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A Beyond the Standard Model Solution using a Two-Step Integrated Physics/Mathematics Methodology

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Abstract

Two astrophysics issue resolution methodologies are: the prevailing Hawking et. al. single primarily mathematics step and a two-step integrated physics/mathematics consisting of a conceptual physics step followed by an equally important mathematics step. The prevailing single step provided most if not all of the spectacularly successful astrophysics achievements over the last century. However, it provided near zero results for multiple interrelated theories such as a beyond the Standard Model (BSM) and a Theory of Everything (TOE) solution. The prevailing single primarily mathematics step and the two-step integrated physics/mathematics methodologies are complementary and essential for future astrophysics achievements.

The Standard Model (SM) consists of 16 matter and force particles: six quark matter particles (up, down, charm, strange, top, and bottom); six lepton matter particles (electron, muon, tau, electron-neutrino, muon-neutrino, and tau-neutrino); and four force particles (photon, W/Z's, gluon, and Higgs). Although the SM is the gold standard of particle physics, it is inadequate because it: does not emphasize Higgs particles' supremacy; does not differentiate between more important permanent and less important transient particles; defines only a single Higgs force; does not include the graviton; and does not include dark matter, dark energy, supersymmetry (SUSY), and super supersymmetry (SSUSY) of Higgs particles. Via amplification of four independent theories (superstring, particle creation, Higgs forces or bosons, and spontaneous symmetry breaking), the SM was amplified to Fig. 7 Fundamental SM/supersymmetric/super supersymmetric matter and force particles. The latter contained a total of 64 fundamental matter and force particles of which 22 were permanent and 42 transient. Figure 7 resolved all SM inadequacies and was a conceptual physics BSM solution.

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I. INTRODUCTION – A TWO-STEP INTEGRATED PHYSICS/MATHEMATICS METHODOLOGY JUSTIFICATION

A new astrophysics mindset is required. Two astrophysics issue resolution methodologies are: the prevailing Hawking et. al. single primarily mathematics step and this article's two-step integrated physics/mathematics consisting of a conceptual physics step followed by an equally important mathematics step. The prevailing single step is applicable to a single independent theory [e.g., Higgs forces or spontaneous symmetry breaking or stellar black holes or inflation or etc.]. **The prevailing single step provided most if not all of the spectacularly successful astrophysics achievements over the last century** (e.g., Higgs force prediction and detection; gravitational waves definition and detection via stellar black hole mergers; etc.). However, **the prevailing single step provided near zero results for multiple interrelated theories such as a TOE and a BSM solution** after a century and half century, respectively. In fact, **the obsessive and exclusive astrophysicists' use of mathematics is a reason for absence of a TOE and a BSM solution.** This author's current versions of the latter two are titled "A Two-Step Integrated TOE – Revision B" and this article's "A BSM Solution using a Two-Step Integrated Physics/Mathematics Methodology." Both consist of multiple interrelated amplified constituent theories, (e.g., Higgs forces and spontaneous symmetry breaking and stellar black holes and inflation and etc.). "A Two-Step Integrated TOE - Revision B" is the superset and defines the TOE as 20 interrelated amplified constituent theories: superstring, particle creation, inflation, Higgs forces, spontaneous symmetry breaking, superpartner and SM decays, neutrino oscillations, dark matter, universe expansions, dark energy, messenger particles, relative strengths of forces/Hierarchy problem, Super Universe (multiverse), stellar black holes (stars and galaxies), black hole entropy, arrow of time, cosmological constant problem, black hole information paradox, baryogenesis, and quantum gravity. This article is the subset and consists of 4 of the 20 TOE interrelated amplified constituent theories.

Four reasons why a BSM solution does not exist are:

1. The BSM solution constituent theories were not defined. In contrast, this article's BSM solution consists of four constituent theories: superstring, particle creation, Higgs forces or bosons, and spontaneous symmetry breaking.
2. Constituent theories were incompletely defined. Section V. An amplified Higgs forces (bosons) contains an order of magnitude more requirements than the existing single Higgs forces theory. For example, requirement amplifications included 32 associated super supersymmetric Higgs particles, one for each of 32 SM and supersymmetric matter and force particles. Similarly, in section VI.A. Comparison between the current astrophysics spontaneous symmetry breaking and this article's descriptions, the amplified spontaneous symmetry breaking contains more requirements than the existing ambiguously defined theory. These incomplete physical requirements of constituent theories must be defined before the second mathematics step begins.

   Furthermore, the prevailing single primarily mathematics step methodology does not consist of just a single mathematics step. Implicit is the conceptual physics step which preceded the mathematics step. For example, Newton defined the first conceptual and absolutely essential physics step as the intimate relationship between gravitational force and matter, before he defined the second gravitational force mathematical step equation ($F = Gm_1m_2/r^2$). For multiple interrelated theories (e.g., a TOE and a BSM solution), the first conceptual physics step is also absolutely essential.
3. The interrelationships between the constituent theories were misunderstood and ignored. For example, during particle creation, matter creation could not occur before or during inflation but after inflation. Otherwise, matter in our universe would not be uniformly distributed on a large scale.
4. Implementation of the above three did not occur because of astrophysicists' obsessive and exclusive use of the single mathematics step instead of using this article's two-step integrated physics/mathematics methodology.

Although one of Einstein's primary goals was a TOE solution using the prevailing single primarily mathematics step, he was specifically excluded from the above Hawking et. al. designation because Einstein was 50 years ahead of his time. Most of "A Two-Step Integrated TOE" 20 interrelated amplified constituent theories (e.g., superstring, Higgs forces, spontaneous symmetry breaking, dark energy, etc.) were unavailable to Einstein a century ago. If he had been born a half century later, his genius would definitely have defined the conceptual physics step and probably the mathematics step of "A Two-Step Integrated TOE."

