillations, even if each neutrino flavor has zero mass. CUSP links the range of the weak interaction and the masses of weak interaction bosons. CUSP explains the weak mixing angle.

Other astrophysics and cosmology phenomena

To the extent the universe started with no baryon asymmetry, interactions involving the not-free-ranging analog to the W boson converted antimatter quarks into matter quarks and were essential to creating baryon asymmetry.

To the extent the universe had an inflationary epoch, the epoch might correlate with the creation of baryon asymmetry and/or at least one phase change within a sea of not-free-ranging elementary fermions and not-free-ranging elementary bosons. CUSP predicts two types of not-free-ranging elementary fermions and two types of not-free-ranging elementary bosons. Thus, CUSP predicts possibilities for at least four phases for such seas.

Other aspects of modeling

CUSP includes a double-entry bookkeeping version of $SU(3) \times SU(2) \times U(1)$ symmetry regarding known elementary bosons. CUSP points to commonalities among kinematics theories and to possible limitations regarding the applicability of specific kinematics theories. CUSP points to possibilities for including, in the elementary particle Standard Model, predicted elementary particles.

Physics constants

CUSP notes arithmetic relationships between some physics constants. For example, CUSP predicts the tauon mass to more accuracy than the measured mass as of the year 2017. The predicted standard deviation reflects the standard deviation for measurements of the gravitational constant.

Foundations of physics

CUSP possibly contributes insight regarding foundations of physics topics including CPT-related symmetries, arrow of time, and numbers of dimensions.

Opportunities for research

CUSP points to opportunities, throughout and beyond topics mentioned above, for research. Bases for opportunities include further analyzing data known as of the year 2017, making new observations, conducting new experiments, and developing new theories and models. Bases for opportunities include further developing and applying mathematics underlying CUSP.

Chapter 1

Perspective - before and about this work

This unit discusses context for this work, notes the scope of this work, previews aspects of the approach this work takes, notes some similarities and differences between this work and traditional physics, discusses some aspects of this presentation of this work, and provides a list of acronyms.

1.1 Context for this work

This unit discusses context for this work.

Physics discusses aspects of nature. Physics includes models of aspects of nature.

People derive, from models, practical value and emotional value.

Models evolve. People test the practical scope of a model. People hone the model. People develop related models. People extend the practical scope of models.

A theory provides a basis for producing and correlating models.

We think that attention to overlaps and distinctions between observations, models, and inferences is useful. Table 1.1 lists topics for which attention to overlaps and distinctions may provide insight. Some aspects of discussions of nature feature observers and observations. Observations can include results from experiments. Some aspects of discussions of nature feature modelers and models. Models can include theories. Some aspects of discussion of nature feature inference-makers and inferences. Inferences can include results of using models to extrapolate from known observations to possible observations. Extrapolation can include interpolation. When discussing nature, people use language. Language can include words and mathematical expressions. Interpretation of language can include literal interpretation and emotional interpretation.

Table 1.2 shows names or themes for some physics theories and models. Physics includes the first six items. As of 2017, physics may lack an adequately useful theory or model that outputs information about elementary particles and their properties.

Each of the first six theories or models has roots in people's efforts to model and understand specific phenomena. Overlaps between the six theories or models exist. For example, people integrate aspects of special relativity and aspects of quantum mechanics. People use such an integration to explain phenomena that people discuss based on classical (or, Newtonian) mechanics and/or classical electrodynamics.

People recognize that each one of some of the first six theories or models likely is incomplete. For example, people know of phenomena for which people think that elementary particles yet to be described or added to the Standard Model may play integral roles. Perhaps dark matter includes elementary particles that people have yet to describe, detect, or infer.

People recognize that each one of some of the first six theories or models does not necessarily integrate well with other ones of the first six theories or models. For example, people try to integrate quantum mechanics and general relativity.

People might recognize the possibility that people do not know the extents to which to try to explain some phenomena based on possibilities for improving individual models, integrating models, and/or developing other

Topic
• Aspects of nature being observed • Techniques for measuring aspects of nature • Environments in which measurements take place • Inferences people derive from observations • Aspects of nature being modeled • Models people try to apply • Inferences people derive from models • Symmetries correlating with models • Mathematics bases for models • Language people use • Other

Table 1.1: Topics regarding nature, observations, models, and inferences

Name or theme	Status (as of 2017)
Classical physics	Established and possibly evolving
Special relativity	”
Quantum mechanics	”
General relativity	”
Elementary particle Standard Model	”
Cosmology timeline	”
Elementary particles and their properties	Needed

Table 1.2: Some physics theories and models

models. A likely example features phenomena people correlate with the term rate of expansion of the universe.

Regarding the elementary particle Standard Model, as of 2017, people seem not to have a list of candidates for new elementary particles, other than perhaps a graviton. Before 2017, people used aspects of the evolving Standard Model to predict particles such as the Higgs boson. As of 2017, people may not have extrapolated from the Standard Model to yet new elementary particles. People might consider the concept that the 2017 Standard Model includes, as an input to the model, a list of known elementary particles.

We think traditional physics lacks a model for elementary particles and their properties. Perhaps, people can use such a model to provide inputs, including a list of possible particles, to work evolving the elementary particle Standard Model. Perhaps people can learn, from such a model for elementary particles, concepts for integrating aspects of all seven theories or models.

TBD

This unit lists opportunities people might want to pursue. (This unit typifies other similarly titled units below. In each such similar unit, there is no introductory paragraph.)

1. Throughout physics and physics-related models, to what extent do topics table 1.1 lists correlate, at least pairwise, with each other?

1.2 Scope of this work

This unit summarizes the scope of this work.

We provide a basis for theories and models that may pertain to and integrate aspects of physics that people correlate with topics including elementary particle physics, atomic physics, dark matter, dark energy, astrophysics, and cosmology.

We develop the basis to develop models that correlate with elementary particles. Using that basis, we develop models that correlate with all known and some possible elementary particles. By extending that basis, we possibly provide means to do the following activities. We attempt to do aspects of the following activities.

1. Predict elementary particles.

2. Provide steps toward understanding contexts for, understanding the scopes of, adding aspects to, and extending the scopes of theories and models that table 1.2 lists.

3. Provide theory correlating with and integrating aspects of theories and models that table 1.2 lists.

4. Explain aspects of various observed or inferred phenomena, including dark matter, dark energy density of the universe, and the rate of expansion of the universe.

Possibly, our work correlates with each of the following statements.

1. Transit the state of physics regarding elementary particles that nature includes from inferences but no established theory to a theory of what (or, a theory that matches inferences).

2. Transit the state of physics regarding various aspects of elementary particle physics and various aspects of cosmology from inferences and possibly some theory to theory and models of how (or, how, given other aspects of our work and/or traditional work, to explain the inferences).

3. Provide bases for uniting theories and models.

4. Provide possible bases for simplifying applications of physics theories and models for the purposes of various applications of physics.

TBD

1. To what extent does work herein provide bases for useful predictions?

2. To what extent does work herein provide bases for useful explanations?

3. To what extent might work herein help extend theories and models, help unify theories and models, help people understand the ranges of applicability of theories and models, and so forth?

1.3 Approach underlying this work

This unit discusses aspects of approaches underlying this work, including the notion that this work explores the elementary particles that nature can and might include before this work incorporates aspects of kinematics and dynamics.

Physics addresses topics including objects nature includes, interactions between objects, and motions of objects.

Our approach features modeling the elementary particles that nature includes before modeling motion. We rely on the traditional physics notion that models for interactions can have bases in models for bosons. Thus, our approach addresses aspects of interactions before our approach addresses motion.

Our approach to the topic of elementary particles and interactions that comport with nature features modeling based on mathematics. The combination of modeling techniques and underlying mathematics lends itself to adding motion by adding symmetries that traditional physics correlates with conservation laws and with motion.

This approach conceptually allows including at least 32 types of theories and models of motion. Here, $32 = 2 \times 4 \times 2 \times 2$. (See table 2.5.) One factor of two correlates with a choice between FREERANG (or, free-ranging motion) and BOUNSTAT (or, bound-state systems). The factor of four correlates with abilities to incorporate, via symmetries, at least NE (or, Newtonian) models, SR (or, special relativistic) models, GR (or, general relativistic) models, and OT (or, other) models. One factor of two correlates with abilities to incorporate least CL (or, classical physics) models and QM (or quantum mechanics) physics models. One factor of two correlates with abilities to incorporate at least LINE (or, linear) models and QUAD (or, quadratic) models. LINE models feature terms that are algebraically linear in energy. An SR QM LINE example is the Dirac equation. An SR CL QUAD example is the equation $E^2 = (Pc)^2 + (mc^2)^2$, which links that square of an energy E, the square of a momentum P, the square of a mass m, and the speed of light c. QUAD models feature terms that are algebraically quadratic energy. This approach embraces the first four items in table 1.2. People might choose not explore some of the at least 32 possible types of theories and models of motion.

A combination of adding symmetries related to motion and using math underlying our approach leads to a prediction for the nature of some or all dark matter and to an explanation of the dark matter density of the universe. Regarding dark matter, this aspect of our work predicts a density ratio of five to one, dark matter to ordinary matter. A five to one ratio seems not inconsistent with measurements pertaining to galaxy clusters and not inconsistent with measurements pertaining to the universe as a whole.

Before (or without) adding the symmetries, the elementary particle model points to some possible composite particles that measurements might not associate with ordinary matter. To the extent a dark matter to ordinary matter ratio of densities is somewhat more than five to one, these composite particles may explain the amount that is greater than five.

Before (or without) adding the symmetries, the elementary particle model points to dark energy forces that govern the rate of expansion of the universe.

Perhaps, this approach can achieve the unity we discuss regarding topics in table 1.2.

We use the acronym CUSP to point to theory and models our work includes. The acronym abbreviates the phrase concepts uniting some physics.

Table 1.3 lists some concepts people can use to motivate people's taking an initial interest in this work.

TBD

1. Develop additional simple motivations for people to consider that CUSP may have merit. (See table 1.3.)

Concept

• CUSP produces results that may explain various phenomena that, as of 2017, people say that physics theory and modeling do not explain.
• An NE QM QUAD model may correlate with each of the four traditional physics fundamental forces.
  – An NE QM QUAD model for composite particles consisting of quarks and gluons features one partial differential equation with terms that correlate with each of three of the four traditional physics fundamental forces - the strong interaction, electromagnetism, and the weak interactions. (See and extend discussions related to equations (7.4) and (7.7).)
  – A term that correlates with electromagnetism can, for other applications, correlate with the fourth traditional fundamental force - gravitation.
• People might say that CUSP approaches correlate with concepts and results that, in an SR context, are more compatible with invariance to change in observer than are traditional physics approaches.
  – A CUSP modeling approach to some aspects of photons features, in effect, one harmonic oscillator term for each of four space-time coordinates (one temporal coordinate and three spatial coordinates). (See the 2G2 row in table 3.21.)
  – In traditional physics, people use just two harmonic oscillator terms (each of which correlates with a spatial coordinate that is perpendicular to the direction of motion of the photon).
• Other.

Table 1.3: Conceptual entrees into this work

Similarities and differences between CUSP and traditional physics
• Each of traditional physics and CUSP discusses elementary particles. – Traditional physics theory accepts, as an input, a list of known elementary particles. Traditional physics theory does not, as of 2017, have a firmly established means for making very specific predictions regarding possible other elementary particles. – CUSP outputs and uses a list of known and possible elementary particles. • Each of traditional physics and CUSP addresses topics including the types of objects nature includes, interactions between objects, and motions objects exhibit. – Traditional physics evolved, to some extent, from models and theories for motion. Then, people developed models and theories for interactions and models and theories for objects that nature includes. – CUSP starts with models correlating with the set of elementary particles nature includes and models correlating with interactions between elementary particles. Then, in effect, CUSP incorporates traditional physics modeling that correlates with motion. • Each of traditional physics and CUSP includes aspects that people would correlate with the term classical physics and aspects that people would correlate with the term quantum physics. – Traditional physics evolved via attempts to quantize aspects correlating with classical physics. – CUSP starts from quantum bases. • Each of traditional physics and CUSP can embrace notions of dark matter and dark energy. – People have yet to find a way to extrapolate from traditional physics to definitive models for the natures of dark matter and dark energy. – In CUSP, in effect, the addition of modeling correlating with motion dovetails with adding well-defined candidate descriptions of dark matter and dark energy.

Table 1.4: Similarities and differences between CUSP and traditional physics (1 of 3)

1.4 Correlations between this work and traditional physics

This unit discusses similarities and differences regarding this work and traditional physics.

Table 1.4 suggests some non-technical similarities and differences between CUSP and traditional physics.

Tables 1.5 and 1.6 list technical similarities and differences between CUSP and traditional physics.

We evolved CUSP from previous work. (See, for example, references [1], [2], and [3].) Possibly, people will consider our current work to transit from the realm of interrelated models to the realm of a theory that includes interrelated models. Perhaps, people will consider that CUSP provides theory, or a basis for theory, that integrates various aspects of CUSP and various aspects of traditional physics.

