Elementary forces and particles correlating with ordinary matter, dark matter, and dark energy

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This paper discusses and applies a basis for modeling elementary forces and particles. We show that models based on isotropic quantum harmonic oscillators describe aspects of the four traditional fundamental physics forces and point to some known and possible elementary particles. We summarize results from models based on solutions to equations featuring isotropic pairs of isotropic quantum harmonic oscillators. Results include predictions for new elementary particles and possible descriptions of dark matter and dark energy.

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I. INTRODUCTION

Much physics theory is incomplete. People seek to predict undiscovered elementary particles, to describe dark matter, and to characterize dark energy. Some physics theories seem disjointed. People seek theory uniting quantum mechanics and gravity. This paper suggests looking beyond traditional approaches to physics theory. This paper suggests a basis for theory that may lead to such predictions and such unification. This paper includes definitive predictions for undiscovered elementary particles and definitive possible characterizations for dark matter and dark energy.

More specifically, we predict undiscovered elementary fermions, predict undiscovered elementary bosons, and show models that correlate with electromagnetism and photons and with gravitation and gravitons. Unlike traditional approaches, that part of work de-emphasizes motions of objects. We then add, via symmetries correlating with conservation of momentum and conservation of angular momentum, aspects regarding motion. By adding the symmetries and using aspects of the modeling basis, we provide a non-traditional symmetry correlating with each of conservation of energy, a description of dark matter, and a description of the stuff that correlates with the dark-energy density of the universe. The description of quantum gravity points to forces that govern the rate of expansion of the universe and that correlate with the three observed eras - initial accelerating expansion, subsequent decelerating expansion, and present accelerating expansion.

Possibly, people can use this basis to produce a unified theory for observationally known physics.

II. ONE PDE ISOTROPIC QUANTUM HARMONIC OSCILLATOR

This unit discusses mathematics correlating with partial differential equations relevant to isotropic quantum harmonic oscillators.

Equations (1) and (2) correlate with QP-like isotropic quantum harmonic oscillators. The term QP-like correlates with spatial or momentum-like and contrasts with QE-like, which correlates with temporal or energy-like. Here, r denotes the radial coordinate and has dimensions of length. The parameter η has dimensions of length. Here, D is a positive integer. Including for $D = 1$, each of equation (1), equation (2), and the function Ψ pertains for $0 < r < \infty$. The parameter η is a non-zero real number. The term PDE abbreviates the phrase partial differential equation.

$$\xi\Psi(r) = (\xi'/2)(-\eta^2\nabla^2 + \eta^{-2}r^2)\Psi(r) \tag{1}$$

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

We consider solutions of the form equation (3) shows. The magnitude $|\eta|$ correlates with a scale length. We de-emphasize the traditional case for which $D = 1$, the function Ψ pertains for $-\infty < r < \infty$, $\Omega = 0$, and solutions include factors that are Hermite polynomial functions of r.

$$\Psi(r) \propto (r/\eta)^\nu \exp(-r^2/(2\eta^2)), \text{ with } \eta^2 > 0 \tag{3}$$

Equations (4) and (5) characterize solutions. The parameter η does not appear in these equations.

$$\xi = (D + 2\nu)(\xi'/2) \tag{4}$$

$$\Omega = \nu(\nu + D - 2) \tag{5}$$

Work above uses the presence of Ω to summarize aspects pertaining to angular coordinates. Traditional math pertaining to angular coordinates results in equation (6) and, therefore, in equation (7).

$$2\nu \text{ is an integer} \tag{6}$$

$$4\Omega \text{ is an integer} \tag{7}$$

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

We consider normalization with respect to D^* dimensions. A factor $r^{(D^*-1)}$ correlates with the expression $\int r^{(D^*-1)}dr$. A factor $r^{2\nu}$correlates with $\Psi^*\Psi$. For $r \to 0^+$, the integrand behaves like $r^{(D^*-1)+2\nu}$. The following three possibilities pertain.