The two-step integrated physics/mathematics methodology is essential for resolution of issues included in a TOE and a BSM solution because of insights provided by its first conceptual physics step. Four examples follow:

1. The first conceptual physics step of this article **describes the TOE as the intimate relationship between atomic/subatomic matter, dark matter, and dark energy as defined by their constituent 22 permanent fundamental matter and force particles.** Atomic/subatomic matter consists of the: up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino or 5% of our universe's energy/mass. Dark matter consists of the: zino, photino, and three permanent Higgsinos associated with the zero energy graviton, gluon, and photon or approximately 26%. Dark energy consists of the sum of eight permanent Higgs forces associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) or 69%.

   Furthermore, these 22 permanent fundamental matter and force particles are constituents of all objects in our universe including: all solar systems, galaxies, and permanent stellar black holes. All permanent stellar black holes consisting of 22 permanent fundamental matter and force particles is in sharp contrast to the unknown constituents of stellar black holes according to current astrophysics theory.

2. Nobel Prize in Physics winners Higgs and Englert predicted the 125 GeV Higgs force using the prevailing, single primarily mathematics step methodology. However, their Higgs force prediction must be amplified by the first conceptual physics step of the two-step integrated physics/mathematics methodology to define Higgs particles' supremacy as associate God particles. Super force particles were God particles because they constituted 100% of our universe's total energy/mass between t = 0 s and the start of matter creation.

During matter creation from t = 10^{-33} to 100 s in Fig. 2, super force particles condensed and decayed to 22 permanent matter and force particles. Higgs particles were associate God particles because the sum of dark energy or eight permanent Higgs force energies and ½ of dark matter or three permanent Higgsino types constituted 69 + ½(26) = 82% of our universe's energy mass.

3. Nobel Prize in Physics winner Weinberg predicted the electroweak unification theory and Higgs force existence using a spontaneous symmetry breaking explanation. However his prediction must be amplified by the first conceptual physics step of the two-step integrated physics/mathematics methodology for two reasons. First, the Higgs force was the product not the cause of spontaneous symmetry breaking. Spontaneous symmetry breaking was caused by temperature, not the Higgs force. At specific temperatures proportional to matter energy/mass according to the formula, eV ~ 10^4 K, each matter particle condensed with its associated Higgs force. For example in Fig. 2, at 10^{-12} s, 10^{15} K, and 80 GeV, spontaneous symmetry breaking occurred for the transient W^- and its associated transient Higgs force. At approximately 100 s, 10^{10} K, and .51 MeV, spontaneous symmetry breaking occurred for the permanent electron and its associated permanent Higgs force. Second, the transient Higgs force associated with W^- has a lifetime of 10^{-25} s. This transient Higgs force gives mass to a transient W^- as Weinberg correctly predicted, but cannot give mass to a permanent fundamental particle such as an electron because the transient Higgs force exists for only 10^{-25} s. A permanent electron requires its permanent associated Higgs force to give it mass. This is one justification for 8 permanent Higgs forces associated with 8 permanent fundamental matter particles.

4. Hawking initially believed in a TOE solution whereas he later stated there probably was no solution. There is agreement that a TOE solution using the prevailing single primarily mathematics step is technically overwhelming. However, definition of the TOE first conceptual physics step is available in "A Two-Step Integrated TOE." Also, preliminary definition of the first part of the two part second mathematics step which consists of a proposed BSM mathematics solution for particles is described in section VIII.A. The second part of the two part second mathematics step is described as an amplified N-body simulation for cosmology (Illustris by Vogelsberger) in "A Two-Step Integrated TOE" [1]. Both parts of the two part second mathematics step are technically formidable but viable. Since this article is a subset of "A Two-Step Integrated TOE," when the formidable second two part mathematics step is resolved for the latter, it will also be resolved for this article.

In summary, the prevailing single primarily mathematics step and the two-step integrated physics/mathematics methodologies are complementary and essential for future astrophysics achievements. The single step defines the leaves, trunk, branches, bark, and roots of a specific tree whereas the equally important two-step defines the forest. This article and "A Two-Step Integrated TOE's" superiority can be demonstrated via a vigorous peer review including an unlimited number of astrophysicists' questions answered by this author.

A. Introduction - Amplifications of four independent theories

The four theories (superstring, particle creation, Higgs forces or bosons, and spontaneous symmetry breaking) were independent of each other because, for example, superstring physicists worked independently of Higgs forces physicists. The four independent theories were modeled as four independent jigsaw puzzle pieces that did not initially fit snuggly together. Each of the four theories' requirements were selectively amplified to integrate them with the three other independent theories without sacrificing the independent theories' integrities. Requirements were always added and never eliminated. For example, to the existing Large Hadron Collider (LHC) detected transient Higgs force of 125 GeV, eight permanent Higgs forces or dark energy were added. These amplifications were required to integrate and interface the independent Higgs force theory with the three other independent theories, superstring, particle creation, and spontaneous symmetry breaking. Four independent theory amplifications are described in four separate sections of this article. They produce four snuggly fitting interrelated amplified constituent theories and four snuggly fitting jigsaw puzzle pieces.

II. AN AMPLIFIED SUPERSTRING

There are 129 fundamental matter and force particles, each defined by a unique closed superstring in a Planck cube. There are 16 SM particles, 16 supersymmetric particles, 32 Higgs super supersymmetric particles, 64 anti-particles, and the super force or mother particle. Table I shows 32 fundamental SM/supersymmetric matter and force particles with SM particles on the left and supersymmetric particles on the right. There are 13 SM matter particles

TABLE I. Fundamental SM/supersymmetric matter and force particles.