TBD

1. What other applications might people make of mathematical bases we use to develop CUSP?

Similarities and differences between CUSP and traditional physics

- Aspects of CUSP parallel aspects of quantum field theory.
- Aspects of CUSP and aspects of traditional physics feature models based on harmonic oscillator mathematics.
  - Traditional physics applications of harmonic oscillator math feature estimating energy levels.
  - CUSP applications of harmonic oscillator math include matching known elementary particles and predicting elementary particles that nature might include.
- Each of CUSP and traditional physics uses radial-wave applications of harmonic oscillator math. Radial wave solutions can feature functions that include a radial factor of the form $\Psi(r) \propto (r/\eta)^{\nu} \exp(-r^2/(2\eta^2))$, with $\eta^2 > 0$, in which r is the radial coordinate and η is a scale length.
- Each of CUSP and traditional physics de-emphasizes functions that do not normalize.
- Traditional physics uses solutions for which 2ν is a non-negative even integer. CUSP uses solutions for which 2ν is a negative integer.
- Aspects of CUSP and aspects of traditional physics feature models for behavior, within objects, of components of objects.
  - Some traditional physics applications of harmonic oscillator math correlate with short-range approximations and results that are linear in energy.
  - Some CUSP applications correlate with long-range aspects of harmonic oscillator equations and with terms (in the equations) and results (from the equations) that correlate with squares of energies.
- Traditional physics applications of harmonic oscillator math feature one possibly multidimensional possibly isotropic oscillator and spatial coordinates. Some CUSP applications feature isotropic pairs of isotropic quantum harmonic oscillators, temporal coordinates for one of the oscillators, and spatial coordinates for the other oscillator.
- Traditional physics applications of multidimensional harmonic oscillator math feature partial differential equations and radial-coordinate solutions. Some CUSP applications of multidimensional harmonic oscillator math feature partial differential equations and radial-coordinate solutions. Some CUSP applications of multidimensional harmonic oscillator math feature, in essence, one-dimensional components of higher-dimensional oscillators and use raising operators and lowering operators that correlate with the one-dimensional components.

Table 1.5: Similarities and differences between CUSP and traditional physics (2 of 3)

Similarities and differences between CUSP and traditional physics
• Each of traditional physics and CUSP addresses opportunities and challenges regarding the extent to which (and how to) model components of an object that interacts with entities that people consider not to be components of the object. • Each of traditional physics and CUSP addresses opportunities and challenges regarding how to model components bound together within an object. Traditional quantum physics tends to use modeling that comports with aspects of special relativity, regarding atomic structure (using quantum electrodynamics or QED) and regarding the structure of composite particles (using quantum chromodynamics or QCD). CUSP points to possible alternatives to QED and QCD. For example, regarding composite particles, CUSP models pertaining to each of quarks and gluons do not necessarily correlate with complete sets of Poincare-group symmetries. Symmetries pertaining to quarks and symmetries pertain to gluons combine to correlate with Poincare-group symmetries for composite particles. • Each of traditional physics and CUSP addresses opportunities and challenges regarding the extent to which models seem to include aspects that people might interpret as an object interacting with itself. Possibly, compared to quantum field theory, CUSP reduces or maybe eliminates so-called self-interactions.

Table 1.6: Similarities and differences between CUSP and traditional physics (3 of 3)

1.5 Notes - narrative, vocabulary, references, research, and paradigms

This unit suggests perspective about this expression of this work and about aspects of this work.

Narrative

This unit discusses aspects of the narrative we develop.

We try to provide information in an order correlating with a narrative that the reader can follow, that fosters understanding, and that the reader can use to discuss our work with other people. In so doing, we intertwine data, interpretations of data, theories and models, development of theories and models, and mathematics underlying theories and models. Sometimes, we provide forward references to information. Sometimes, we repeat information. For each some topics, we explore more than one possible extrapolation, with the anticipation that some of the extrapolations may prove not be useful.

Vocabulary

This unit discusses concepts related to terminology.

Possibly, we use a term, such as a word or phrase or symbol, when discussing more than one of observations, our theory and models, and other theories and models. Possibly, people do or should interpret a term differently in each of some contexts.

For example, we make two distinct uses of the two-word term dark energy. One use correlates with observations and theory pertaining to changes in the rate of expansion of the universe. Regarding this use, traditional physics provides the three-word phrase dark energy pressure and the three-word phrase dark energy forces. One use correlates with inferences and theory regarding dark energy densities of the universe. CUSP suggests that dark energy forces and dark energy densities correlate with different phenomena.

For example, consider the terms elementary particle and mode. In traditional physics, the term elementary particle can correlate with W boson or with one of the W^+ and W^- bosons. People use the term W boson to correlate with a concept of both of the W^+ and W^- bosons or with a concept of either one of the W^+ and W^- bosons. People might not use the term mode to correlate with just one of W^+ and W^-. In traditional physics, the term elementary particle can correlate with photon. People might use the term photon mode to correlate with a concept of one of a left-circularly polarized photon and a right-circularly polarized photon. People do not use the term elementary particle to correlate with just one photon mode.

We try to offer some clarity by emphasizing terminology centric to observations and to models. In doing so, we sometimes introduce a term such as a word or symbol. We may suggest relationships between the term we introduce and vocabulary people use in traditional models.

Sometimes, we relate two statements or concepts, say St1 and St2. We might say that St1 correlates with St2. We might say that St1 links with St2. We might say that St1 dovetails with St2. Such wording does not necessarily imply that St1 equals St2. Such wording does not necessarily imply that St1 implies, causes, or includes as a subset St2. Such wording does not necessarily imply that St2 implies, causes, or includes as a subset St1.

Sometimes, we start a sentence with the four words people might say that. We use this wording to indicate, for example, that interpretations of the sentence might vary based on interpretations of words in the sentence, interpretations of data about nature, theories and models that people use, and so forth. We use this wording to indicate, for example, that further thought or research may be appropriate. We think that, generally, by using this writing device, we provide useful transparency. We hope that, generally, this transparency supports credibility for the work. We think that, generally, this transparency does not cloud the narrative.

Regarding the elementary particle Standard Model, we use terms such as Standard Model and 2017 Standard Model. Regarding the cosmology standard Model, we use terms such as cosmology timeline.

Regarding terms such as elementary particle, field, photon, graviton, electromagnetism, and gravity, the following statements pertain.

1. People might say that people make various uses of each of the terms field and elementary particle.

2. People might say that our work offers the possibility of considering that three CUSP fields, 2G2, 2G24, and 2G248, combine to correlate with a field for electromagnetism and/or with a field with which people might correlate the word photons. (See equation (3.32) or table 3.32.) People might say that definitions and uses of the fields 2G2, 2G24, and 2G248 can depend on the choices people make regarding what phenomena to model and regarding how to model phenomena. For example, for some models of the earth, 2G2 correlates with a net charge (if any) of the earth, 2G24 correlates with a magnetic dipole moment of the earth, and 2G248 correlates with a possible quadrupole moment that correlates with the earth's axis of rotation not matching an axis correlating with the magnetic dipole moment. People might say that, here, 2G2 intermediates interactions based on the charges of interacting objects and on motions of those charged objects. People might say that, here, models feature notions of a magnetic dipole moment for objects and de-emphasize notions of charge currents within such objects. In CUSP, similar concepts can pertain regarding models for effects of elementary fermions. CUSP models for elementary particles correlate with points with respect to spatial space-time coordinates. 2G2 correlates with the charge of an elementary fermion. People might say that a model cannot correlate with a current within an object that models as a point. 2G24 correlates with nominal magnetic dipole moment.

3. People might say that our work offers the possibility of considering that four CUSP fields combine to correlate with a field for gravitons. (See equation (3.33) or table 3.32.)

References

This unit discusses aspects related to references and bibliography.

We emphasize providing references regarding data we use. We de-emphasize providing references regarding general phenomena about which people can use terminology we use and online search tools to find information. We de-emphasize providing references regarding traditional theory about which people can use terminology we use and online search tools to find information.

A reference regarding data may occur in a detailed discussion and not occur in a summary discussion that comes before or after the detailed discussion.

Research

This unit suggests aspects related to interpreting our work.

People might say that some of our work regarding elementary particles correlates with the phrase pattern matching, with the phrase theory of what, and/or with the phrase models of what. People might say that the pattern matching features mathematical bases that are relatively simple compared to some mathematical bases people traditionally use regarding the physics of elementary particles. People might say that, in some cases, known data does not suffice for making firm choices from lists of choices our work produces. People might say that, for such a list, each of the choices correlates with a possible math-based extrapolation that is consistent with known data. People might say that such lists feature tractable numbers of discrete, somewhat well defined choices. People might say that existences of such choices provide improvements compared to traditional theories for which choices may be less well defined and/or may feature continuous ranges of numbers.

Absent direct evidence that the possible elementary particles that we discuss exist, we explore possible existence of the particles by showing how their existence might provide explanations for known phenomena people correlate with the topics dark matter, dark energy, astrophysics, and cosmology.

People might say that some of our work regarding topics other than elementary particles correlates with the phrase theory of how and/or with the phrase models of how.

People might say that some of our work provides models for how to integrate models pertaining to elementary particle phenomena and models pertaining to cosmology.

People might say that our work provides new choices for modeling phenomena for which traditional models provide useful results.

People might say that our work tends, to a significant degree, to feature traditional interpretations of observations and to feature traditional inferences based on observations. People might say that our work tends, to a significant degree, to dovetail with aspects of traditional theories and/or models that produce appropriately physics-relevant results. People might say that our work does not necessarily feature aspects of some theories and/or models that have yet to produce desired scopes of appropriately physics-relevant results.

People might say that, to the extent our work correlates with and does not misinterpret known data, the scope of the work points to possible usefulness for the work and to possible usefulness for extensions to the work. Here, the variety of aspects of nature we address correlates with the phrase scope of the work. People might say that, to the extent the work does not correlate with or does misinterpret known data, such discrepancies do not necessarily invalidate some portions of the work and/or some applications of the work. People might say that, to the extent such discrepancies exist, people might be able to remove discrepancies by improving aspects of the work and/or by reinterpreting data.

Paradigms

This unit suggests aspects related to mindsets regarding interpreting our work.

People might say that, to the extent CUSP comports with nature, CUSP provides an opportunity for a paradigm shift regarding aspects of physics.

People might say that CUSP provides a useful new framework that embraces useful aspects of traditional physics theories and models.

People might say that people should be careful to the extent people try to map narrow aspects of CUSP theory onto traditional theories and/or into traditional frameworks for theories.

TBD

1. Develop and propagate vocabulary that helps people avoid negative aspects of ambiguities.

2. Resolve, to an appropriate extent, ambiguities that correlate with sentences that start with the four-word phrase people might say that.

1.6 Acronyms - a glossary of acronyms

This unit lists acronyms that this work uses.

Table 1.7 provides a glossary of acronyms we use. For some items, see discussion related to the table that table 1.7 cites.

Table 1.7: Acronyms

Acronym	Concept, phrase, or application	In or near table ...
0F−B2F	Vertex that creates a matter/antimatter fermion pair	3.3 on page 49
1F−B1F	Interaction vertex that de-excites a boson	3.3 on page 49
1F+B1F	Interaction vertex that excites a boson	3.3 on page 49
1F±B1F	1F−B1F or 1F+B1F	3.3 on page 49
2F+B0F	Vertex that destroys a matter/antimatter fermion pair	3.3 on page 49
ALG	Algebraic	2.3 on page 24
ALG|COR	Known and possible elementary particles	2.4 on page 25
ALG|DYN|7	Dynamics within composite particles	2.4 on page 25
ALG|GEN	Generations of elementary fermions	2.4 on page 25
ALG|HAN	Handedness of neutrinos	2.4 on page 25
ALG|KIDY	Particle kinematics, dynamics, and interactions	2.4 on page 25
ALG|KIN|17	Kinematics of free-ranging elementary particles	2.4 on page 25
ALG|PRO	Known and possible elementary particles	2.4 on page 25
ANGM	Angular momentum	2.28 on page 44
APM	Anti-particle and/or anti-mode	2.11 on page 32
BOUNSTAT	Bound state	2.23 on page 42
C (elementary particles)	A family of known elementary particles	2.12 on page 33
C (symmetry)	Charge-reversal (transformation)	2.11 on page 32
C:..	Conservation of ..	2.28 on page 44
CHAR	Charge	2.28 on page 44
CL	Classical mechanics	2.5 on page 25
COLC	Color charge	2.28 on page 44
CPT	Charge-reversal, parity-reversal, and time-reversal	10.1 on page 142
CQI	Correlated quantum interaction	3.5 on page 50
CUSP	Concepts uniting some physics	1.4 on page 12
DE	Dark energy	4.3 on page 76
DED	DE density	4.3 on page 76
DEDU	DE density of the universe	4.3 on page 76
DEE	DE ensemble(s)	4.3 on page 76
DEE-centric	DEE-centric - Objects made substantially from DEES	4.3 on page 76
DEES	DEE stuff	4.3 on page 76
DES	DE stuff	4.3 on page 76
DM	Dark matter	4.3 on page 76
DMD	DM density	4.3 on page 76
DMDU	DM density of the universe	4.3 on page 76
DME	DM ensemble(s)	4.3 on page 76
DME-centric	DME-centric - Objects made substantially from DMES	4.3 on page 76
DMES	DME stuff	4.3 on page 76
DMS	DM stuff	4.3 on page 76
ENER	Energy	2.28 on page 44
FERA	Fermion asymmetry	2.28 on page 44
FREERANG	Free-ranging	2.23 on page 42
G	A family of known and possible elementary particles	2.12 on page 33