- For $D^* + 2\nu > 0$, normalization occurs for any $\eta^2 > 0$. We correlate solutions that correlate with this case with the term volume-like.
- For $D^* + 2\nu = 0$, normalization occurs only in the limit $\eta^2 \to 0^+$. We correlate solutions that correlate with this case with the term point-like.
  - For $D^* = 1$ and $\nu = -1/2$, relevant math correlates with an expression for a delta function. Note equation (8). Noticing that $-r^2/(2\eta^2) + \{-r^2/(2\eta^2)\} = -r^2/(\eta^2)$, we correlate η^2 with 4ϵ. We correlate r^2 with x^2. People use equation (8) with the domain $-\infty < x < \infty$. We use the domain $0 < x < \infty$ and posit that the answer to the question of whether a function normalizes does not depend on our choice of domain.

$$\delta(x) = \lim_{\epsilon\to 0^+}(1/(2\sqrt{\pi\epsilon}))e^{-x^2/(4\epsilon)} \tag{8}$$

  - Similar normalization results pertain for other positive integer values of D^* and negative integer values of 2ν for which $D^* + 2\nu = 0$.
- For $D^* + 2\nu < 0$, normalization fails. We de-emphasize solutions that do not normalize.

III. THE FOUR TRADITIONAL FUNDAMENTAL PHYSICS FORCES

This unit explores the concept that models based on one isotropic harmonic oscillator might correlate with the four traditional fundamental physics forces.

Equations (9), (10), (11), and (12) re-express equations (1) and (2). Here, $\hbar$ is Planck's constant (reduced) and τ_t is an as yet undetermined non-zero time. Each of equations (10), (11), and (12) shows an operator with dimensions of square of energy. We consider that $\Psi(r)$ pertains for a non-zero-mass object or particle that provides a component of a composite particle, atomic nucleus, atom, or neutron star. For example, for a composite particle, $\Psi(r)$ correlates with a model pertaining to a quark. For an atomic nucleus $\Psi(r)$ correlates with a nucleon. For an atom, $\Psi(r)$ correlates with an electron. For purposes of this discussion, we assume that the particle has zero magnetic moment and zero spin. For $D = D^* = 3$, this system of equations correlates with a simple model for squares of potential. We consider solutions of the form equation (3) shows. For cases in which the strong interaction pertains, equation (10) provides the long-distance behavior of the square of the potential correlating with the strong interaction. For cases in which the strong interaction does not play much a role, equations (13) and (14) pertain. Equation (11) provides for the long-distance behavior of the square of the potential correlating with the electromagnetic and/or gravitational interaction. Equation (15) correlates Ω with an orbital angular momentum correlating with the state occupied by the object or particle. Here, 2ν is a non-negative even integer and L is a non-negative integer. For solutions of the form equation (3) shows, $V_{2,ST|WE|EM|GR}$ provides terms that are the negatives of the results of operators $V_{2,ST}$ and $V_{2,EM|GR}$ provide. Other terms correlating with $V_{2,ST|WE|EM|GR}$ exist and correlate with equation (16). For the cases we consider, the weak interaction is short-ranged and the constant long-range term $V_{2,WE}$, which correlates with the square of a potential and with zero long-range force, pertains.

$$(\hbar^2/(\tau_t)^2)(2\xi/\xi')\Psi(r) = (V_{2,ST|WE|EM|GR} + V_{2,EM|GR} + V_{2,ST})\Psi(r) \tag{9}$$

$$V_{2,ST} = (\hbar^2/(\tau_t)^2)\eta^{-2}r^2 \tag{10}$$

$$V_{2,EM|GR} = (\hbar^2/(\tau_t)^2)\eta^2\Omega r^{-2} \tag{11}$$

$$V_{2,ST|WE|EM|GR} = (\hbar^2/(\tau_t)^2)(-\eta^2)r^{-(D-1)}(\partial/\partial r)(r^{D-1})(\partial/\partial r) \tag{12}$$

$$\xi' \eta^{-2} \to 0^+ \tag{13}$$

$$\xi' \eta^2 \text{ is a positive constant} \tag{14}$$

$$\Omega = L(L+1), \text{ with } L = \nu \tag{15}$$

$$V_{2,WE} \propto (\hbar^2/(\tau_t)^2)(D+2\nu) = (\hbar^2/(\tau_t)^2)(3+L) \tag{16}$$

Work just above is quadratic in energy. Aspects of other physics models that feature terms quadratic in energy include the stress-energy tensor in general relativity, the Klein-Gordon equation in quantum mechanics, $E^2 = (mc^2)^2 + (Pc)^2$ in special relativity, and the electromagnetic stress-energy tensor.