Symbol	SM	Matter	Force	Symbol	Supersymmetric	Matter	Force
p_1	graviton		x	p_{17}	gravitino	x	
p_2	gluon		x	p_{18}	gluino	x	
p_3	top quark	x		p_{19}	stop squark		x
p_4	bottom quark	x		p_{20}	sbottom squark		x
p_5	tau	x		p_{21}	stau		x
p_6	charm quark	x		p_{22}	scharm squark		x
p_7	strange quark	x		p_{23}	sstrange squark		x
p_8	muon	x		p_{24}	smuon		x
p_9	tau-neutrino	x		p_{25}	stau-sneutrino		x
p_{10}	down quark	x		p_{26}	sdown squark		x
p_{11}	up quark	x		p_{27}	sup squark		x
p_{12}	electron	x		p_{28}	selectron		x
p_{13}	muon-neutrino	x		p_{29}	smuon-sneutrino		x
p_{14}	electron-neutrino	x		p_{30}	selectron-sneutrino		x
p_{15}	W/Z's (hybrid)	x		p_{31}	wino/zinos	x	
p_{16}	photon		x	p_{32}	photino	x	

16	SM	$p_1 \ldots p_{16}$
16	Supersymmetric	$p_{17} \ldots p_{32}$
32	Higgs super supersymmetric particles	$h_{1 \ldots} h_{32}$
64	anti-particles	$p_{1bar} \ldots p_{32bar}$, $h_{1bar} \ldots h_{32bar}$
1	super force (mother)	p_{sf} (32 types)

129	total	

and 3 SM force particles including an added graviton force particle. W/Z's are reclassified as hybrid matter/force particles because they are transient matter particles associated with transient Higgs forces but have force particle spins of 1. There are 4 supersymmetric matter particles and 12 supersymmetric force particles.

Because of particle creation and spontaneous symmetry breaking, each of these 32 SM/supersymmetric matter and force particles has one of 32 associated Higgs super supersymmetric particles. The 32 SM/supersymmetric matter and force particles are related to their 32 associated Higgs super symmetric particles via common subscripts (e.g., up quark p_{11} and its associated Higgs force h_{11}, and photon p_{16} and its associated Higgsino h_{16}). The primary reason for replacing inadequate existing matter and force particle symbols (e.g. u for up quark) with Table I symbols was existing symbols could not be easily related to their associated super supersymmetric Higgs particle. The second reason was elimination of existing symbol ambiguities via standardization of subscripts and capitals as described in "A Two-Step Integrated TOE [1].

Seventeen matter particles/Higgs forces and three Higgsinos/associated forces or 40 particles manifested themselves during matter creation. Twelve Higgsinos/associated supersymmetric force particles or 24 particles manifested themselves prior to matter creation and were inflatons which expanded our universe during inflation. Each of these 64 matter and force particles had an associated anti-particle for a total of 128 matter and force particles.

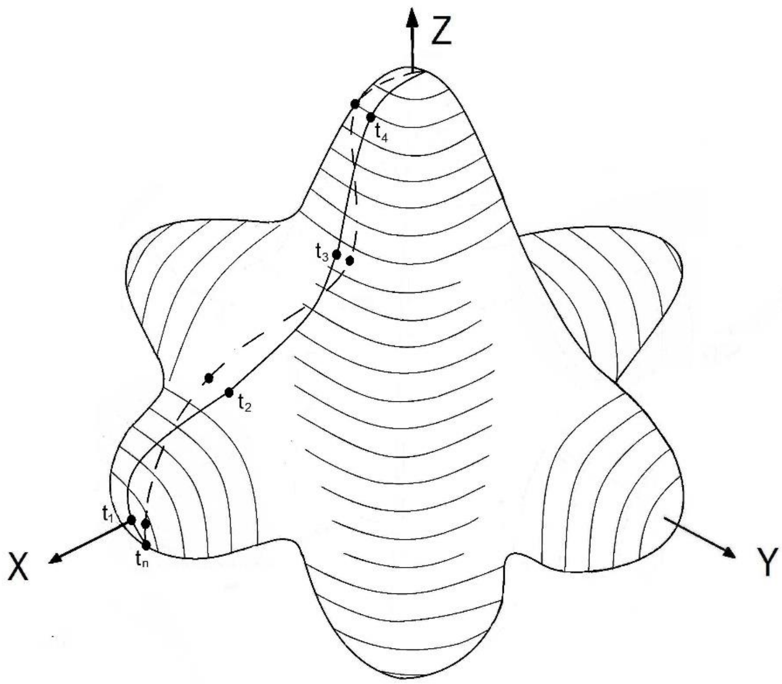

FIG. 1. Electron Calabi-Yau membrane.

There were 32 super force types identified for example by p_{sfpxy} where the subscripts (sf) signify super force and the following subscripts (e.g., p_{xy}) signify one of 32 associated SM/supersymmetric matter and force particles (e.g., p_{11} or up quark). The 32 super force types produced 32 SM/supersymmetric matter and force particles and their 32 associated super supersymmetric Higgs matter and force particles for a total of 64 matter and force particles (see Table III). Since the same 32 super force types produced both particles and their anti-particles, a total of 128 particles were produced.