Table 1.7: Acronyms

Acronym	Concept, phrase, or application	In or near table ...
GENE	Generation	2.28 on page 44
GR	General relativity	2.5 on page 25
GRS	A KREL symmetry, correlating with general relativity	4.6 on page 78
H	A family of known elementary particles	2.12 on page 33
HA	Hydrogen-atom-like	2.3 on page 24
IQI	Isolated quantum interaction	3.5 on page 50
KREL	Three symmetries related to the Poincare group	4.5 on page 78
KREL1	One of the KREL symmetries	4.10 on page 81
KREL2	One of the KREL symmetries	4.10 on page 81
KREL3	One of the KREL symmetries	4.10 on page 81
LINE	Linear - Equations are linear in energy	2.5 on page 25
MEQ0	Mass equals zero	2.6 on page 25
MMB0	Mass might be zero or might be non-zero and small	2.6 on page 25
MNE0	Mass is non-zero	2.6 on page 25
MOME	Momentum	2.28 on page 44
N	A family of known elementary particles	2.12 on page 33
NT	Newtonian physics	2.5 on page 25
O	A family of possible elementary particles	2.12 on page 33
OM	Ordinary matter	4.3 on page 76
OMD	OM density	4.3 on page 76
OMDU	OM density of the universe	4.3 on page 76
OME	OM ensemble	4.3 on page 76
OME-centric	OME-centric - Objects made substantially from OMES	4.3 on page 76
OMES	OME stuff	4.3 on page 76
OMS	OM stuff	4.3 on page 76
OT	Other (such as sea state or Cooper pairing) dynamics	2.5 on page 25
P	Parity-reversal (transformation)	2.11 on page 32
PDE	Partial differential equation	2.3 on page 24
PDE|ALG	ALG techniques within PDE-based models	2.3 on page 24
PDE|HER	PDE work that feature Hermite polynomials	2.3 on page 24
PDE|PDE	PDE work that de-emphasizes Hermite polynomials	2.3 on page 24
Point-like	A function defined only at a point	2.15 on page 36
Q	A family of known elementary particles	2.12 on page 33
QCD	Quantum chromodynamics	2.5 on page 25
QCD|ALTE	Possible alternative QCD	2.5 on page 25
QCD|TRAD	Traditional QCD	2.5 on page 25
QED	Quantum electrodynamics	2.5 on page 25
QED|ALTE	Possible alternative QED	2.5 on page 25
QED|TRAD	Traditional QED	2.5 on page 25
QE-like	Temporal or energy-centric	2.3 on page 24
QM	Quantum mechanics	2.5 on page 25
QP-like	Spatial or momentum-centric	2.3 on page 24
QUAD	Quadratic - Equations are quadratic in energy	2.5 on page 25
R	A family of possible elementary particles	2.12 on page 33
SDF	Spatial dependence of force	3.23 on page 64
SGR	Either SRS or GRS	4.6 on page 78
SIDM	Self-interacting dark matter	6.2 on page 117
SP	Spatial parity	2.11 on page 32
SR	Special relativity	2.5 on page 25

Table 1.7: Acronyms

Acronym	Concept, phrase, or application	In or near table ...
SRS	A KREL symmetry, correlating with special relativity	4.6 on page 78
T	Time-reversal (transformation)	2.11 on page 32
TP	Temporal parity	2.11 on page 32
Volume-like	A function defined for at least all but a point	2.15 on page 36
W	A family of known elementary particles	2.12 on page 33
WHO	W and/or H and/or O	2.12 on page 33
WIMPs	Weakly interacting massive particles	6.4 on page 118
Y	A family of known elementary particles	2.12 on page 33
ZNZM	Zero mass / non-zero mass	2.28 on page 44

Chapter 2

Modeling and models

This unit defines math terminology and symbols we use, introduces means to model known elementary particles and predict other elementary particles, provides context for modeling masses of elementary bosons and elementary fermions, catalogs types of models for kinematics and types of models for dynamics, lists conserved quantities, and provides context for extending modeling to include composite particles and other objects that include more than one elementary particle.

2.1 Summary - CUSP modeling

This unit lists goals for CUSP modeling, summarizes the scope of introductions we make to mathematics of and some physics-relevant applications for isotropic quantum harmonic oscillators, discusses similarities and differences between applications of CUSP and applications of traditional physics models, and lists and discusses some terms we use.

Table 2.1 lists goals for CUSP modeling. Modeling of particles includes modeling properties of particles. Properties include spin and mass. Modeling of particles includes modeling some aspects of interactions in which particles partake. Interaction-related aspects include abilities and lack of abilities to interact directly with other elementary particles. Interaction-related aspects include, for elementary bosons, characteristics of forces that elementary bosons intermediate. Modeling of elementary particles does not include aspects of motion (or, kinematics and/or dynamics). We aim to incorporate motion by incorporating into models symmetries that correlate with conservation laws and with kinematics models and dynamics models. Kinematics models include special relativity and general relativity.

CUSP features and uses solutions based on, in effect, solving equations that feature isotropic pairs of isotropic quantum harmonic oscillators. People might say that, within each pair, one isotropic harmonic oscillator correlates with temporal aspects of physics phenomena. People might say that, within each pair, the other isotropic harmonic oscillator correlates with spatial aspects of physics phenomena. People might say that solutions correlate with a parallel to the concept that, in accounting, people call double-entry bookkeeping.

CUSP models regarding elementary particles and their properties feature harmonic oscillator math that other physics theories and models seem not to use much. CUSP models regarding composite particles and other multi-particle objects feature more-traditional harmonic oscillator math.

Table 1.5 notes similarities and differences between uses, in traditional physics, of some models based on harmonic oscillators and uses, in CUSP, of models based on harmonic oscillators.

Table 2.2 lists some foci of physics models and notes some aspects regarding each of CUSP, specifically, and, generally, some traditional physics models. People might say that CUSP outputs a list of elementary particles and points to properties of elementary particles, whereas traditional physics models take in (or assume), from observations, a more restricted list of elementary particles and their properties. People might say that traditional physics outputs a list of conservation laws and symmetries correlating with those conservation laws and with related kinematics, whereas CUSP models take in (or assume), from traditional physics, aspects of that kinematics, those

Goals
• Provide a math-based framework via which people can do the following. – Model all known elementary particles. – Predict elementary particles people have yet to find. – Incorporate known kinematics models and known dynamics models. – Catalog known and possible composite particles. – Model known known aspects of astrophysics and cosmology. – Predict aspects of astrophysics and cosmology. • Use the framework to accomplish the above-mentioned tasks. • Gain insight regarding the following topics. – Integrating, extending the scope of, and limiting the applicability of physics models and theories. – Foundations of physics topics.

Table 2.1: Goals for CUSP modeling

symmetries, and those conservation laws.

Table 2.3 lists and discusses some terms we use. Our work de-emphasizes PDE|HER.

Regarding modeling the existence, in nature, of known and possible elementary particles, table 2.4 lists aspects that people might want physics models to address. For each item in the table, the table provides a symbol for a modeling basis that correlates with $A = A_{QE} - A_{QP} = 0$. (See equation (2.34).) The two-element term G family correlates with some solutions and with some elementary particles, including photons and gravitons.

2.2 Acronyms - kinematics models, dynamics models, and mass

This unit lists acronyms pertaining to choices regarding kinematics and dynamics modeling and provides acronyms regarding differentiating between zero mass and non-zero mass.

Table 2.5 lists acronyms related to modeling kinematics and/or dynamics. The acronym OT stands for other. People might say that, with QM, CUSP points to possibilities for an alternative (QED|ALTE) to traditional QED (or, QED|TRAD). People might say that, with QM, CUSP points to possibilities for an alternative (QCD|ALTE) to traditional QCD (or, QCD|TRAD).

Table 2.6 lists acronyms related to rest masses (or rest energies) of elementary particles. People might say that, for some known elementary particles and for some predicted elementary particles, people do not necessarily know whether the rest mass is zero. People might say that, for neutrinos, in the table, the word small correlates with the notion of much less than the mass of the electron. (See discussion related to table 5.8.)

2.3 Math for one QP-like PDE oscillator

This unit defines notation for and discusses solutions pertaining to a partial differential equation model correlating with one isotropic quantum harmonic oscillator.

We discuss mathematics correlating with partial differential equations relevant to isotropic quantum harmonic oscillators. The term PDE correlates with such mathematics. Equations (2.1) and (2.2) correlate with QP-like isotropic quantum harmonic oscillators. Here, r denotes the radial coordinate and has dimensions of length. The

Focus	CUSP ...	Some traditional models ...
Existence, in nature, of components for objects • Properties of components	... outputs a list of elementary particles	... take in a list of elementary particles
Existence, in nature, of objects • Internal states of objects	... outputs internal states of some objects	... output internal states of some objects
External effects of objects • Properties of objects	... outputs properties of elementary particles	... output properties of some objects other than elementary particles
Motion of objects • Interactions with other objects	... takes in a set of symmetries correlating with conservation laws and kinematics	... output a set of symmetries correlating with conservation laws and kinematics

Table 2.2: Foci of some physics models

parameter η has dimensions of length. Here, D is a positive integer. Including for $D = 1$, each of equation (2.1), equation (2.2), and the function Ψ pertains for $0 < r < \infty$. The parameter η is a non-zero real number.

$$\xi\Psi(r) = (\xi'/2)(-\eta^2\nabla^2 + \eta^{-2}r^2)\Psi(r) \tag{2.1}$$

$$\nabla^2 = r^{-(D-1)}(\partial/\partial r)(r^{D-1})(\partial/\partial r) - \Omega r^{-2} \tag{2.2}$$

We consider solutions of the form equation (2.3) shows. The magnitude $|\eta|$ correlates with a scale length. We de-emphasize PDE|HER, which is a traditional case for which $D = 1$ and for which the function Ψ pertains for $-\infty < r < \infty$, $\Omega = 0$, and solutions include factors that are Hermite polynomial functions of r.

$$\Psi(r) \propto (r/\eta)^\nu \exp(-r^2/(2\eta^2)), \text{ with } \eta^2 > 0 \tag{2.3}$$

Equations (2.4) and (2.5) characterize solutions. (See table 2.7.) The parameter η does not appear in these equations.

$$\xi = (D + 2\nu)(\xi'/2) \tag{2.4}$$

$$\Omega = \nu(\nu + D - 2) \tag{2.5}$$

People might say that work above uses the presence of Ω to summarize aspects pertaining to angular coordinates. People might say that CUSP modeling de-emphasizes some aspects, of equation (2.1), correlating with angular coordinates. CUSP modeling limits consideration to solutions that comport with equation (2.6) and, therefore, with equation (2.7).

$$2\nu \text{ is an integer} \tag{2.6}$$

$$4\Omega \text{ is an integer} \tag{2.7}$$

The set of solutions to which work above points is too broad for our work. We de-emphasize solutions that do not normalize.

Term	Discussion
QE-like	For applications to physics, QE-like constructs generally correlate with temporal space-time coordinates and/or with energy.
QP-like	For applications to physics, QP-like constructs generally correlate with spatial space-time coordinates and/or with momentum and mass.
PDE	PDE provides an acronym for the phrase partial differential equation. PDE correlates with mathematics based on representing an isotropic quantum harmonic oscillator via partial differential equations that feature radial coordinates and solutions that feature radial coordinates. As used in this work, the term PDE includes mathematics pertaining to one PDE isotropic quantum harmonic oscillator and includes mathematics pertaining to an isotropic pair of PDE isotropic quantum harmonic oscillators.
ALG	ALG provides an acronym for the word algebraic. ALG correlates with mathematics based on raising operators and lowering operators pertaining to individual harmonic oscillators that contribute to an isotropic quantum harmonic oscillator. As used in this work, the term ALG includes mathematics pertaining to one ALG isotropic quantum harmonic oscillator and includes mathematics pertaining to an isotropic pair of ALG isotropic quantum harmonic oscillators.
PDE|ALG	PDE|ALG provides a label for mathematics based on raising operators and lowering operators pertaining to spherical coordinate representations for solutions correlating with PDE.
PDE|HER	PDE|HER provides a label for mathematics based on harmonic oscillators that feature partial differential equations based on one linear coordinate. Each solution includes a factor that correlates with a Hermite polynomial in that linear coordinate.
PDE|PDE	PDE|PDE provides a label for PDE modeling we use. People might say that this modeling does not use PDE|HER. People might say that this modeling tends to de-emphasize, but does make some use of, PDE|ALG.
PDE|PDE|HA	PDE|PDE|HA provides a label for PDE modeling we use regarding hydrogen-atom-like entities.
$N_{QE\|...}$	$N_{QE\|...}$ denotes the number of QE-like one-dimensional harmonic oscillators that correlate with a QE-like ALG isotropic quantum harmonic oscillator. $N_{QE\|...}$ is a non-negative integer. We designate each oscillator by the letter E and an integer in the list $N_{QE\|...}-1$, $N_{QE\|...}-2$, ..., 1, and 0.
n_{Ej}	n_{Ej} denotes the excitation number for the QE-like oscillator that the label Ej specifies. n_{Ej} is an integer.
$N_{QP\|...}$	$N_{QP\|...}$ denotes the number of QP-like one-dimensional harmonic oscillators that correlate with a QP-like ALG isotropic quantum harmonic oscillator. $N_{QP\|...}$ is a non-negative integer. We designate each oscillator by the letter P and an integer in the list 0, 1, ..., $N_{QP\|...}-2$, and $N_{QP\|...}-1$.
n_{Pj}	n_{Pj} denotes the excitation number for the QP-like oscillator that the label Pj specifies. n_{Pj} is an integer.