Regarding the hydrogen atom, work above can produce the same set of principle quantum numbers and the same number of states per principle quantum number as a Schrodinger-equation-based approach produces. In its simplest form, each approach features orbital angular momentum, ignores electron magnetic moment and spin, ignores any magnetic field associated with the nucleus, and ignores spin-orbit coupling. In each case, for electrons and for a principle quantum number N that is a positive integer, one can invoke the Pauli exclusion principle and correlate $2N^2$ states with the principle quantum number. A key concept is that each of the set of principle quantum numbers and the numbers of states correlates with the Laplacian.

IV. SOME ELEMENTARY PARTICLES

This unit explores the concept that models based on one isotropic quantum harmonic oscillator might correlate with the existence in nature of some non-zero-mass elementary particles.

Equations (1) through (7) include solutions for which equations (17), (18), and (19) pertain. Here, $2S$ is a non-negative integer.

$$\Omega = \sigma S(S+D-2) \tag{17}$$

$$\sigma = \pm 1 \tag{18}$$

$$\nu < 0 \tag{19}$$

Each known elementary particle has a spin $S\hbar$ that comports with equations (20) and (21).

$$S(S+1) = S(S+D^*-2) \tag{20}$$

$$D^* = 3 \tag{21}$$

Table I shows solutions for which 2ν is an odd negative integer and equations (19) and (21) pertain. For each row in the table, we use the radial component of a D-dimensional solution as the radial solution of a D^*-dimensional solution and then add angular coordinates correlating with $D^* = 3$ dimensions. For each row in the table, Ω and σ pertain to the D-dimensional solution. For each row in the table, the D-dimensional radial solution and the D^*-dimensional radial solution share a common value of S and share a common value of $|\Omega|$. D^*-dimensional solutions for which $\nu = -1/2$ are volume-like. D^*-dimensional solutions for which $\nu = -3/2$ are point-like. The right-most two columns propose correlating families of elementary particles with solutions. The symbol Σ denotes $2S$. The symbol Φ denotes an

Table I. Fermion-centric PDE solutions

D^*	ν	$D^*+2\nu$	S	Ω	σ	D	D	$D+2\nu$	$2S+1$	$\Sigma\Phi$	
										$(m \neq 0)$	$(m \approx 0)$
3	$-1/2$	2	$1/2$	$3/4$	$+1$	$(5-4\Omega)/2$	1	0	2	1C	1N
3	$-1/2$	2	$1/2$	$-3/4$	-1	$(5-4\Omega)/2$	4	3	2	1Q	1R
3	$-1/2$	2	$3/2$	$-15/4$	-1	$(5-4\Omega)/2$	10	9	4	(3Q)	(3R)
3	$-1/2$	2	...								
3	$-3/2$	0	$3/2$	$15/4$	$+1$	$(21-4\Omega)/6$	1	-2	4	(3C)	(3N)
3	$-3/2$	0	$1/2$	$3/4$	$+1$	$(21-4\Omega)/6$	3	0	2	1C	1N
3	$-3/2$	0	$1/2$	$-3/4$	-1	$(21-4\Omega)/6$	4	1	2	1Q	1R
3	$-3/2$	0	$3/2$	$-15/4$	-1	$(21-4\Omega)/6$	6	3	4	(3Q)	(3R)
3	$-3/2$	0	...								

Table II. Relationships between some PDE parameters for ΣW, ΣH, and ΣO solutions

D^*	ν	$D^*+2\nu$	S	Ω	σ	D	D	$D+2\nu$	$2S+1$	$\Sigma\Phi$
3	-1	1	1	2	$+1$	$3-\Omega$	1	-1	3	2W
3	-1	1	0	0	$+1$	$3-\Omega$	3	1	1	0H
3	-1	1	0	0	-1	$3-\Omega$	3	1	1	(0O)
3	-1	1	1	-2	-1	$3-\Omega$	5	3	3	2O
3	-1	1	2	-6	-1	$3-\Omega$	9	7	5	(4O)
3	-1	1	...							

abbreviation for family name. The symbol m denotes mass. The C family includes the known charged leptons and no other particles. The N family includes the known neutrinos and no other particles. The 1Q particles include the known quarks and no other particles. We point to the possibility that nature includes 1R particles. Elsewhere, we discuss reasons correlating with the notion that nature might not include elementary fermions for which $\Sigma \geq 3$. (See reference [2].) Below, we discuss the topic of the extent to which neutrinos have non-zero-mass. (See subsection VIII A.) We assume that volume-like solutions correlate with field-like constructs and that point-like solutions correlate with particle-like constructs. We assume that the lack of a volume-like solution that would correlate with 3C and 3N correlates with the notion that the point-like solution that correlates with 3C and 3N is not physics-relevant.