Each of the 128 fundamental SM/supersymmetric/super supersymmetric particles and the 129th super force particle are equivalently represented by: a dynamic point particle, its unique closed superstring, or its associated Calabi-Yau membrane (cloud) as shown in Fig. 1 Electron Calabi-Yau membrane. In traditional string theory descriptions, a one brane vibrating string generates a two brane Calabi-Yau membrane over time. Superstring theory was amplified so that a zero brane dynamic point particle generates particle positions over time for both a one brane vibrating superstring and a two brane vibrating Calabi-Yau membrane. According to Greene, two basic Calabi-Yau membrane types are beach balls and doughnuts. Conifold transitions are the transformations of the two membrane types into each other. The Planck cube sized beach ball electron Calabi-Yau membrane of Fig. 1 contains periodic surface hills and valleys where particle energy/mass is proportional to their amplitude displacement and frequency [2].

The only differences between the 129 matter and force particles are the amplitude displacement and frequency of their hills and valleys, or their energy/masses. A superstring just touching the sides of a Planck cube with no amplitude displacement and frequency represents zero energy (e.g. photon, gluon, and graviton). In contrast, Fig. 1 shows an electron as a superstring and Planck cube sized beach ball with amplitude displacement and frequency of its hills and valleys and has an energy/mass of .51 MeV. The periodic surface hills and valleys of Fig. 1 are shallower than shown and were exaggerated for visibility.

Other matter and force particles having energy/masses (e.g., up quark, down quark, zino, photino, W/Z's, Higgs, and super force particles) have closed superstrings similar to the electron but with different amplitude displacement and frequency of their hills and valleys. A range of amplitude displacements and frequencies defined the 32 SM/supersymmetric matter and force particles' energy/masses, from the lightest photon (zero) to the top quark (172 GeV) to supersymmetric particles (100 to 1500 GeV) [3].

In Fig. 1, the electron dynamic point particle position is identified by x, y, z coordinates measured from the Planck cube's center with velocity components v_x, v_y, and v_z. Superstring theory's six extra dimensions are these six dynamic point particle position and velocity coordinates. In the figure, the electron dynamic point particle positions are shown at sequential times t_1, t_2, t_3, t_4…..t_n and define an electron closed superstring. The electron Calabi-Yau membrane or cloud is the sum of individual electron dynamic point particle positions from t_1, t_2, t_3, t_4…..t_m where m is much larger than the n points over an electron closed superstring. An electron exists sequentially in time as n dynamic point particle positions in an electron closed superstring or m dynamic point particle positions in an electron Calabi-Yau membrane or cloud.

Quantum fluctuations are jitter or a temporary change in energy caused by the uncertainty principle of a dynamic point particle's position and momentum in a Planck cube. Quantum fluctuations jitter the electron's dynamic point particle position by Δ y as shown in the figure by the displaced dots on the dashed closed superstring. The figure shows a closed electron superstring as a solid line with dots whereas the dots on the dashed closed superstring represent dynamic positions of the electron with quantum fluctuations. Although the jitter is three dimensional in position and velocity (Δ x, Δ y, Δ z, Δv_x, Δv_y, Δv_z), for simplicity jitter is shown in the figure in only one dimension Δ y. If the electron dynamic point particle position is defined over n points, the result is a vibrating closed superstring. If the electron dynamic point particle position is defined over a much larger m points, the result is a vibrating Calabi-Yau membrane or cloud. The dynamic point particle in the closed superstring jitters in position and momentum according to the uncertainty principle $\Delta y \Delta p_y \geq h/4\pi$.

III. AN AMPLIFIED PARTICLE CREATION

Our universe's 128 matter and force particle types were created from the super force during particle creation between t = 5.4 x 10^{-44} and 100 s as shown in Fig. 2 Big Bang time line of Rees [4]. Although graviton and gluon force energies were created at 5.4 x 10^{-44} and 10^{-36} s respectively, they manifested themselves as force particle superstrings in Planck cubes during inflation (5 x 10^{-36} to 10^{-33} s), when the size of our universe was larger than a Planck cube. All matter particles and the photon force particle manifested themselves during matter creation between t = 10^{-33} s and t = 100 s and at extremely high temperatures between 10^{25} and 10^{10} K. Condensation of matter particles required both Planck cube size to accommodate matter particle superstrings and condensation temperatures related to their energy/masses. The X axis was shown both as time in seconds and temperature in Kelvins because of the intimate relationship between particle creation time and particle temperature or energy/mass (e.g., W^- at 10^{-12} s, 10^{15} K, and 80 GeV). Energy/mass in electron volts was related to temperature via eV ~ 10^4 K. For simplicity, Fig. 2 excluded 64 anti-particles.

Figure 2 shows creation of our universe's 64 matter and force particle types from the super force physical singularity P_{sf} having energy of 10^{54} kg. Upper case letters are exclusively used because particle creation involves total particle energy/mass. For example, total up quark energy/mass or the energy/mass of all up quarks in our universe is P_{11}. Total energy/mass (e.g., P_{11}) consists of three types of energies: rest mass, kinetic (translational and rotational), and potential (gravitational, electromagnetic, nuclear binding) energies.

At t = 0 our universe was a doughnut physical singularity at a Planck cube center which transformed to a spherical physical singularity via Greene's conifold transition. Following this conifold transition, our universe was spherical in shape and remained spherical for the next 13.8 billion years. Our universe expanded from a spherical physical singularity at t > 0 s, to a larger spherical physical singularity but smaller than a Planck cube at the start of