Table 2.3: Terminology correlating with the terms QE-like, QP-like, PDE, and ALG

Aspect	Model	Relationship
Known and possible elementary particles	ALG|PRO	
Known and possible elementary particles	ALG|COR	extends ALG|PRO
Generations of elementary fermions	ALG|GEN	extends ALG|COR
Handedness for neutrinos	ALG|HAN	extends ALG|GEN
Dynamics within composite particles	ALG|DYN|7	extends ALG|GEN
Kinematics of free-ranging elementary particles	ALG|KIN|17	extends ALG|HAN
Interactions correlating with the G family	ALG|KIN|17	extends ALG|HAN
Elementary particle motion and interactions	ALG|KIDY	includes ALG|KIN|17 and ALG|DYN|7

Table 2.4: Notation for models, based on $A = A_{QE} - A_{QP} = 0$, regarding some aspects of elementary particle physics

Aspect	Acronym	Phrase - Note
System	FREERANG	Free-ranging motion
”	BOUNSTAT	Bound-state system
Branch	NT	Newtonian physics
”	SR	Special relativity
”	GR	General relativity
”	OT	Other dynamics (such as sea states)
Mechanics	CL	Classical mechanics
”	QM	Quantum mechanics
Equations	LINE	Linear - Equations are linear in energy
”	QUAD	Quadratic - Equations are quadratic in energy
Electrodynamics	QED	Quantum electrodynamics - Falls within QM
”	QED|TRAD	Traditional QED
”	QED|ALTE	Possible alternative QED
Chromodynamics	QCD	Quantum electrodynamics - Falls within QM
”	QCD|TRAD	Traditional QCD
”	QCD|ALTE	Possible alternative QCD

Table 2.5: Acronyms pertaining to kinematics modeling and/or dynamics modeling

Acronym	Phrase
MEQ0	Mass equals zero
MMB0	Mass might be zero or might be non-zero and small
MNE0	Mass is non-zero

Table 2.6: Acronyms pertaining to rest energy

Chapter 3

Elementary particles and their properties and interactions

This unit describes elementary particles and interactions that, together, may suffice to underlie and/or explain all known and various inferred natural phenomena.

3.1 Summary - known and possible elementary particles

This unit summarizes CUSP results regarding elementary particles.

Table 3.1 alludes to all known elementary particles and to possible other elementary particles. For each row for which the known-particles entry is not blank, people have found all of elementary particles to which CUSP points. For each row for which the known-particles entry is blank, as of 2017, people had found none of the possible elementary particles to which CUSP points. The column labeled Φ provides a family name that pertains to the relevant elementary particles and to mathematical solutions that CUSP correlates with the particles. The column labeled S lists spins. Regarding the $\Sigma\Phi$ column, $\Sigma = 2S$. We use a symbol of the form $\Sigma\gamma$ for each of the four G-family particles the table lists. Each of these particles correlates with a set of more than one G-family solution, with each such solution being of the form $\Sigma\mathrm{G}\Lambda$ for some Λ. For each G-family particle, two modes exist. One mode is left-circularly polarized. The other mode is right-circularly polarized. People might say that 4γ correlates with the term graviton. The table shows, in the column labeled matter/antimatter particles, the number of particles that people would consider not to correlate with either matter or antimatter. Each of the particles is its own antiparticle. Examples include the Higgs boson and the Z boson. A Dirac-fermion neutrino correlates, with respect to table 3.1, with zero matter/antimatter particles and with one matter particle. A Majorana-fermion neutrino correlates, with respect to table 3.1, with one matter/antimatter particle and zero matter particles. In the table, $\pi_{j',j''}$ denotes the concept that j' pertains for one of the two relevant columns and j'' pertains for the other of the two relevant columns. The table shows, in the column labeled matter particles, the number of particles that people would consider to be matter particles. For each matter particle, there is an antimatter particle. An example is the W boson, regarding which people consider each of the W^- and W^+ bosons to be the antiparticle of the other particle. Table 3.1 does not take into account some G-family solutions that are possibly physics-relevant. People might say that some of the G-family solutions that the table does not take into account correlate with anomalous moments, such as anomalous dipole magnetic moments that people correlate with elementary particles. Each particle for which $n_{P0} = 0$ has non-zero mass. Each boson particle for which the table states that $n_{P0} \leq -1$ has zero mass. Regarding neutrino masses, see discussion related to tables 5.7 and 5.8. For each $\Sigma\gamma$ the table lists, the G-family solution $\Sigma\mathrm{G}\Sigma$ pertains and correlates with $n_{P0} = -1$. For each $\Sigma\gamma$ the table lists, at least one other G-family solution $\Sigma\mathrm{G}\Lambda$ pertains and correlates with $n_{P0} \leq -2$. For each $\Sigma\gamma$ the table lists, the G-family solution $\Sigma\mathrm{G}\Sigma$ correlates with a monopole interaction. A monopole interaction correlates, in the sense of Newtonian physics, with a radial SDF (or, spatial dependence of force) of r^{-2}. Here, r correlates with a distance from a center of property for an object. For example, 2G2 is a component of 2γ and correlates with interactions based on electric

Known particles	Φ	S	$\Sigma\Phi$	G-family modes	Matter/antimatter particles	Matter particles	n_{P0}	σ
Higgs boson	H	0	0H		1	0	0	+1
Charged leptons	C	1/2	1C		0	3	0	+1
Neutrinos	N	1/2	1N		$\vert\leftarrow$ ... $\pi_{0,3}$	... $\rightarrow\vert$	−1	+1
Z and W bosons	W	1	2W		1	1	0	+1
Photon	G	1	2γ	2	1		≤ -1	+1
	G	2	4γ	2	1		≤ -1	+1
	G	3	6γ	2	1		≤ -1	+1
	G	4	8γ	2	1		≤ -1	+1
Quarks	Q	1/2	1Q		0	6	0	−1
	R	1/2	1R		0	6	−1	−1
Gluons	Y	1	2Y		0	8	−1	−1
	O	1	2O		1	1	0	−1

Table 3.1: Numbers of elementary particles and/or modes

charge. 2G24 is a component of 2γ and correlates with $n_{P0} = -2$ and with a dipole interaction. A dipole interaction correlates, in the sense of Newtonian physics, with a radial SDF of r^{-3}. For a model, of an object, that includes a non-zero magnetic dipole moment for the object and that does not base that magnetic dipole moment on motions of charges within the object, 2G24 correlates with effects that correlate with the magnetic dipole moment of the object. (For the moment we note, but do not dwell on the notion that 2γ also includes a quadrupole term with SDF of r^{-4}. Such a term can correlate with a familiar property of the earth. For the earth, the axis of spin and the axis correlating with magnetic dipole moment do not align with each other. People might say that a quadrupole moment pertains.) People might say that, for each elementary particle for which $\sigma = +1$, the term free-ranging pertains. People might say that, for each elementary particle for which $\sigma = -1$, the term free-ranging does not pertain.

Table 3.2 lists elementary particles CUSP predicts.

TBD

1. Regarding each of the possible elementary particles to which table 3.2 alludes, to what extent can people show, based on experiments, observations, or inferences, that nature includes or does not include the elementary particle?

3.2 Notes - interactions and interaction vertices

This unit summarizes some CUSP results regarding models for interaction vertices.

Table 3.3 summarizes some terms we use regarding interaction vertices pertaining to interactions involving only elementary particles.

Possibly, CUSP need not include types of interactions that the left-most column of table 3.4 discusses. Traditional quantum field theory includes each of these type of interactions.

We note some concepts regarding models, interactions, and symmetries correlating with free-ranging states and regarding models, interactions, and symmetries correlating with bound-state physics. The symbol IQI correlates with modeling an interaction that features only one quantum interaction. The acronym IQI abbreviates the phrase isolated quantum interaction. We use the symbol CQI to denote interrelated interactions. The acronym CQI abbreviates the phrase correlated quantum interaction.

People might say that table 3.5 pertains.

Possible elementary particles
• One 4γ elementary boson. This particle has zero mass, correlates with spin-2, and has two polarization modes. People might say that this particle correlates with the term graviton. • One 6γ elementary boson. This particle has zero mass, correlates with spin-3, and has two polarization modes. • One 8γ elementary boson. This particle has zero mass, correlates with spin-4, and has two polarization modes. • Six 1R elementary fermions. Each particle is a zero-mass or low-non-zero-mass, zero-charge, spin-1/2 counterpart to one quark. For each of these particles, a distinct antiparticle exists. These particles can exist within composite particles. These particles do not correlate with the term free-ranging. • Two 2O elementary bosons. Each particle is a non-zero-mass, spin-1 counterpart to one spin-1 weak-interaction boson. One 2O particle has zero charge. This particle is its own antiparticle. One 2O particle has one-third the charge of a W boson (that is, of one of the W^- particle and the W^+ particle). For this particle, a distinct antiparticle exists and has negative one-third the charge of the same W boson. These particles can exist within composite particles. These particles do not correlate with the term free-ranging.

Table 3.2: Predicted elementary particles

Term	Discussion
1F−B1F	The symbol 1F−B1F denotes an interaction vertex in which one fermion enters, a boson de-excites by one unit, and one fermion exits.
1F+B1F	The symbol 1F+B1F denotes an interaction vertex in which one fermion enters, a boson excites by one unit, and one fermion exits.
1F±B1F	The symbol 1F±B1F denotes one or both of 1F−B1F and 1F+B1F.
0F−B2F	The symbol 0F+B2F denotes an interaction vertex in which no fermions enter, a boson de-excites by one unit, and a matter-and-antimatter pair of fermions exits.
2F+B0F	The symbol 2F+B0F denotes an interaction vertex in which a matter-and-antimatter pair of fermions enters, a boson excites by one unit, and no fermions exit.

Table 3.3: Terminology correlating with interaction vertices pertaining to interactions involving only elementary particles

Chapter 4

Motion, conservation laws, dark matter, and dark energy

This unit incorporates motion and motion-related conservation laws into CUSP, proposes explanations for dark matter and dark energy, discusses composite particles and seas that include elementary particles that comprise composite particles, develops a CUSP double-entry bookkeeping construct correlating with $SU(3) \times SU(2) \times U(1)$ boson symmetries from traditional physics, and discusses various topics regarding modeling interactions.

4.1 Summary - ordinary matter, dark matter, and dark energy

This unit describes similarities and differences among ordinary matter, dark matter, dark energy stuff, and dark energy forces.

We distinguish among four phenomena - ordinary matter, dark matter, dark energy stuff, and dark energy forces (or, pressure).

We correlate effects of dark energy forces with phenomena that people correlate with phrase rate of expansion of the universe. Regarding that rate, people identify three eras - initial accelerating expansion, subsequent decelerating expansion, and recent accelerating expansion. (Regarding observations, see discussion, including references, related to table 4.14.) People might say that observations of the rate of expansion correlate with repulsion (for the first some billion years), then attraction (for some billion years), and now repulsion (for the most recent some billion years) between, at least, objects that are larger than galaxy clusters. CUSP suggests that such interactions correlate with forces that correlate with components of 4γ (or, gravity). Phenomena correlating with the three words rate of expansion correlate primarily with components, for which the SDFs (or, spatial dependences of forces) are r^{-5}, r^{-4}, and r^{-3}. (Here, r correlates with a distance from a center-of-property for an object.) People might say that SDFs of r^{-5}, r^{-4}, r^{-3}, and r^{-2} correlate, respectively with the terms static octupole, static quadrupole, static dipole, and static monopole. Each SDF equals the $r^{n_{P0}-1}$ correlating with one or more relevant G-family solutions. (See table 3.32.)

Regarding observations and data, we correlate with the two-word term ordinary matter the acronym OMS (for ordinary-matter stuff). We correlate with the two-word term dark matter the acronym DMS (for dark matter stuff). We correlate the acronym DES with the term dark energy stuff. Each of OMS, DMS, and DES contributes to effects people correlate with the term density of the universe. (Table 4.3 lists and discusses acronyms related to OM (ordinary matter), DM (dark matter), and DE (dark energy).)

CUSP suggests that each of dark matter and dark energy stuff consists primarily of copies (or, instances) of some ordinary-matter elementary particles and all ordinary-matter composite particles. Regarding each instance, we use the term ensemble. Table 4.1 summarizes results regarding particles, solutions, and ensembles. (See, for example, table 3.1 and discussion related to table 3.1.) Each ensemble includes a set of 0H, 1C, and 1N elementary particles. Each ensemble includes a set of all possible composite particles, including 1Q⊗2Y composite particles and possibly including, for example, 1R⊗2Y composite particles. (See table 4.15.) Known composite particles

σ	Particle sets and/or solution sets 2017 Standard Model	Possible	One instance correlates with one ensemble	Span (ensembles per instance)
+1	1C, 1N	-	Yes	1
+1	0H	-	”	”
	Composite particles (1Q⊗2Y)	Composite particles (e.g., 1R⊗2Y)	”	”
+1	2G2⊕2G24	6G24, ΣG246, ΣG2468	”	”
+1	-	8G8	”	”
+1	-	4G4	No	6
+1	-	Other G-family	”	2 or 6
+1	2W	-	”	6
−1	2Y	2O	”	6
−1	1Q	1R	”	8

Table 4.1: Particles and/or solutions that correlate with one ensemble and particles and/or solutions that might correlate with more than one ensemble

include the pion and the proton. All known composite particles are of the type 1Q⊗2Y. Each ensemble includes its own instance of the 2G2 and 2G24 components of 2γ (or, photons). Instances of some solutions correlate with more than one ensemble. For example, consider the 4G4 solution, which is a component of 4γ (or, gravitons). 4G4 is the only component of 4γ for which the SDF is r^{-2}. An instance of 4G4 correlates with gravitational interactions between entities correlating with six ensembles. Regarding interactions, we say that each instance of 2G2⊕2G24 has a span of one ensemble and that each instance of 4G4 has a span of six ensembles. Each of 2γ and 4γ includes components with spans greater than one. (For example, 2G248 is a component of 2γ. The span correlating with the 2G248 solution is six. The solution correlates, in table 4.1, with the term other G-family.) People might say that the correlation of 1Q with more than one ensemble, from a standpoint of modeling, is mathematically useful, and, from a standpoint of observable phenomena, is not necessarily physics-relevant.