Table II shows solutions for which 2ν is an even negative integer and equations (19) and (21) pertain. Solutions for which $\nu = -1$ are volume-like. The right-most column proposes correlating families of elementary particles with solutions. The W family includes the known Z and W bosons and no other particles. The H family includes the known Higgs boson and no other particles. We think that, for the purposes of elementary-particle physics, the 0O solution is the same as the 0H solution. We point to the possibility that nature includes 2O particles. Elsewhere, we discuss reasons correlating with the notion the nature might not include non-zero-mass elementary bosons for which $\Sigma \geq 4$ and we discuss the topic of the point-like solutions for non-zero-mass elementary bosons. (See reference [2] and subsection VIII G.) Assuming that one counts antiparticles as being distinct from particles and that one ignores results for rows that correlate with parenthesized $\Sigma\Phi$, the column labeled $2S+1$ provides the number of elementary particles correlating with $\Sigma\Phi$.

V. PERSPECTIVE, ISOTROPIC PAIRS OF ISOTROPIC QUANTUM HARMONIC OSCILLATORS, AND TRANSITION

This unit notes some aspects of physics that work above does not address and summarizes ways to address some of those aspects.

We note some aspects of physics that work above does not address. Work above does not address motion and does not explicitly dovetail with either special relativity or general relativity. The work does not explicitly discuss energies for states of, for example, electrons in atoms. Work above regarding the elementary particles that nature includes or may include does not explicitly address zero-mass elementary bosons, fermion generations, or the notion that that nature includes twice as many quarks as charged leptons. The work does not explicitly discuss relative magnitudes, for various elementary particles, of properties such as charge and mass.

We think that work above points to promise for using models based on isotropic quantum harmonic oscillators to catalog and describe elementary particles and their properties. Reference [2] explores using isotropic pairs of isotropic pairs of isotropic quantum harmonic oscillators. As above, one oscillator in a pair correlates with notions of space-like. The other oscillator in a pair correlates with notions of time-like. While work above correlates with PDE models, work in reference [2] uses PDE results and adds results based on ALG models. The letters ALG abbreviate the word algebraic.

The following equations show aspects of an ALG isotropic pair of isotropic quantum harmonic oscillators. Equations (22) and (23) show aspects of a QE-like isotropic quantum harmonic oscillator. QE-like denotes temporal or energy-like. Equations (24) and (25) show aspects of a QP-like isotropic quantum harmonic oscillator. QP-like denotes spatial or momentum-like. Equation (26) shows aspects of the isotropic pair of isotropic quantum harmonic oscillators. Based on the equality that equation (26) features, we use the word solution to correlate with a relevant construct correlating with one non-negative integer $N_{QE|...}$, one non-negative integer $N_{QP|...}$, and the relevant set of integers n_{Ej} and n_{Pj}. For all uses of the equation $A = 0$, a concept similar to double-entry bookkeeping pertains. For example, adding one to an n_{Ej} requires adding one to an n_{Pj}. Equation (27) follows from equation (26).

$$A_{QE} = \Sigma_{j=0}^{N_{QE|...}-1}(n_{Ej} + 1/2), \text{ for } N_{QE|...} \geq 1 \tag{22}$$

$$A_{QE} = 0, \text{ for } N_{QE|...} = 0 \tag{23}$$

$$A_{QP} = \Sigma_{j=0}^{N_{QP|...}-1}(n_{Pj} + 1/2), \text{ for } N_{QP|...} \geq 1 \tag{24}$$

$$A_{QP} = 0, \text{ for } N_{QP|...} = 0 \tag{25}$$

$$0 = A = A_{QE} - A_{QP} \tag{26}$$

$$|N_{QE|...} - N_{QP|...}| \text{ is an even integer} \tag{27}$$

Reference [2] uses ALG models to achieve the following. Count numbers, including generations, of fermions within each fermion family. Include solutions correlating with zero-mass bosons. Discuss the topic of which bosons interact with which fermions. Introduce a concept, which applies for some boson-fermion interactions and not for other boson-fermion interactions, of conservation of fermion generation. (For example, for a sufficiently isolated interaction between an incoming charged lepton and an incoming W boson, the outgoing neutrino has the same generation as the incoming charged lepton.) Predict charges for the 2O bosons. Dovetail with charge-centric and magnetic-moment-centric aspects of electromagnetism and photons. Dovetail with and predict aspects of gravitation, gravitons, and changes in the rate of expansion of the universe.