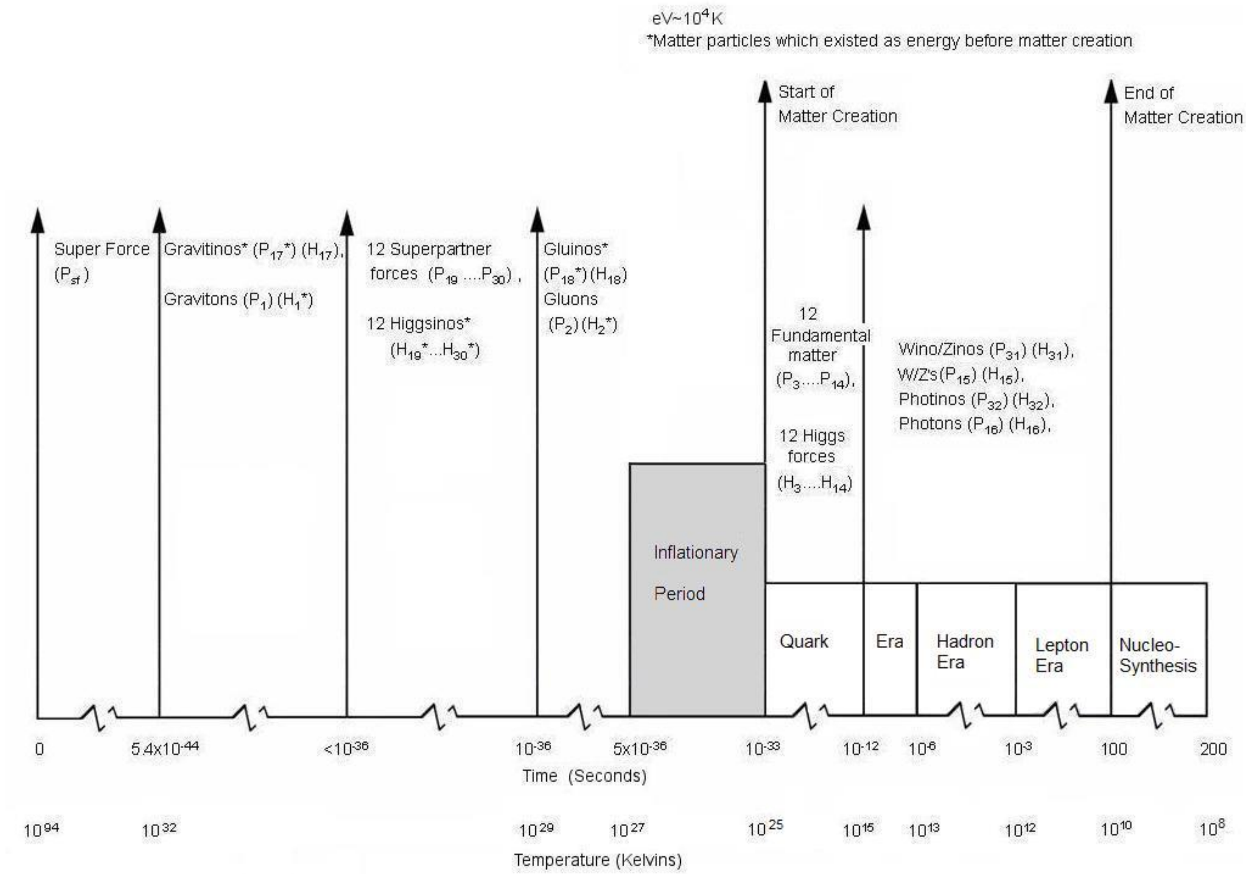

FIG. 2. Big bang.

inflation (t = 5 x 10^{-36} s), to an 8 m radius sphere of individual super, graviton, or gluon force particle closed superstrings at the end of inflation or 10^{-33} s. Currently, our spherical universe has a radius of 46.5 billion light years.

Inflation start time (5 x 10^{-36} s) was amplified to be time synchronous with the one to seven Planck cubes spherical physical singularity to individual super, graviton, or gluon force particle closed superstrings expansion. Since individual super force, matter, and force particles existed as closed superstrings in Planck cubes, they could not exist before the start of inflation at t = 5 x 10^{-36} s when our universe was smaller than a Planck cube. The one to seven Planck cubes spherical physical singularity to individual super, graviton, or gluon force particle closed superstrings expansion consisted of six contiguous Planck cubes attached to the six faces of our universe's original Planck cube as shown in Fig. 3. The center cube numbered 1 but hidden from view, contained our universe's spherical physical singularity (10^{54} kilograms) of superimposed super force closed superstrings. Part of the super force's energy condensed into six individual super, graviton, or gluon force particle closed superstrings in the six contiguous Planck cubes. In Fig. 3, the six force particle cubes are explicitly shown and numbered as 2, 3, 4, 5, 6, and 7, whereas the center super force singularity cube numbered 1, is hidden from view. The first force particle Planck cube shell consisting of six force particles was then pushed out, and a second force particle Planck cube shell between the center Planck cube and the first force particle shell was created. This process continued until enough shells with enough Planck cubes existed to accommodate all our universe's individual super, graviton, and gluon force particles. By the end of inflation, our spherical universe had expanded from a super force physical singularity inside a Planck cube to a sphere with a radius of 8 meters. The exponential inflation factor was approximately 8 meters/.8 x 10^{-35} meters or 10^{36}.