Based on symmetries that CUSP dovetails with traditional physics conservation laws and kinematic symmetries, CUSP suggests that the universe includes 48 ensembles.

Ordinary matter (or, OM) correlates with one ensemble. Regarding this ensemble, we use the acronym OME, for ordinary-matter ensemble. The OME might include some dark matter (or, DMS). (People might say that, for example, 1R⊗2Y performs functions that people might expect of axions. See table 4.15.) We use the term OME DMS to denote stuff that correlates with the OME and seems to be DMS.

People might say that most dark matter stuff (or, DMS) correlates with the five non-OME ensembles that interact with the instance of 4G4 that interacts with the OME. Regarding the five dark matter ensembles, we use the acronym DME, for dark matter ensemble (or ensembles).

People might say that this explanation of dark matter adequately comports with inferred ratios of density of dark matter to density of ordinary matter. (We use the acronym DMD for dark matter density. We use the acronym OMD for ordinary matter density. Based on, for example, effects people correlate with gravitational lensing, people infer DMD/OMD ratios for individual galaxy clusters. People might say that inferred ratios approximate five to one. We use the acronym DMDU for dark matter density of the universe. We use the acronym OMDU for ordinary matter density of the universe. Based on, for example, analyses of cosmic microwave background radiation, people infer DMDU/OMDU ratios for the observed universe. People might say that inferred DMDU/OMDU ratios somewhat exceed five to one.) People might say that, to the extent inferred DMD/OMD and/or inferred DMDU/OMDU ratios accurately exceed five to one, OME DMS contributes to the amount in excess to five to one. (People might say that the notion of non-zero amounts of OME DMS correlates with sub-optimal use of the two-word term dark matter. People might say that the notion of non-zero amounts of OME DMS correlates with omitting, from tallies of OMD, contributions correlating with the existence of OME DMS. People might say that such omissions would parallel, for example, omitting from OMD the contribution correlating with OME photons. See table 4.4.) People might say that at least one of OME DMS and DME stuff populates galactic halos that help gravitationally to keep

Aspect
1. Each dark matter ensemble is sufficiently similar to the ordinary-matter ensemble that possibly the dark matter ensemble includes adequately physics-savvy beings. Here, adequately physics-savvy denotes concepts including the beings doing the following. (a) Developing models of physics at least to the extent that people have developed regarding ordinary matter. (b) Knowing about electromagnetic, gravitational, and astrophysical aspects, from the standpoint of that dark matter ensemble. (c) Inferring the presence of phenomena paralleling phenomena people attribute, relative to the ordinary-matter ensemble, to dark matter.
2. Between two ensembles, a relationship of one ensemble's comprising part of the other ensemble's dark matter is reciprocal.
3. Each dark energy ensemble is sufficiently similar to the ordinary-matter ensemble that possibly the dark energy ensemble includes adequately physics-savvy beings. Here, adequately physics-savvy denotes concepts including the beings doing the following. (a) Developing models of physics at least to the extent that people have developed regarding ordinary matter. (b) Knowing about electromagnetic, gravitational, and astrophysical aspects, from the standpoint of that dark energy ensemble. (c) Inferring the presence of phenomena paralleling phenomena people attribute, relative to the ordinary-matter ensemble, to dark energy stuff.
4. Between two ensembles, a relationship of one ensemble's comprising part of the other ensemble's dark energy stuff is reciprocal.

Table 4.2: Similarities and relationships between ensembles

stars and gas from escaping from OME-centric galaxies. Later, we discuss the possibility that, for OME-centric galaxies, DME constitutes most of the stuff in galactic halos. (See table 6.2.)

Dark energy stuff (or, DES) correlates with the remaining 42 ensembles. Regarding the 42 dark energy ensembles, we use the acronym DEE, for dark energy ensemble (or ensembles). People might say that CUSP explains, at least qualitatively, a perceivable gap between predicted and inferred ratios of density of DES to density of OMS⊕DMS. People might say that inferred ratios grow, since the big bang, from zero to about 2.2. CUSP provides the notion that the actual ratio is seven-to-one. CUSP suggests the notion that impact of DES on observations from which people infer densities of DES is indirect and adequately slow to account for results that are less than seven-to-one.

People might say that people can envision, at least the physical laws of and possibly many details of, nature correlating with ensembles other than the ordinary-matter ensemble. Table 4.2 pertains.

Thus, CUSP suggests that dark energy forces and dark energy stuff differ from each other.

4.2 Acronyms - ordinary matter, dark matter, and dark energy

This unit discusses terminology regarding dark matter and dark energy and lists acronyms pertaining to the terms dark matter and dark energy.

Chapter 5

Particle phenomena

This unit discusses nominal moments and anomalous moments pertaining to elementary fermions, a possible correlation between masses of weak-interaction bosons and the range of the weak interaction, modeling neutrinos as being Dirac fermions and/or Majorana fermions, neutrino oscillations, neutrino masses, handedness and parity violation, possible concepts regarding applications involving lasing and/or quantum computing, possibilities for correlating some symmetries with aspects of elementary fermions, and possibilities for directly detecting dark matter.

5.1 Summary - elementary particle and dark matter phenomena

This unit summarizes results regarding some elementary particle phenomena.

People might say that we do the following.

1. We discuss aspects of fermion nominal moments with respect to G-family interactions. We suggest that people can correlate nominal moments with each of the components, that CUSP suggests, of 2γ (or, photons), 4γ (or, gravitons), 6γ, and 8γ.

2. We discuss CUSP modeling of contributions to anomalous magnetic dipole moments and of contributions to other possible anomalous moments.

   (a) We discuss the possibility that CUSP QED|ALTE models for anomalous magnetic dipole moments might produce results that correlate with results from QED|TRAD (or, traditional quantum electrodynamics).

   (b) We show the possibility that, given the anomalous magnetic dipole moments for the electron and the muon, people can use QED|ALTE modeling to estimate a tauon anomalous magnetic dipole moment that approximates a QED|TRAD result.

3. We discuss a model that correlates the range of the weak interaction with the masses of weak-interaction bosons.

4. We discuss aspects of modeling neutrinos as Dirac neutrinos and aspects of modeling neutrinos as Majorana neutrinos.

5. We discuss interactions that contribute to neutrino oscillations.

6. We discuss aspects related to masses of neutrinos.

   (a) People might say that CUSP nominally correlates with each neutrino flavor having zero mass and with the notion that zero-mass neutrinos need not be incompatible with data as of 2017.

   (b) People might say that people can use CUSP to model aspects involving non-zero-mass neutrinos, should people determine that at least one neutrino flavor has non-zero mass.

7. We discuss the notion that the left-handed or right-handed aspect of weak-interaction parity violation may differ by ensemble.

8. We discuss possible phenomena correlating with photon lasing. We allude to possible practical applications regarding controlling or detecting aspects of laser-produced light. Applications might pertain to lasing and/or quantum computing.

9. We discuss bases for possible symmetries that might correlate with aspects of elementary fermions. Possibly, such symmetries have at least some conceptual similarity to elementary boson $SU(3) \times SU(2) \times U(1)$ symmetries.

10. We discuss the extent to which people may be able to directly detect dark matter.

5.2 Nominal moments

This unit discusses possibilities that people can correlate nominal moments, correlating with interactions that photons or gravitons intermediate, that our theory suggests with aspects of traditional physics.

Work above correlates the object property charge with the 2G2 solution, the object property nominal magnetic dipole moment with the 2G24 solution, and the object property rest energy (or, rest mass) with the 4G4 solution. People might say that people have opportunities to correlate object properties with solutions 2G248, 4G48, 4G246, 4G2468a, and 4G2468b. (See table 3.32.)

In discussion leading to equation (3.32), we suggest attributes of the earth that might correlate with the 2G248 solution. People might say that Larmor precession provides an application, correlating at least with classical electromagnetism, that people can correlate with a quantum application featuring the 2G248 solution. People might say that people have explored use of various techniques to suggest, for phenomena correlating with 2G248, in effect, an analog to $g \approx 2$ for magnetic dipole moment and 2G24. Results may correlate with Thomas precession and/or the Bargmann-Michel-Telegdi equation. Techniques might include applications of the Dirac equation and/or applications of an electromagnetic field strength tensor.

TBD

1. To what extent might people use traditional modeling, based on classical gravitation physics and/or general relativity, to correlate each of solutions 4G48, 4G246, 4G2468a, and 4G2468b with an appropriate set of concepts such as concepts table 3.28 mentions (and/or with other similar concepts)? (Note, for example, that the solutions correlate, respectively, with nominal dipole, quadrupole, octupole, and octupole moments.)

2. To the extent people correlate each of solutions 4G48, 4G246, 4G2468a, and 4G2468b with an appropriate set of concepts such as concepts table 3.28 mentions (and/or with other similar concepts), to what extent do relevant concepts correlate with properties of elementary fermions, absent clouds of virtual particles? Of elementary fermions, including clouds of virtual particles? Of elementary bosons, absent clouds of virtual particles? Of elementary bosons, including clouds of virtual particles?

5.3 Anomalous moments

This unit discusses possibilities that people can correlate CUSP models with anomalous magnetic dipole moment data, with traditional QED calculations of anomalous magnetic dipole moments, and with other possible anomalous moments.

People might say that G-family solutions that CUSP does not associate with $\Sigma\gamma$, for $2 \leq \Sigma \leq 8$, correlate with possible ways to model anomalous moments, such as anomalous magnetic dipole moments. Table 5.1 lists G-family solutions that do not correlate with $\Sigma\gamma$, for $2 \leq \Sigma \leq 8$. The column labeled count shows the number of solutions with which a row in the table correlates.

Chapter 6

Cosmology timeline and some astrophysics phenomena

This unit suggests specifics regarding aspects of the cosmology timeline and discusses some astrophysics phenomena.

6.1 Summary - cosmology timeline and phenomena

This unit summarizes contributions we suggest regarding the cosmology timeline and astrophysics.

People exhibit cosmology timelines. Generally, the timelines include events and eras. People might say that, generally, the earliest item is an event that people call the big bang.

People might say that our work provides insight regarding eras on the timeline regarding the following items.

1. The instant of and an era after the big bang.
   (a) At the instant of the big bang, conservation of energy does not pertain for the universe. Possibly, energy populates states for at least some G-family bosons correlating with at least some of solutions 2G2; ΣG24, for at least $\Sigma = 2$; ΣG246, for at least $\Sigma = 4$; and ΣG2468, for at least $\Sigma = 4$.
   (b) Then, conservation of energy pertains; physics-relevant ensembles populate roughly equally; and, possibly, pair production based on G-family bosons populates fermion states such that, within each physics-relevant ensemble, matter fermions and antimatter fermions balance.
2. Expansion of the universe, from the big bang until now.
   (a) Forces mediated by G-family bosons provide mechanisms driving expansion and provide for changes in the inferred rate of expansion of the universe. The components of 4γ (or, gravitons) play key roles. For the largest objects that people can directly infer, ...
      i. Dominance by forces for which SDF of r^{-5} pertains correlates with the first few billion years of accelerating expansion of the electromagnetically observable universe;
      ii. Dominance by forces for which SDF of r^{-4} pertains correlates with a next few billion years of decelerating expansion of the electromagnetically observable universe; and
      iii. Dominance by forces for which SDF of r^{-3} pertains correlates with the recent few billion years of accelerating expansion of the electromagnetically observable universe.
3. A possible evolution from baryon balance to baryon asymmetry. Here, balance or asymmetry refers to relative numbers of matter particles and antimatter particles.
   (a) In the ordinary-matter ensemble, interactions mediated by charged 2O bosons convert antimatter quarks into matter quarks. Concurrently, interactions mediated by W bosons convert antimatter charged leptons

into neutrinos and convert neutrinos into matter charged leptons. To the extent neutrinos behave as Dirac neutrinos, the number per unit of volume of background antimatter neutrinos exceeds the number per unit volume of background matter neutrinos.

4. A possible inflationary epoch and possible composite sea phase transitions.

   (a) To the extent nature exhibits phenomena that people correlate with the phrase inflationary epoch, perhaps at least one of the following correlates with that epoch.

      i. Evolution from baryon balance to baryon asymmetry.
      ii. One or more phase transitions, within a sea, with each transition correlating with at least one of the following transitions: (1Q⊕1R)→1Q, (1Q⊕1R)→1R, (2Y⊕2O)→2O, (2Y⊕2O)→2Y, 1Q→1R, and 2O→2Y.