Reference [2] uses hybrid ALG-and-PDE models to achieve the following. Extrapolate from masses of the H^0 (or, Higgs) boson, Z boson, and W bosons to predict masses for 2O bosons.

Reference [2] uses ALG models to incorporate, via symmetries, conservation of momentum, conservation of angular momentum, and motion. Symmetries resulting from this work show that results correlate with either special relativity or general relativity. Symmetries correlating with conversation of energy suggest definitions and explanations for dark matter and for dark-energy stuff.

Below, we summarize such results.

VI. KNOWN AND POSSIBLE ELEMENTARY PARTICLES

This unit summarizes results regarding elementary particles. We use the acronym CUSP to correlate with our work. CUSP abbreviates the phrase concepts uniting some physics.

Table III 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, people have 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

Table III. Numbers of elementary particles and/or modes

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

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 $\Sigma G\Lambda$ for some Λ. For each G-family particle, two modes exist. One mode is left-circularly polarized. The other mode is right-circularly polarized. We propose 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 III, with zero matter/antimatter particles and with one matter particle. A Majorana-fermion neutrino correlates, with respect to table III, with one matter/antimatter particle and zero matter particles. (See subsection VIII B.) 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 III does not take into account some G-family solutions that are possibly physics-relevant. Some of the G-family solutions that the table does not take into account correlate with anomalous moments, such as anomalous magnetic dipole moments that people correlate with elementary particles. (See subsection VIII M.) Such anomalous moments correlate with circumstances in which elementary particles are components of entities that are not single 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. We discuss neutrino masses below. (See subsection VIII A.) For each $\Sigma\gamma$ the table lists, the G-family solution $\Sigma G\Sigma$ pertains and correlates with $n_{P0} = -1$. For each $\Sigma\gamma$ the table lists, at least one other G-family solution $\Sigma G\Lambda$ pertains and correlates with $n_{P0} \leq -2$. For each $\Sigma\gamma$ the table lists, the G-family solution $\Sigma G\Sigma$ correlates with a monopole interaction. For example, 2G2 is a component of 2γ and correlates with interactions based on electric charge. 2G24 is a component of 2γ and correlates with $n_{P0} = -2$ and with a dipole interaction. 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. 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. A quadrupole moment pertains. The relevant G-family solution is 2G248.) For each elementary particle for which $\sigma = +1$, the term free-ranging pertains. For each elementary particle for which $\sigma = -1$, the term free-ranging does not pertain.

Table IV lists elementary particles CUSP predicts.

Equation (28) shows relative magnitudes of charges for known and predicted elementary particles correlating with non-zero charge. The 2O1 and 2O2 particles would have opposite charges. The 2O0 particle would have zero charge.

$$\mathrm{1C} : \mathrm{1Q(some)} : \mathrm{1Q(some)} : \mathrm{W} : \mathrm{2O1} : \mathrm{2O2} :: 3 : 2 : 1 : 3 : 1 : 1 \tag{28}$$

Equation (29) shows relative squares of approximate masses for known and predicted elementary bosons correlating with non-zero mass. (Regarding accuracy of ratios correlating with known particles, see subsection VIII H.)

Table IV. Predicted elementary particles

Possible elementary particles
• One 4γ elementary boson. This particle has zero mass, correlates with spin-2, and has two polarization modes. We propose 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 1R particle, a distinct antiparticle exists. 1R particles can exist within composite particles. 1R 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. The 2O counterpart to the Z boson has zero charge. This 2O particle is its own antiparticle. A 2O counterpart to a W boson has one-third the charge of the W boson. For this 2O particle, a distinct antiparticle exists and has negative one-third the charge of the same W boson. 2O particles can exist within composite particles. 2O particles do not correlate with the term free-ranging.