Figure 2 describes the creation of the 64 SM/supersymmetric/super supersymmetric matter and force particles as follows. At t = 5.4 x 10^{-44} s or the Planck time, four fundamental forces were unified. Gravitons (P_1), their gravitino*

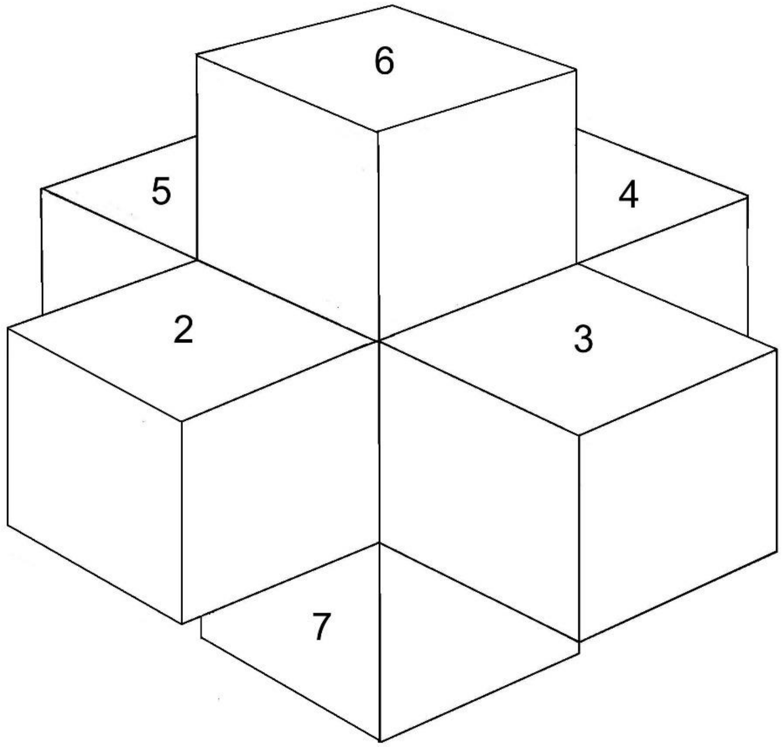

FIG. 3. One to seven Planck cubes expansion.

superpartners (P_{17}*), and their two associated super supersymmetric Higgs particles (H_1*, H_{17}) condensed from the super force. At t = 10^{-36} s or the Grand Unified Theory (GUT) time, three forces were unified. Gluons (P_2), their gluino superpartners (P_{18}*), and their two associated super supersymmetric Higgs particles (H_2*, H_{18}) condensed from the super force. At t = 10^{-12} s, two forces were unified. Photons (P_{16}), their photino superpartners (P_{32}), and their two associated super supersymmetric Higgs particles (H_{16}, H_{32}) condensed from the super force. Also, W/Z's (P_{15}), their Wino/Zino superpartners (P_{31}), and their two associated super supersymmetric Higgs particles (H_{15}, H_{31}) condensed from the super force. At t < 10^{-36} s, 12 superpartner forces (P_{19}….P_{30}) and their 12 associated Higgsinos (H_{19}*….H_{30}*) condensed from the super force. Twelve fundamental matter (P_3….P_{14}) and their associated super supersymmetric Higgs forces (H_3….H_{14}) condensed during matter creation. The asterisk (*) signifies matter particles which existed as energy before condensation to matter particle closed superstrings in Planck cubes during matter creation. Twelve superpartner forces and their 12 associated Higgsinos* were X bosons or the latent energy which expanded our universe during the inflationary period [5]. X bosons were to the inflation period as eight permanent Higgs forces (dark energy) were to our universe's expansion from the start of matter creation to the present time.

The general relativity/quantum gravity (mechanics) boundary was the start of inflation at t = 5 x 10^{-36} s when our universe was a spherical physical singularity inside a Planck cube. General relativity was applicable for all times in our universe between t = 0 and t = 13.8 billion years, whereas quantum gravity theory was applicable for all those times except between 0 and 5 x 10^{-36} s. Between 0 and 5 x 10^{-36} s, quantum gravity theory was not applicable because our universe was a singularity smaller than the Planck cube quantum. The latter was required for matter (e.g. electron, up quark) and force (e.g. graviton) closed superstring particles.

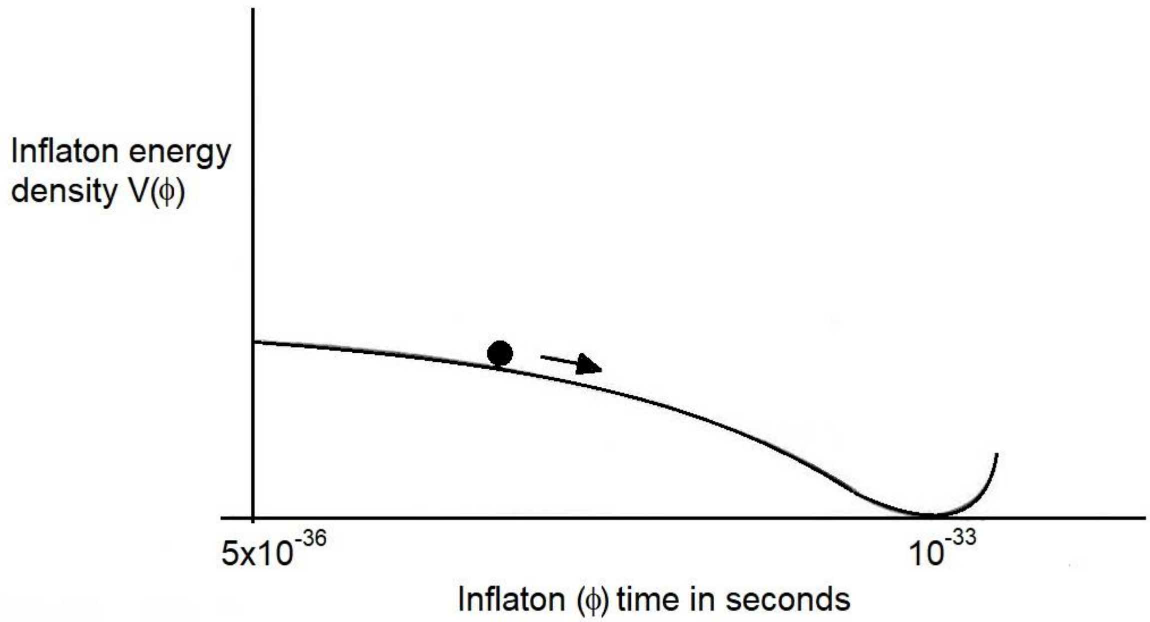

FIG. 4. Single field inflation.