   (b) Possibly one or more such phase transitions occurred during times not correlating with the notion of an inflationary epoch.

5. Mechanisms leading to CMB (or, cosmic microwave background) cooling.

6. The relative densities, in galaxy clusters, of ordinary matter and dark matter.

   (a) Inferences about dark matter within galaxy clusters seem to be not inconsistent with density ratios of about five to one, dark matter to ordinary matter. CUSP suggests that this ratio correlates with the ratio of number of dark matter ensembles to number of ordinary matter ensembles.

   (b) CUSP suggests that, to the extent the actual density ratio (averaged over clusters and/or as determined via data regarding CMB radiation) is $5 + x$ to one, people can consider adding a component correlating with $x/6$ to the otherwise inferred density of ordinary matter. People calculate ordinary matter density of the universe by summing densities for baryonic matter, photons, and neutrinos. CUSP suggests that a fourth component, correlating with $x/6$, might correlate with ordinary matter composite particles other than composite particles made exclusively from quarks and gluons. (Some of these composite particles would not interact with light.)

7. Scenarios for the formation and evolution of galaxies, including possible changes over time in the relative densities within individual galaxies of ordinary matter and dark matter.

   (a) A CUSP-based scenario seems to dovetail with data published during the period 2015 to 2017. Early on, an ordinary matter galaxy can be essentially all ordinary matter. Over time, the galaxy attracts and accumulates other-ensemble dark matter, leading to about 79 percent of the galaxy being dark matter. The scenario features mechanisms that correlate with the monopole and dipole components of gravity and with electromagnetism. The scenario is not incompatible with notions that more than 83 percent of a galaxy cluster may be dark matter and that about five-sixths of the galaxies in a cluster may be dark matter galaxies. This explanation is not incompatible with the existence of ordinary matter stars in dark matter galaxies. This explanation is not incompatible with collisions between originally essentially single-ensemble galaxies creating mixed-ensemble galaxies and/or deformed or irregular galaxies. To the extent traditional theories of galaxy formation might suggest that concepts above would correlate with galaxies not being adequately spatially large, the repulsive force of the dipole component of gravity might have contributed to adequate dispersal of stuff. This explanation is not incompatible with the notion that, in ordinary matter galaxies, dark matter halos can include one or both of other-ensemble material and ordinary-ensemble composite particles.

8. Mechanisms possibly leading to the formation of quasars and to black hole jets.

9. The possibility that CUSP provides bases for resolving the spacecraft flyby anomaly.

TBD

1. Beyond items traditional cosmology timelines include and/or items we discuss, what other events or eras might a cosmology timeline feature?

6.2 Notes - dominant forces in and between two neighboring clumps

This unit discusses an evolution regarding forces that dominate in and between neighboring clumps of stuff.

We do a thought experiment.

We consider two similar, neighboring clumps of stuff. Each clump, in today's universe could be, for example, a galaxy. For the moment, we consider that the two clumps correlate with the same ensemble. For the moment, we de-emphasize effects correlating with other ensembles. For the moment, we assume that the clumps form in a way such that the dominant forces within and between the two clumps are, for some time, forces for which SDF of r^{-5} pertains. We assume that these forces feature repulsion. As the objects expand and move apart, forces correlating with SDF of r^{-4} become dominant. We assume that these forces feature attraction and that the attraction does not trigger implosion of an object and does not reverse the moving apart of the two objects. Then, forces with SDF of r^{-3} become dominant. We assume that these forces feature repulsion. Then, forces with SDF of r^{-2} become dominant. For a period in which a particular SDF roughly dominates, we use the term era. (See table 4.14.)

Some notes pertain regarding cosmology and astrophysics.

1. Smaller objects progress through eras faster than do larger objects. Pairs of neighboring smaller objects progress through eras faster than do neighboring pairs of larger objects.

2. The above analysis emphasizes G-family forces.

3. People might say that the possibility that the universe includes more than one ensemble does not significantly affect general results of this thought experiment.

4. Some known or inferable large objects have yet to transit from an era in which SDF of r^{-3} pertains to an era in which SDF of r^{-2} pertains. Within such objects, adequately smaller objects have made the transition.

5. People might say that concepts such as that the material in a solar system or galaxy may not have been a clump earlier in the history of the universe do not significantly impact the usefulness of the concept of such eras.

6.3 The moment of the big bang and shortly thereafter

This unit suggests models pertaining to the instant of the big bang and to times somewhat thereafter.

People might say that the following statements pertain.

1. Regarding the instant of the big bang, the following pertain.
   (a) Conservation of energy does not pertain. Models correlating with IQI+c symmetry do not pertain. (See discussion related to table 4.18.)
   (b) Models correlating with IQI+b_1 or IQI+b_2 might pertain.
   (c) For each of the 48 ensembles, non-zero non-ground-state energy populates states correlating with at least one of solutions 2G2, ΣG24, ΣG246, and ΣG2468 and possibly with other solutions.
      i. Each of 2G2, ΣG24, ΣG246, and ΣG2468 correlates with 48 instances.
      ii. For 2G2, ΣG24, ΣG246, and ΣG2468, models for these phenomena might correlate with IQI+b_1 or IQI+b_2. (See table 4.18.)

2. Starting essentially instantly after the instant of the big bang, the following pertain.

Chapter 7

Multi-component objects

This unit discusses applications of CUSP modeling to composite particles, objects similar to the hydrogen atom, decay, fused systems, and fissionable systems.

7.1 Summary - internal aspects of objects

This unit summarizes results regarding modeling internal aspects of multi-component objects.

People might say that we do the following.

1. We discuss possibilities for using CUSP to model composite particles.
2. We show possible similarities, regarding modeling the hydrogen atom, between results of some traditional models and results of some CUSP models.
3. We explore aspects of CUSP modeling possibly relevant to decay, fused systems, and fissionable systems.

7.2 Bases for modeling multi-component objects

This unit discusses aspects of using CUSP techniques to model aspects of objects that include more than one elementary particle.

We consider PDE QUAD modeling. We extend results correlating with, for example, equation (2.26). People might say that this work also extends work related to equation (10.5). Regarding, at least, objects consisting of multiple elementary particles, equations (7.1) and (7.2) generalize from equation (2.86). People might say that positive values of f_{QE} can correlate with bound states. People might say that positive values of f_{QP} can correlate with possibilities for fission or radioactive decay.

$$A_{QE}^{PDE} \propto E^2 + f_{QE} \tag{7.1}$$

$$A_{QP}^{PDE} \propto (mc^2)^2 + f_{QP} \tag{7.2}$$

Table 7.1 pertains. Table 7.1 correlates with PDE|PDE modeling. We use PDE|PDE modeling for aspects related to the existence of elementary particles, as well as for aspects related to internal states of objects. Here, E^2 correlates with the term square of total energy. Here, $(mc^2)^2$ correlates with the term square of rest energy. The table includes a case of $m = 0$ because PDE modeling pertains to neutrinos. (See table 3.14.) People might say the $m = 0$ case is not physics-relevant for objects that include more than one elementary particle.

Per remarks in or pertaining to tables 2.30, 2.31, and 2.10 and to equations (2.28) and (2.29), we anticipate discussing modeling based on aspects that table 7.1 notes. People might say that $f_{QP} > 0$ correlates, in effect, with adding rest energy and correlates with a decay constant t_d that has dimensions of time and correlates with

Chapter 8

Physics constants

This unit notes a possible numerical relationship within a set, that includes the mass of the tauon and the gravitational constant, of physics constants and notes possibly new roles, in formulas, for the fine-structure constant.

8.1 Summary - physics constants

This unit summarizes results regarding physics constants.

1. Regarding physics constants, ...
   (a) We discuss a formula that possibly relates the mass of the tauon to various physics constants including G_N (or, the gravitational constant). As of 2017, equation (8.1) predicts a more accurate tauon mass than people measure. (The symbol m_τ denotes the mass of a tauon.)
   (b) People might say that we show at least one new appearance of α (or, the fine-structure constant). This appearance correlates with a formula linking masses of quarks and charged leptons.
   (c) We raise a question regarding the extent of physics-relevance for the Planck length.

$$(4/3)(m_\tau/m_e)^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{8.1}$$

8.2 A correlation between m_τ and G_N

This unit explores aspects regarding a possible numerical relationship within a set, that includes the mass of the tauon and the gravitational constant, of physics constants.

Regarding equation (2.78), we correlate the factor of 4 with the number of channels correlating with 2G2 and we correlate the factor of 3 with the number of channels correlating with 4G4. (See discussion pertaining to equation (3.28) and see table 4.5.) People might say that β^{12} correlates with a relative strength, per channel, for the 2G2 component of electromagnetism and the 4G4 component of gravitation.

Above, we discuss a possible correlation between m_τ and G_N. (See equation (2.79).)

We factor the exponent 12, in the left-hand side of equation (2.78), as $12 = 2 \times 6$. We correlate the factor 2 with two interaction vertices. Models correlate with the concept that each G-family boson excites (or, is created) at one vertex, which correlates with one of two interacting objects, and de-excites at a second vertex, which correlates with the other of two interacting objects.

We consider a concept of interpolating between 2G2 electromagnetism and 4G4 gravitation. (See, for example, table 3.19.) People might think of $M'' = 0$ as correlating with a maximally 2G2 electrostatic (or, minimally 4G4 gravitational) interaction between two charged leptons. $M'' = 3$ correlates with a tauon. People might think of, in essence, five more ranges of M''. Those ranges are $3 \leq M'' \leq 6$, $6 \leq M'' \leq 9$, $9 \leq M'' \leq 12$, $12 \leq M'' \leq 15$, and $15 \leq M'' \leq 18$. (Also, people might consider, in essence, six ranges regarding quarks and either of $|M'| = 2$

Chapter 9

CUSP modeling and traditional modeling

This unit discusses relationships between and uses for some CUSP models and traditional models.

9.1 Summary - CUSP and traditional models

This unit summarizes aspects regarding some CUSP models and traditional models.

People might say that we do the following.

1. We explore possibilities that the traditional physics concept of action pertains, in CUSP, to temporal aspects and/or to models regarding the existence and properties of elementary particles.

2. We compare advantages of using some CUSP models and traditional models. We compare advantages of some technical aspects of CUSP models and traditional models.

3. We explore the notion that, though people obtain useful results from models based on general relativity, CUSP might provide alternative means for modeling phenomena that people model via general relativity. People might say that, possibly, people can extend our work to model such results based on SR (or, special relativity) or NE (or, Newtonian physics) bases.

4. We discuss aspects regarding general relativity, including ...

   (a) Possible limitations on the applicability of general relativity.

   (b) Possible bases for extensions to general relativity.

5. We note that possibilities may exist to bridge between and integrate aspects of the Standard Model and aspects of CUSP.

9.2 Notes - current and future models

This unit notes possibilities for integrating current and future physics models.

People might say that we point to possibilities for integrating some current physics models and some future physics models. (See table 1.2.) Table 2.5 points to various types of physics models.

TBD

1. To what extent might people use CUSP techniques to integrate useful traditional physics models?

Chapter 10

Physics foundation topics

This unit discusses aspects of the topics including CPT-related symmetries, arrow of time, numbers of dimensions, minimum non-zero magnitudes, the extent to which nature exhibits wave functions, entanglement, entropy, and other topics.

10.1 Summary - physics foundation topics

This unit summarizes results regarding foundation of physics topics.

People might say that we do the following.

1. Regarding CPT-related symmetries, ...
   (a) We contrast CUSP APM, SP, and TP symmetries with traditional C, P, and T symmetries.
   (b) We show a potentially significant difference between TP and T symmetries.
2. Regarding the topic of arrow of time, we provide mathematical modeling that people might consider when discussing the topic. Each of the following points to possibilities that people need not necessarily consider that an arrow of time can run backwards.
   (a) Notions related to TP symmetry.
   (b) Notions correlating with normalization of solutions.
3. Regarding topics people correlate with terms such as numbers of dimensions or extra dimensions, we list some bases for dimension-like constructs that people might find useful.
4. Regarding minimum non-zero magnitudes, such as a minimum magnitude of non-zero charge, we list some quantities that people might find significant.
5. Regarding the topic of wave functions, we note that, for each of some aspects of nature, the existence of possibly useful alternative models calls into question the notion that nature includes wave functions.
6. Regarding entanglement, we point to possible challenges and opportunities regarding modeling.
7. We point to a possible link between exponential relationships between masses of charged leptons and modeling aspects of entanglement.
8. We discuss notions regarding the extent to which models correlate with the possible existence of space-time.
9. Regarding the topic of entropy, we point to a possibility for correlating CUSP with concepts related to entropy.

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
$n_{Ej''}$ and $n_{Ej'}$	-	Yes	Yes	No	No	No	No
-	n_{E0} and n_{P0}	No	No	No	No	No	No
$n_{Pj'}$ and $n_{Pj''}$	-	No	Yes	Yes	No	No	No

Table 10.1: P, C, and T transformations (regarding ALG|COR, ALG|GEN, ALG|HAN, ALG|KIN|17, and ALG|DYN|7 models)

10. Regarding the number of generations for elementary fermions, we discuss aspects related to modeling number of fermion generations and modeling properties that correlate with generations.