$$\mathrm{H}^0 : \mathrm{Z} : \mathrm{W} : 2\mathrm{O}0 : 2\mathrm{O}1 : 2\mathrm{O}2 :: 51 : 27 : 21 : 9 : 7 : 7 \tag{29}$$

VII. 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. These forces correlate primarily with components of 4γ. 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.) SDFs of r^{-5}, r^{-4}, r^{-3}, and r^{-2} correlate, respectively with the terms octupole, quadrupole, dipole, and monopole. Each SDF equals the $r^{n_{P0}-1}$ correlating with one or more relevant G-family solutions. We consider the largest astrophysical objects of which people know. Based respectively on initial accelerating expansion of the universe, subsequent decelerating expansion, and recent accelerating expansion, CUSP suggests that the two r^{-5} components of 4γ mediate a repulsive force, the one r^{-4} component of 4γ mediates an attractive force, and the one r^{-3} component of 4γ mediates a repulsive force.

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.

CUSP suggests that each of dark matter and dark-energy stuff consists primarily of copies of some ordinary-matter elementary particles and all ordinary-matter composite particles. Regarding each copy, we use the term ensemble. Table V summarizes results regarding particles, solutions, and ensembles. (See, table III and discussion related to table III.) 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, 1Q∪2O composite particles. Known composite particles include the pion and the proton. All known composite particles are of the type 1Q∪2Y. Each ensemble includes its own copy 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.

Table V. Particles and/or solutions that correlate with one ensemble and particles and/or solutions that might correlate with more than one ensemble

σ	Particle sets and/or solution sets		One instance correlates with one ensemble	Span (ensembles per instance)
	2016 Standard Model	Possible		
+1	1C, 1N	-	Yes	1
+1	0H	-	"	"
	Composite particles (1Q∪2Y)	Composite particles (other)	"	"
+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

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 V, with the term other G-family.) 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. (See subsection VIII E.) Ordinary matter (or, OMS) correlates with one ensemble. Regarding this ensemble, we use the acronym OME, for ordinary-matter ensemble. Dark matter (or, DMS) correlates with the five 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). Possibly, this explanation adequately comports with inferred ratios of density of dark matter to density of ordinary matter. (Regarding the ratios, see data that reference [3] provides.) 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). Possibly, CUSP explains, at least qualitatively, a perceivable gap between predicted and inferred ratios of density of DES to density of OMS∪DMS. Inferred ratios grow, since the big bang, from zero to about 2.2. (Regarding the number 2.2, see data that reference [3] provides.) CUSP provides the notion that the actual ratio is seven-to-one. CUSP provides the notion that impacts of DES on observations from which people infer densities of DES are indirect and adequately slow to account for results that are less than seven-to-one.

Each non-OME ensemble features elementary particles that are essentially identical to OME elementary particles. Differences between ensembles might occur with regard to which one of matter (by some definition) and antimatter (by the same definition) dominates. People can, in essence, envision dark matter and dark-energy stuff. People might consider the possibility that, for any DME or DEE, adequately physics-savvy beings exist. Here, adequately physics-savvy denotes having at least as much knowledge of physics as people have. Between any two ensembles, the relationship of being or not being the other ensemble's dark matter is reciprocal. Thus, from our perspective, adequately physics-savvy DME beings would consider our OME (including us) to be made of what those DME beings would consider to be dark matter. Between any two ensembles, the relationship of being or not being the other ensemble's dark energy-stuff is reciprocal.

VIII. NOTES

This unit provides some details regarding concepts previous units discuss and summarizes some CUSP results for some topics for which units above do not provide much information. Elsewhere, we discuss these results and other in more detail. (See references [2] and [1].)

A. Neutrino masses

CUSP points to interactions that would catalyze neutrino oscillations, even if each flavor of neutrino has zero mass. CUSP suggests that, for models that consider that gravitational interactions correlate with an energy-and-momentum m-tensor with m≥ 1, zero-mass neutrinos need not be inconsistent with astrophysical data that people interpret as suggesting that non-zero masses pertain for at least some neutrinos. For elementary bosons, $n_{P0} \leq -1$ correlates with zero mass. For neutrinos, $n_{P0} = -1$ pertains. Nevertheless, we think CUSP models can be compatible with either no or some non-zero mass neutrino flavors.