IV. SPONTANEOUS SYMMETRY BREAKING AND INFLATION FUNCTIONS

There were two similar but different potential field functions for spontaneous symmetry breaking and inflation. During matter creation, spontaneous symmetry breaking was the condensation of super force particles to matter particles and their associated Higgs forces. In contrast, inflation was the exponential increase (10^{36}) of the spherical size of our universe between t = 5 x 10^{-36} to 10^{-33} s [1]. Inflation was caused by the condensation of inflatons to expansion energy.

Up quark baryogenesis and spontaneous symmetry breaking functions is shown in Fig. 5. The true or permanent vacuum state (dark energy density) consisted of space between matter particles, or the sum of eight permanent Higgs force energy densities. Currently in our universe, the true vacuum state between galaxies has an average temperature of 2.72 K or 2.72 x 10^{-4} eV. The false vacuum state was the intermediate or transient state between the super force state and the permanent matter/Higgs force or true vacuum state. During matter creation (10^{-33} to 100 s), there were two false vacuum states. First during baryogenesis for each of 17 matter particles, particle/anti-particle pairs condensed from and evaporated back to the super force. The second false vacuum state occurred during the decay of nine transient SM/supersymmetric matter particles to eight SM/supersymmetric permanent matter particles. These are described in detail in section VI. An amplified spontaneous symmetry breaking and shown in Fig. 5 Up quark baryogenesis and spontaneous symmetry breaking functions.

In contrast, inflation was a single field potential field function shown in Fig. 4 [6] and validated by Planck satellite measurements [7]. The vertical Z axis of Fig. 4 represents inflaton energy density V(ϕ) while the X axis represents inflaton (ϕ) time during the inflationary period, t = 5 x 10^{-36} to 10^{-33} s. The instantaneous value of inflaton energy density versus inflaton time is shown by the ball position as it rolls down the Fig. 4 function. When all the inflaton energy density has been expended, inflation is “gracefully exited” as the ball stops rolling at time t = 10^{-33} s. Since inflation expanded space faster than the speed of light and matter particles could not travel faster than the speed of light, if matter particles were created before or during inflation they would not be uniformly distributed in space. This is contrary to the measured homogeneous and isotropic nature of our universe on a large scale (490 million ly cube) [8]. Thus, no matter particles were created before or during inflation.

V. AN AMPLIFIED HIGGS FORCES (BOSONS)

Amplifications to Higgs force theory were key to this article's a BSM solution. First, amplifications included 32 associated super supersymmetric Higgs particles, one for each of 32 SM and supersymmetric matter and force particles. These 32 Higgs particles defined a "Super supersymmetry (SSUSY)." If a SM/supersymmetric particle was a matter particle (e.g., up quark, gravitino), its associated Higgs particle was a Higgs force. If a SM/supersymmetric particle was a force particle (e.g., graviton, sup squark), its associated Higgs particle was a Higgsino. In reference to quantum fluctuations and according to Carroll [9], contributions from fermions (e.g., up quark) were exactly cancelled by equal and opposite contributions from their supersymmetric force particles (e.g., sup squark) before supersymmetry was broken. In the Minimal Supersymmetric Standard Model according to Randall [10], the strength of three forces (strong, weak, and electromagnetic) precisely met at the Grand Unification time $t = 10^{-36}$ s with an energy of 10^{16} GeV. Similarly, perhaps contributions of a SM or supersymmetric matter particle (e.g. up quark or gravitino) were exactly cancelled by equal and opposite contributions from their super supersymmetric Higgs force particles before super supersymmetry was broken. Under these conditions, the strength of four forces (strong, weak, electromagnetic, and gravitational) may have precisely met at the Planck time $t = 5.4 \times 10^{-44}$ s or 10^{19} GeV.

Matter creation included a super force particle's condensation to a matter particle/Higgs force. Just as an electron or up quark have electric fields because of their electric charges, an electron or up quark also have Higgs force fields because of their masses. The matter particle/Higgs force were one and inseparable, created simultaneously during matter creation, and modeled as an undersized porcupine (e.g., up quark Planck cube closed superstring) with overgrown spines (e.g., a three dimensional radial Higgs force field quantized into Higgs force Planck cube closed superstrings).

Extremely high temperatures between 10^{25} and 10^{10} K in our early universe caused matter creation via baryogenesis and spontaneous symmetry breaking. The Higgs force was the product not the cause of spontaneous symmetry breaking. The super force condensed into 17 matter particles/Higgs forces at 17 different temperatures. There were nine transient matter particles (top quark, bottom quark, charm quark, strange quark, tau, muon, gravitino, gluino, and W/Z's) and eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino). The zino and photino were dark matter particles. Spontaneous symmetry breaking was similar to the three condensation phases of H_2O from steam, to water, to ice as temperature decreased from 212° to 32° F. Similarly the super force, three W/Z's/three Higgs forces, down quark/Higgs force, up quark/Higgs force, etc., were the same but manifested themselves differently as temperature decreased from 10^{25} to 10^{10} K. There was an intimate relationship between matter creation time and the matter particle's energy/mass or temperature. That is, 17 SM/supersymmetric matter particles had specific matter creation times and related temperatures or energy/masses (e.g., W^- at 10^{-12} s, 10^{15} K, or 80 GeV). The earlier the matter creation time, the greater was the matter particle's temperature or energy/mass.