11. Regarding gravity and electromagnetism, we discuss the possibility that theory cannot completely disassociate gravity and electromagnetism and the possibility that people can develop theory that better (than we do) integrates the two concepts.

12. We discuss possibilities that our work provides both new perspective on traditional aspects of possible equivalence of gravitational mass and inertial mass and new perspective regarding the possibility that gravitational mass and inertial mass might differ.

10.2 CPT-related symmetries and APM, SP, and TP symmetries

This unit discusses a way in which our work correlates with CPT symmetry.

Table 2.11 defines transformations (or, swaps) correlating with APM, SP, and TP symmetries. APM, SP, and TP symmetries pertain throughout uses of ALG|COR, ALG|GEN, ALG|HAN, ALG|KIN|17, and ALG|DYN|7 models.

People might say that people introduced into physics modeling notions of C (or, charge-reversal) transformations and symmetries, P (or, parity-reversal) transformations and symmetries, and T (or, time-reversal) transformations and symmetries before people knew of the concepts of gluons and color charge. People might say that P transformations equal SP transformations. People might say that, if people extend C and T transformations and symmetries to include concepts correlating with appropriate notions of COLC (or, color charge) transformations, C symmetry would equal APM symmetry and T symmetry would equal TP symmetry. People might say that such an extension can embrace the notion of 48 ensembles.

People might say that table 10.1 correlates with notions of T, C, and P symmetries that are both traditional and useful.

People might say that the following statements pertain.

1. Each of the set of TP, APM, and SP symmetries and the set of T, C, and P symmetries correlates with a notion of QE-like parity.

2. Regarding the set of TP, APM, SP symmetries, the following statements pertain.

   (a) QE-like parity correlates with an effective $D^*_{QE|TP} = 3$, per equation (10.1).

   (b) TP reversal correlates with notions of temporal parity reversal, in three dimensions and without time (or, lone temporal coordinate) reversal.

3. Regarding the set of T, C, and P symmetries, the following statements pertain.

   (a) QE-like parity correlates with an effective $D^*_{QE|T} = 1$, per equation (10.2).

   (b) T reversal correlates with notions of temporal parity reversal, in one dimension and therefore with time (or, lone temporal coordinate) reversal.

Chapter 11

Perspective - about and after this work

This unit suggests perspective about physics progress, notions regarding CUSP contributions to physics progress, and opportunities for further research.

11.1 Measuring physics progress

This unit notes some aspects of physics, discuses some aspects of how physics progresses, and mentions some aspects via which people might evaluate theories and models, discusses the notion that CUSP might suffice to describe much physics, and lists categories of opportunities for further research.

Table 11.1 lists aspects of physics. People might correlate with theories or models that match inferences the word what. A theory or model of what correlates with pattern matching. People might correlate with theories or models that explain inferences the word how. A theory or model of how, in effect, explains inferences based on applications of theories and/or models of what and/or how.

Table 11.2 lists aspects of progress regarding physics. Some breakthroughs correlate with transitions, regarding some inferences, from having no theories or models that match the inferences, to having theories or models that match the inferences. Some breakthroughs correlate with transitions, regarding some inferences, from having only theories or models that match the inferences to having theories and/or models that explain the inferences.

Table 11.3 lists aspects via which people might evaluate theories and models.

People might say that phenomena that tables 3.1 and 4.1 match and/or predict suffice to explain much physics. People might say that CUSP provides a framework for integrating some physics theories. (See, for example, tables 2.5, 2.23, and 4.5.)

People might say that, to the extent CUSP explains much physics and/or CUSP provides a framework for integrating theories, ...

Aspects
• Observations • Inferences based on observations • Theories and models that match inferences • Theories and models that explain inferences • Applications of physics

Table 11.1: Aspects of physics

Aspects
• Sets of useful observations improve and/or grow. • Inferences based on observations become more useful. • Theories and models match previously unmatched inferences. • Theories and models explain inferences that had otherwise been matched but not explained. • Theories and models output seemingly useful predictions. • Theories and models become united and/or easier to apply. • Applications of physics become more encompassing and useful.

Table 11.2: Aspects of physics progress

Aspects

• Aspects for which less might be better than more ...
  – Inconsistency with observations
  – Inputs, such as parameters and other assumptions
• Aspects for which more might be better than less ...
  – Scope of possible uses
  – Ease of use
  – Scope of predictions
  – Possibilities to test predictions
  – Consistency, within scope
  – Coherence, within scope
• Other aspects for which more might be better than less ...
  – Consistency with useful results that other theories and models produce (though not necessarily consistency with methods inherent in other theories or models)
  – Overlaps with useful other theories and models
  – Research opportunities

Table 11.3: Aspects of quality, for theories and models

Opportunities
• Modify CUSP so as to take care of any discrepancies between CUSP and verified phenomena in nature. • Try to anticipate and look for phenomena beyond those of which people know or CUSP predicts. • Try to extend CUSP so as to gain insight about phenomena correlating with terms such as nuclear physics, solid state physics, tunneling, and decay. • Develop theories of how to underlie CUSP theories of what. • Address topics and opportunities that this work identifies in units labeled TBD. • Extend and/or clarify work and statements that this work identifies in sentences that start with the words people might say that. • Develop theories or models correlating with QCD|ALTE and QED|ALTE. • Use the CUSP framework to integrate and extend useful physics theories and to understand limits on the applicability of physics theories. • Find other applications for mathematics underlying CUSP. Some mathematics underlying CUSP correlates with the term quantum harmonic oscillator and/or the term group theory.

Table 11.4: General opportunities for research

1. CUSP and traditional physics suffice to model much physics.
2. Table 11.4 points to possible further opportunities for research.

TBD

1. To what extent do the known and possible elementary particles to which table 3.1 alludes and the multiple instances, to which table 4.1 alludes, of these particles suffice to explain known phenomena and inferred aspects of nature?
2. To the extent the known and possible elementary particles to which table 3.1 alludes and the multiple instances, to which table 4.1 alludes, of these particles do not suffice to explain known phenomena and inferred aspects of nature, how might people change CUSP to close gaps between theory and nature? (For example, to what extent might people predict other elementary particles based on more ALG solutions?)
3. To the extent the known and possible elementary particles to which table 3.1 alludes and the multiple instances, to which table 4.1 alludes, of these particles suffice to explain known phenomena and inferred aspects of nature, what insight might people gain regarding each of the following?
   (a) Possible non-existence of magnetic monopoles.
   (b) Possible lack of physics-relevance of supersymmetry.

11.2 Applications and implications of this work

This unit alludes to applications and implications of work we present.

The following statements provide examples of work above that may provide insight regarding topics of interest.

- The work comports with the notion that two non-zero charges and three generations pertain for spin-1/2 elementary leptons. (See remarks regarding the 1C row of table 4.5.)
- Decomposition of aspects of photons into three components may provide insight into physics foundation topics or into so-called classical-quantum boundaries. (See equation (3.32).)
- People may find significant the use of models based on harmonic oscillators to catalog and describe fermions. (Note, for example, equations (2.44), (2.42), and (2.43).)
- The work may correlate with a lack of need to address notions of possibly infinite sums of boson ground-state energies. (Note equation (2.34).)
- The work may correlate with a lack of need to address notions of renormalization.
- The work may indicate that much traditional physics correlates modeling assumptions correlating with ALG|PRO, whereas modeling assumptions correlating with ALG|KIDY can lead, with less complexity, to similar results and to broader results. (See, for example, table 2.4, discussion related to table 2.20, and tables 4.5 and 4.9.)
- The work may provide insight regarding possible uses for the term quantum gravity. People might consider that 4γ correlates with gravitons and quantum gravity.
- Facets of bases of PDE|PDE seem well suited for describing aspects of phenomena leading up to an interaction vertex and aspects of phenomena occurring after an interaction vertex. (See, for example, equations (2.3) and (2.21).) Applications of ALG|GEN seem well suited for describing aspects of phenomena correlating with interaction vertices. Applications of ALG|KIDY seem well suited for describing aspects of phenomena before, at, and after interaction vertices.

Applications and implications related to cosmology and astrophysics include the following.

- Concepts for populating elementary particle states at and just after the big bang.
- Mechanisms leading to baryon asymmetry. (The 2O2 boson has a charge of $-|q_e|/3$ and plays a key role in converting antimatter quarks to matter quarks. Here, q_e denotes the charge of an electron.)
- The possibility that cosmic background neutrinos feature more antimatter neutrinos than matter neutrinos and that the difference in count correlates with baryon asymmetry. (This possibility correlates with the concept of Dirac neutrinos and does not correlate with Majorana neutrinos.)
- Clumping and anti-clumping of ordinary matter and dark matter, leading to galaxies initially forming with mostly material correlating with one ensemble and leading to galaxy clusters forming with approximately five times as much dark matter as ordinary matter.
- Correlations between scenarios via which galaxies and other objects form and the dark matter content of objects that originally feature mostly ordinary matter.
- Correlations between scenarios via which galaxies and other objects form and the ordinary matter content of objects that originally feature mostly dark matter.
- Phenomena that might help resolve the galaxy rotation problem.
- A possible basis for explaining the spacecraft flyby anomaly.

Possible applications and implications of PDE|PDE techniques regarding nuclear physics and atomic physics include the following.

- A way to catalog atomic states.

- Possibly, a way to parallel and/or augment QED (or, quantum electrodynamics).
- Possibly, a way to parallel and/or augment the nuclear shell model.

Applications and implications regarding elementary particle physics include the following.

- A correlation between the range of the weak interaction and the masses of weak-interaction bosons.
- A technique for, at least approximately, matching ratios of squares of masses for the H^0, Z, and W bosons and for providing approximate masses for 2O bosons. (The technique correlates with the boson point-like case in table 2.15 and may explain the weak mixing angle. Equation (11.1) results.)

$$(m_{\mathrm{H}^0})^2 : (m_{\mathrm{Z}})^2 : (m_{\mathrm{W}})^2 :: 17 : 9 : 7 \tag{11.1}$$

- Interactions that produce neutrino oscillations.
- Possibly, a way to parallel and/or augment QCD (or, quantum chromodynamics). (See table 4.9.)
- Possibly, a way to parallel and/or augment QED (or, quantum electrodynamics), including to produce algebra-based expressions correlating with anomalous moments.

Applications and insight regarding physics constants include the following.

- A prediction regarding the tauon mass. (See equation (3.27). Reference [5] provides the experimental result equation (11.3) shows and provides the data - about G_N and so forth - we use to make the prediction equation (11.2) shows.)

$$m_{\tau,\text{ predicted}} \approx (1776.8445 \pm 0.024)\ MeV/c^2 \tag{11.2}$$

$$m_{\tau,\text{ experimental}} \approx (1776.86 \pm 0.12)\ MeV/c^2 \tag{11.3}$$

- The appearance of α (or, the fine-structure constant) in a formula approximately linking the masses of the three charged leptons and the six quarks. (The formula involves six constants and two integer variables. Four of the six constants are m_e, m_μ, m_τ, and α.)

Applications and insight regarding foundations physics topics include the following.

- Possible insight regarding CPT-related symmetries.
- Possible insight regarding arrow of time.
- Possible insight regarding numbers of dimensions.
- Possible insight regarding minimal non-zero magnitudes of some properties.

Applications and insight regarding traditional theory and models include the following.

- Possible correlations between constructs in our Hamiltonian-centric work and action in Lagrangian-centric work.
- Possible limitations regarding applications of general relativity and/or of concepts of space-time geodesics and curvature of space-time.
- Possible alternative ways to obtain results people obtain via general relativity.
- Both a QE-like method and a QP-like method to obtain the Standard Model $SU(3)\times SU(2)\times U(1)$ symmetry.
- Possibilities for adding, based on $SU(3) \times SU(2) \times U(1)$, to the Standard Model all elementary particle phenomena we predict, other than phenomena correlating with boson components correlating with $\sigma = +1$, $N_{QE|COR} = 5$ or 7, and $n_{P0} \leq -1$.
- Possibilities for adding to the Standard Model elementary particle phenomena we predict correlating with boson components correlating with $\sigma = +1$, $N_{QE|COR} = 5$ or 7, and $n_{P0} \leq -1$.

11.3 Opportunities for research regarding phenomena

This unit discusses phenomena that people might try to detect, measure, or infer.

Previous units allude to some of the possible opportunities this unit discusses. Previous units provide details regarding some of the possible opportunities this unit discusses. Previous units discuss other possible opportunities. (See, for example, table 11.4.)

People might say that people might want to attempt, soon or eventually, to verify or to rule out, to some degree of confidence, the existence of the following; to measure properties of the following; and/or to measure the following properties more accurately.