B. 2O particles, baryon asymmetry, and one aspect of the topic of Dirac and/or Majorana neutrinos

Perhaps, early in the universe, the number of antimatter charged leptons equaled the number of matter charged leptons and the number of antimatter quarks equaled the number of quarks. If so, charged 2O leptons may have converted antimatter quarks into matter quarks and W bosons could have converted antimatter charged leptons into neutrinos and converted neutrinos into matter charged leptons. To the extent neutrinos behaved as Dirac fermions, cosmic background neutrinos would include more antimatter neutrinos than matter neutrinos.

C. Threshold energies for producing 2O bosons

Possibly, people can produce 2O bosons only by producing 1Q∪2O composite particles or 1R∪2O composite particles. We predict masses for 2O bosons. (See equation (29).) We do not predict minimum energies needed to produce 1Q∪2O composite particles or 1R∪2O composite particles.

D. $SU(3) \times SU(2) \times U(1)$ boson symmetries

CUSP correlates $SU(3) \times SU(2) \times U(1)$ boson symmetries and electroweak symmetry breaking with each of interaction-centric aspects of models and instance-centric (or span-centric) aspects of models. The Standard Model development of $SU(3) \times SU(2) \times U(1)$ boson symmetries correlates with interactions. The Standard Model does not include instance-centric aspects. 2O bosons would correlate with interaction symmetries and instance symmetries similar to interaction symmetries and instance symmetries correlating with 2W bosons. People might be able to add straightforwardly 2O bosons to the elementary-particle Standard Model.

Aspects of $SU(3) \times SU(2) \times U(1)$ boson symmetries may correlate with a possible narrative in which the first elementary-particle states populated during the big bang correlate with specific G-family solutions, some of which are components of 2γ (or, photons) and some of which are components of 4γ (or, gravitons).

E. Symmetries correlating with traditional conservation laws and with numbers of ensembles

In traditional physics, each of conservation of momentum and conservation of angular momentum correlates with an $SU(2)$ symmetry and three generators. In CUSP ALG modeling for free-ranging elementary particles, each of conservation of momentum and conservation of angular momentum correlates with an $SU(2)$ symmetry and with a pair of harmonic oscillators that comprise the QP-like isotropic quantum harmonic oscillator. For CUSP models that correlate with special relativity, boost correlates with an $SU(2)$ symmetry and a QP-like pair of harmonic oscillators. For CUSP models that correlate with general relativity, boost-related symmetry does not pertain; a $U(1)$ symmetry pertains and correlates with two QP-like harmonic oscillators. Each of the above-mentioned harmonic oscillators is interaction-centric. CUSP adds the relevant six QP-like (or, interaction-centric) harmonic oscillators to ALG models for the properties of free-ranging particles. In traditional physics, conservation of energy correlates with a one-generator symmetry. In CUSP ALG modeling for free-ranging elementary particles, single-ensemble models correlate conservation of energy, with one QE-like harmonic oscillator, and with a one-generator symmetry. For single-ensemble models for free-ranging elementary particles, Poincare-group symmetries pertain for models that correlate with special relativity. The double-entry bookkeeping

Swap (for each odd j' and with $j'' = j' + 1$)	Swap	Swap pertains for the transformation		
		T	C	P
$n_{Ej''}$ and $n_{Ej'}$	-	Yes	Yes	No
-	n_{E0} and n_{P0}	No	No	No
$n_{Pj'}$ and $n_{Pj''}$	-	No	Yes	Yes

Table VI. C, P, and T transformations

aspect of CUSP ALG models correlates with a need to add, to ALG models for the properties of free-ranging particles, six QE-like (or, instance-centric) oscillators. CUSP considers a set of seven QE-like (or, instance-centric) oscillators. The set includes the six QE-like oscillators that, in effect, provide double-entry balance correlating with the six added QP-like (or, interaction-centric) oscillators. The set includes the one QE-like oscillator that correlates with single-ensemble conservation of energy. CUSP multi-ensemble models correlate conservation of energy with those seven QE-like (or, instance-centric) harmonic oscillators, an $SU(7)$ symmetry, 48 generators, and 48 ensembles. Regarding the kinematics of free-ranging composite particles and the number instances of free-ranging composite particles, CUSP assumes that similar thinking and results pertain. (See table V.) Regarding instances and spans for elementary particles for which $\sigma = -1$, CUSP develops results, that table V shows, by using double-entry principles. For example, regarding each of the known 1Q and 2Y particles, a complete set of Poincare-group symmetries does not pertain. However, for 1Q∪2Y composite particles and under the assumption that such particles contain at least two quarks, 1Q and 2Y symmetries combine to produce (for models correlating with special relativity) Poincare-group interaction-centric symmetry for the composite particles and to produce instance-centric symmetries that correlate with the span, for 1Q, that table V shows. (See subsection VIII M.)