1. Predicted elementary particles. (See table 3.2.)
2. O-family interactions that table 3.16 predicts.
3. Composite particles that include O-family bosons, including the following.
   (a) Composite particles consisting of quarks and 2O bosons.
   (b) Composite particles that include 1R fermions.
   (c) Threshold energies for producing composite particles.
4. CP-violations that correlate with 2O2 and 2O1 particles.
5. CUSP predictions regarding conservation of generation and non-conservation of generation.
6. Ranges for interactions mediated by various 2W, 0H, and 2O bosons.
7. Masses, to more accuracy than has been determined, of W- and H-family bosons.
8. Aspects regarding G-family phenomena, including the following.
   (a) Interaction strengths correlating with solutions other than 2G2, 2G24, and 4G4.
      i. Perhaps, consider effects on the rate of expansion of the universe.
      ii. Perhaps, consider effects regarding simple atoms.
   (b) Possible interactions mediated by interactions correlating with G-family solutions that couple ordinary-matter to dark matter elementary particles.
9. Aspects, regarding lasing correlating with various G-family solutions, including the following.
   (a) Possibilities for correlations and/or anti-correlations between aspects correlating with various solutions that correlate with photons.
   (b) Possibilities for exciting, detecting, and/or gaining practical benefit from such correlations and/or anti-correlations.
10. Neutrino masses.
11. The tauon mass and/or G_N.
    (a) Of special interest is the possibility that equation (11.4) pertains. Based on PDG 2016 data, the equation predicts a tauon mass with a standard deviation of less than one quarter of the standard deviation correlating with the experimental result. Possibly, more accurate experimental determination of the tauon mass could predict a more accurate, than experimental results, value for the gravitational constant, G_N.

$$(4/3) \times (m_\tau/m_e)^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{11.4}$$

12. Neutrino oscillations.

   (a) Of special interest are correlations, based on the surroundings through which neutrinos pass, with interactions mediated by various elementary bosons.

13. Ratios, during the evolution of the universe, of the density of dark matter to the density of ordinary matter.

   (a) Of special interest is the possibility that dark matter consists mostly of five, in essence, copies of a set consisting of 2017 Standard Model particles, some possible composite particles, and effects correlating with some G-family solutions. (See table 4.1.)

14. Ratios, for the cosmic neutrino background, of antimatter neutrinos to matter neutrinos.

   (a) Of special interest is the possibility that a preponderance, compared to matter neutrinos, of antimatter neutrinos could correlate with a CUSP scenario for creating the baryon asymmetry (or, charged-matter/charged-antimatter imbalance) people observe regarding much of the history of the universe. People might say that the scenario is of particular interest to the extent matter and antimatter charged particles were approximately in balance early in the history of the universe.

15. Inferred ratios, regarding various times during the evolution of the universe, of the density of dark energy stuff to the density of dark matter plus ordinary matter.

   (a) Of special interest is the evolution of those ratios. The ratios may correlate with the strength of interactions intermediated, in effect, by 1R fermions and/or with the strength of other interactions. (People might say that these ratios might not vary based on notions of dark energy as a pressure or on notions of creation, over time, of dark energy.)

16. Aspects, within galaxies and similar objects, pertaining to dark matter and ordinary matter.

   (a) Of special interest are statistics regarding ratios of ordinary matter to dark matter.
   (b) Of special interest are possibilities for clustering and/or anti-clustering within and between clumps the feature ordinary matter, within and between clumps that feature dark matter, and between clumps that feature ordinary matter and clumps that feature dark matter. Here, the term feature does not necessarily imply the notion of include only. Such aspects may correlate with effects of G-family bosons.

11.4 Opportunities for theoretical research

This unit discusses theory that people might enhance or develop.

Previous units allude to some of the possible opportunities this unit discusses. Previous units may provide details regarding some of the possible opportunities this unit discusses. Previous units discuss other possible opportunities. (See, for example, table 11.4.)

People might say that people might want to enhance or develop theory regarding the following topics. Doing so could help determine experiments and observations to attempt and/or advances in techniques that may be needed in order to conduct useful experiments or to make useful observations.

1. What might a better (or more accurate), than CUSP includes, model for masses of non-zero-mass elementary bosons entail?

2. What minimum energies are required to produce 2O bosons or composite particles that include 2O bosons?

3. Under what circumstances might people create 2O bosons or composite particles that include 2O bosons?

4. What are the sizes of coupling constants that pertain to producing and detecting phenomena correlating with 2O bosons?

5. What would lifetimes and decay products be for composite particles that include 2O bosons?

6. How best might people detect or infer or rule out, to some confidence level, the possible existence of 2O bosons?

7. To what extent can people use CUSP techniques to predict composite particles that involve just quarks and gluons?

8. What would a better, than CUSP now includes, model for masses of non-zero-mass elementary fermions entail?

9. For various models of interactions between gravity and each of various types of elementary particles, which non-negative integer m, as in m-tensor, pertains and what are the components of the m-tensor? (People might say that the m-tensor likely correlates with E (or, the energy) and P (or, the momentum) of a zero-mass elementary particle.)

10. To what extent, if any, do inferences rule out the existence of three generations of zero-mass neutrinos?

11. What perturbation theory might pertain for CUSP models? (Note that CUSP includes notions of clouds of virtual particles.)

12. What interaction coupling strengths pertain correlating with G-family solutions other than 2G2, 2G24, 4G26 (in the context of electromagnetism and not necessarily in the context of 6G-related phenomena), and 4G4?

13. To what extent, regarding G-family lasing, might correlations and/or anti-correlations pertain regarding, in effect, various G-family solutions and their modes?

14. To what extent might people develop a traditional physics field-like formulation for G-family physics such that there are ten fields correlating, respectively, with 2G, 4G, ..., 18G, and 20G? Or, four fields correlating, respectively, with 2γ, 4γ, 6γ, and 8γ?

15. To what extent do G-family interactions, possibly other-family interactions, and/or virtual clouds affect measurements regarding masses of 2W, 0H, and 2O bosons?

16. What magnitudes of CP-violations correlate with interactions mediated by 2O2 and 2O1 elementary bosons?

17. What magnitudes of CP-violations correlate with interactions mediated by 2W1 and 2W2 bosons, in CQI environments?

18. To what extent might interactions, in effect, split G-family solutions (other than 2G2, 4G4, 6G6, and 8G8) into components? (CUSP does not necessarily include such possible interactions. Such interactions might appear to perform functions people attribute to as yet hypothetical axions.)

19. How might people better (than CUSP does now) extend theory related to absorption or emission of elementary bosons by elementary fermions to theory related to elementary-fermion pair production and pair annihilation? (See, for example, table 3.16.)

20. To what extent does work, similar to work regarding PDE|PDE, regarding possible symmetries pertaining to hydrogen atoms and similar systems provide useful insight regarding atomic and molecular physics?

21. To what extent might effects of G-family forces, associated with G-family solutions other than 2G2, 2G24, and 4G4, lead to black holes becoming quasars and/or lead to black hole jets?

22. To what extent might people use CUSP techniques to shape discussion and understanding regarding topics people might correlate with the phrase quantum/classical boundary?

23. How might people better (than we do now) harmonize or integrate CUSP models and traditional models and theories?

11.5 Opportunities for societal progress

This unit discusses some possible opportunities for societal progress based on aspects of our work.

TBD

1. To what extent might people benefit from concepts that people might develop regarding circumstances, techniques, and so forth correlating with our work?

11.6 Concluding remarks

This unit provides future-oriented perspective regarding aspects of this work.

We think that this work provides, at least, precedent and impetus for people to try tackle an agenda to unite much physics; make predictions regarding elementary particles; and explain aspects of sub-atomic physics, atomic physics, astrophysics, and cosmology. This work may provide a means to tackle such an agenda. This work may provide progress toward fulfilling that agenda.

Bibliography

[1] Thomas J. Buckholtz. *Models for Physics of the Very Small and Very Large*, volume 14 of *Atlantis Studies in Mathematics for Engineering and Science*. Springer, 2016. Series editor: Charles K. Chui.

[2] Thomas J. Buckholtz. Predict particles beyond the standard model; then, narrow gaps between physics theory and data. In *Proceedings of the 9th Conference on Nuclear and Particle Physics (19-23 Oct. 2015 Luxor-Aswan, Egypt)*, May 2016.

[3] Thomas J. Buckholtz. *Unitedly Broadened Physics: Toward One Theory for Elementary Particles, Objects, and the Cosmos*. CreateSpace Independent Publishing Platform, September 2017.

[4] N. G. Busca, T. Delubac, J. Rich, S. Bailey, A. Font-Ribera, D. Kirkby, J.-M. Le Goff, M. M. Pieri, A. Slosar, E. Aubourg, J. E. Bautista, D. Bizyaev, M. Blomqvist, A. S. Bolton, J. Bovy, H. Brewington, A. Borde, J. Brinkmann, B. Carithers, R. A. C. Croft, K. S. Dawson, G. Ebelke, D. J. Eisenstein, J.-C. Hamilton, S. Ho, D. W. Hogg, K. Honscheid, K.-G. Lee, B. Lundgren, E. Malanushenko, V. Malanushenko, D. Margala, C. Maraston, K. Mehta, J. Miralda-Escude, A. D. Myers, R. C. Nichol, P. Noterdaeme, M. D. Olmstead, D. Oravetz, N. Palanque-Delabrouille, K. Pan, I. Paris, W. J. Percival, P. Petitjean, N. A. Roe, E. Rollinde, N. P. Ross, G. Rossi, D. J. Schlegel, D. P. Schneider, A. Shelden, E. S. Sheldon, A. Simmons, S. Snedden, J. L. Tinker, M. Viel, B. A. Weaver, D. H. Weinberg, M. White, C. Yeche, and D. G. York. Baryon acoustic oscillations in the ly[[alpha]] forest of boss quasars. *Astronomy & Astrophysics*, 552(A96), April 2013.

[5] C. Patrignani et. al. (Particle Data Group). *Chin. Phys. C*, 40, 100001, 2016.

[6] R. Genzel, N. M. Forster Schreiber, H. Ubler, P. Lang, T. Naab, R. Bender, L. J. Tacconi, E. Wisnioski, S. Wuyts, T. Alexander, A. Beifiori, S. Belli, G. Brammer, A. Burkert, C.M. Carollo, J. Chan, R. Davies, M. Fossati, A. Galametz, S. Genel, O. Gerhard, D. Lutz, J. T. Mendel, I. Momcheva, E. J. Nelson, A. Renzini, R. Saglia, A. Sternberg, S. Tacchella, K. Tadaki, and D. Wilman. Strongly baryon-dominated disk galaxies at the peak of galaxy formation ten billion years ago. *Nature*, 543(7645):397–401, March 2017.

[7] N. Gnedin. Cosmological calculator for the flat universe, 2015. Link: http://home.fnal.gov/ [[tilde]] gnedin/cc/.

[8] Particle Data Group. Electroweak (web page), the particle adventure, 2017. Link: http://www.particleadventure.org/electroweak.html.

[9] J. Jimenez-Vicente, E. Mediavilla, C. S. Kochanek, and J. A. Munoz. Dark matter mass fraction in lens galaxies: New estimates from microlensing. *The Astrophysical Journal*, 799(2):149, 2015.

[10] Ewa L. Lokas and Gary A. Mamon. Dark matter distribution in the coma cluster from galaxy kinematics: breaking the mass-anisotropy degeneracy. *Monthly Notices of the Royal Astronomical Society*, 343(2):401–412, August 2003.

[11] S. Perlmutter, G. Aldering, G. Goldhaber, R. A. Knop, P. Nugent, P. G. Castro, S. Deustua, S. Fabbro, A. Goobar, D. E. Groom, I. M. Hook, A. G. Kim, M. Y. Kim, J. C. Lee, N. J. Nunes, R. Pain, C. R. Pennypacker, R. Quimby, C. Lidman, R. S. Ellis, M. Irwin, R. G. McMahon, P. Ruiz-Lapuente, N. Walton, B. Schaefer, B. J. Boyle, A. V. Filippenko, T. Matheson, A. S. Fruchter, N. Panagia, H. J. M. Newberg, and

W. J. Couch. Measurements of [[omega]] and [[lambda]] from 42 high-redshift supernovae. *The Astrophysical Journal*, 517(2):565–586, June 1999.

[12] Elena Rasia, Giuseppe Tormen, and Lauro Moscardini. A dynamical model for the distribution of dark matter and gas in galaxy clusters. *Monthly Notices of the Royal Astronomical Society*, 351(1):237–252, June 2004.

[13] Adam G. Riess, Alexei V. Filippenko, Peter Challis, Alejandro Clocchiatti, Alan Diercks, Peter M. Garnavich, Ron L. Gilliland, Craig J. Hogan, Saurabh Jha, Robert P. Kirshner, B. Leibundgut, M. M. Phillips, David Reiss, Brian P. Schmidt, Robert A. Schommer, R. Chris Smith, J. Spyromilio, Christopher Stubbs, Nicholas B. Suntzeff, and John Tonry. Observational evidence from supernovae for an accelerating universe and a cosmological constant. *The Astronomical Journal*, 116(3):1009–1038, September 1998.

[14] Adam G. Riess, Louis-Gregory Strolger, John Tonry, Stefano Casertano, Henry C. Ferguson, Bahram Mobasher, Peter Challis, Alexei V. Filippenko, Saurabh Jha, Weidong Li, Ryan Chornock, Robert P. Kirshner, Bruno Leibundgut, Mark Dickinson, Mario Livio, Mauro Giavalisco, Charles C. Steidel, Txitxo BenÃtez, and Zlatan Tsvetanov. Type ia supernova discoveries at z $>$ 1 from the hubble space telescope: Evidence for past deceleration and constraints on dark energy evolution. *The Astro[physical Journal*, 607:665–687, June 2004.

[15] Pieter van Dokkum, Roberto Abraham, Jean Brodie, Charlie Conroy, Shany Danieli, Allison Merritt, Lamiya Mowla, Aaron Romanowsky, and Jielai Zhang. A high stellar velocity dispersion and 100 globular clusters for the ultra-diffuse galaxy dragonfly 44. *The Astrophysical Journal Letters*, 828(1):L6, 2016.

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