F. CPT symmetries

For ALG models, table VI pertains. CPT symmetry pertains throughout CUSP.

G. Point-like solutions for and relative masses of non-zero-mass elementary bosons

CUSP discusses point-like solutions for elementary bosons. (See reference [2].) Aspects of such solutions correlate with results equation (29) shows.

H. Relative masses of known non-zero-mass elementary bosons

As of the year 2016, of the masses of H^0, Z, and W bosons, people knew most accurately the mass of the Z boson. (For data, see reference [3].) Equation (29) predicts the mass of H^0 to accuracy of about one standard deviation, based on 2016 data. Equation (29) predicts the mass of W to accuracy of about 2.3 standard deviations, based on 2016 data.

I. Relative masses of some elementary fermions

Equation (30) possibly pertains. Here, m denotes mass, τ denotes tauon, e denotes electron, q denotes charge, ε_0 denotes the vacuum permittivity, and G_N denotes the gravitational constant. Based on 2016 data, equation (30) predicts a tauon mass with a standard deviation of less than one quarter of the standard deviation correlating with the experimental result. (For data, see reference [3].) Possibly, more accurate experimental determination of the tauon mass could predict a more accurate, than experimental results, value for the gravitational constant, G_N.

$$(4/3) \times (m_\tau/m_e)^{12} = ((q_e)^2/(4\pi\varepsilon_0))/(G_N(m_e)^2) \tag{30}$$

J. Sums of energies of photon ground states

Equation (26) pertains throughout CUSP. Regarding correlating CUSP models with special relativity, people might correlate E^2 (or, energy squared) with A_{QE}. People might correlate with A_{QP} one of $(mc^2)^2$, for objects having non-zero mass, or $(Pc)^2$, for elementary particles having zero mass. Double-entry bookkeeping pertains. For example, excitation by one unit of a photon mode adds one unit of E^2 to the A_{QE} for that mode, adds one unit of $(Pc)^2$ to the A_{QP} for that mode, and preserves $A = 0$ for that mode. The sum of A across all elementary-particle states is zero. Possibly, CUSP models obviate possible needs to consider sums of photon ground-state energies and to consider the possible infinity in which such a sum might result.

K. The Planck length

Possibly, CUSP models attribute no physics-relevance to the Planck length. (See subsection VIII J.)

L. Geodesic motion

Consider a thought experiment. For simplicity, assume that the sun is spherically symmetric and does not rotate. Consider an OME photon for which the sun's gravity bends the trajectory of the photon. CUSP correlates the bending with effects correlating with the OME∪DME instance of 4G4. Consider a DEE photon that starts on the same trajectory as the OME photon traverses. The OME∪DME instance of 4G4 does not affect the trajectory of the DEE photon.

CUSP suggests that the concept of geodesic motion correlates with applications of models based on general relativity and does not correlate with space-time geodesics.

M. Possible alternatives to QED and QCD

Work that section III discusses may point to possibilities for approaches that would be alternatives to QED (or, quantum electrodynamics) and QCD (or, quantum chromodynamics). For example, regarding QED, reference [2] shows the possibility that a sum of a few terms, each correlating with a G-family solution, might correlate with the anomalous magnetic dipole moment of a charged lepton. For example, regarding QCD, reference [2] develops results based on the notion that symmetries correlating with special relativity or general relativity pertain to a free-ranging composite particle but do not necessarily pertain regarding kinematics of elementary-fermion components of a free-ranging composite particle or regarding kinematics of elementary-boson components of a free-ranging composite particle. Possibly, CUSP-based alternatives to QED and QCD would obviate or reduce needs to consider techniques such as renormalization.

IX. 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.

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[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.
[2] Thomas J. Buckholtz. *Unitedly Broadened Physics: Toward One Theory for Elementary Particles, Objects, and the Cosmos*. CreateSpace Independent Publishing Platform, 1 edition, September 2017.
[3] C. Patrignani et. al. (Particle Data Group). *Chin. Phys. C*, 40, 100001, 2016.