Ice evaporated or melted to water which then evaporated to steam as temperature increased from 32° to 212° F. Similarly, particle creation and spontaneous symmetry breaking were bidirectional. For example as temperature increased, the down quark/Higgs force evaporated back to the super force.

Therefore, the super force condensed into a matter particle/Higgs force or a matter particle/Higgs force evaporated to the super force. In Beta minus decay, the down quark decayed to an up quark and a W^-. The W^- then decayed to an electron and an anti-electron-neutrino. The Beta minus decay equation produced correct results with a misunderstood process because indivisible fundamental particles such as the down quark or W^- cannot be split into two other fundamental particles.

Particle decay was the evaporation of a heavy matter particle/Higgs force to the super force and the condensation of the super force to lighter and permanent matter particles/Higgs forces. In the Beta minus decay with Higgs force amplification or "New Physics," the down quark/Higgs force evaporated to a super force particle. Division of energy not matter occurred as one portion of the super force condensed to the up quark/Higgs force, and a second portion to the W^- particle/Higgs force. The three W/Z's (W^+, W^-, and Z^0) were transient matter particles because, for example, within 10^{-25} s of its creation, the W^- transient matter particle/Higgs force evaporated back to a super force particle. The super force then condensed into an electron/Higgs force and an anti-electron-neutrino/Higgs force. Since the W/Z's were reclassified as transient matter (hybrid) particles, this produced the asymmetrical number 17 instead of 16 matter particles, that is, 9 transient and 8 permanent matter particles. By 100 seconds after the big bang, the nine transient matter particles/Higgs forces decayed via evaporation/condensation cycles to and from the super force to eight permanent matter particles/Higgs forces. The latter included the permanent: up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, photino and their eight permanent Higgs forces or dark energy.

Mass was given to a matter particle by its Higgs force and gravitons or gravitational force messenger particles. Graviton requirements were amplified to include embedded clocks/computers. The embedded graviton clock/computer calculated Newton's gravitational force by extracting masses of the transmitting and receiving matter particles from their Higgs forces, calculating the range factor $1/r^2$ as $1/ [(t_r - t_t) (c)]^2$ from the graviton transmission (t_t) and reception (t_r) times, and providing gravitational force to the receiving particle. Permanent Higgs forces give mass to their permanent associated matter particles. Transient Higgs forces (e.g., that associated with W^-) cannot give mass to permanent matter particles (e.g. up quark) because the former exist for only 10^{-25} s.

VI. AN AMPLIFIED SPONTANEOUS SYMMETRY BREAKING

Baryogenesis, matter decays, and spontaneous symmetry breaking occurred at extremely high temperatures in our early universe and created 22 permanent fundamental matter and force particles: eight permanent matter particles and their eight associated Higgs forces and three permanent Higgsinos and their three associated forces (graviton, gluon, and photon).

Baryogenesis occurred for: 17 transient and permanent SM/supersymmetric matter particles and three permanent Higgsinos; decay for nine transient SM/supersymmetric matter particles; and spontaneous symmetry breaking for eight permanent SM/supersymmetric matter particles. All three occurred during matter creation between 10^{-33} and 100 s and at temperatures between 10^{25} and 10^{10} K. Since baryogenesis was similar for 17 matter particles and three permanent Higgsinos, and spontaneous symmetry breaking was similar for eight permanent matter particles, only the up quark baryogenesis and spontaneous symmetry breaking functions are described. Decay is described for both SM and supersymmetric matter particles.

Baryogenesis, matter decays, and spontaneous symmetry breaking had the following approximate time sequential phases.

1. Baryogenesis of nine transient matter particles
2. Baryogenesis of three permanent Higgsinos
3. Decay of nine transient matter particles to eight permanent matter particles
4. Baryogenesis and spontaneous symmetry breaking of eight permanent matter particles.

Because of the intimate relationship between matter creation time and particle temperature or energy/mass, the four phases occurred for the heaviest matter particle (e.g., assumed to be the gravitino) at the earliest matter creation time and highest energy/mass and for the lightest matter particle (e.g., electron-neutrino) at the latest matter creation time and lowest energy/mass.

Baryogenesis of nine transient matter particles was similar to the permanent up quark's baryogenesis shown in Fig. 5 from Guth's amplified energy density of Higgs fields [11]. The Z axis represented super force energy density allocated to up quarks/Higgs forces, the X axis a Higgs force (h_{11}) associated with an up quark, and the Y axis a Higgs force (h_{11bar}) associated with an anti-up quark. During up quark baryogenesis, the ball initially at its peak position (x = 0, y = 0, z = 2), moved down the baryogenesis and spontaneous symmetry breaking functions equidistant between the X and Y axes. Super force particles condensed in equal amounts to: up quarks and up quark Higgs forces; and anti-up quarks and anti-up quark Higgs forces. A portion of these four particles then annihilated by evaporating back to super force particles as the ball returned to its peak position. Another portion remained as up quarks/Higgs forces. During the second condensation/evaporation cycle, the ball moved down the baryogenesis and spontaneous symmetry breaking function closer to the X axis than the Y axis and then back to its peak position. After n of these condensation/evaporation cycles in the false vacuum state, the ball eventually moved to the Fig. 5 ball position (x = -2, y = 0, z = 1.5) or the true vacuum state. In the true vacuum state the super force condensed totally to the permanent up quark/Higgs force and none to the anti-up quark/Higgs force. Charge, parity, and time (CPT) violation caused baryogenesis. CPT violation had three arguments by T. D. Lee, N. E. Mavromatos, and F. Hulpke which supported each other and "A Two-Step Integrated TOE section 21 Baryogenesis" conclusions [1].

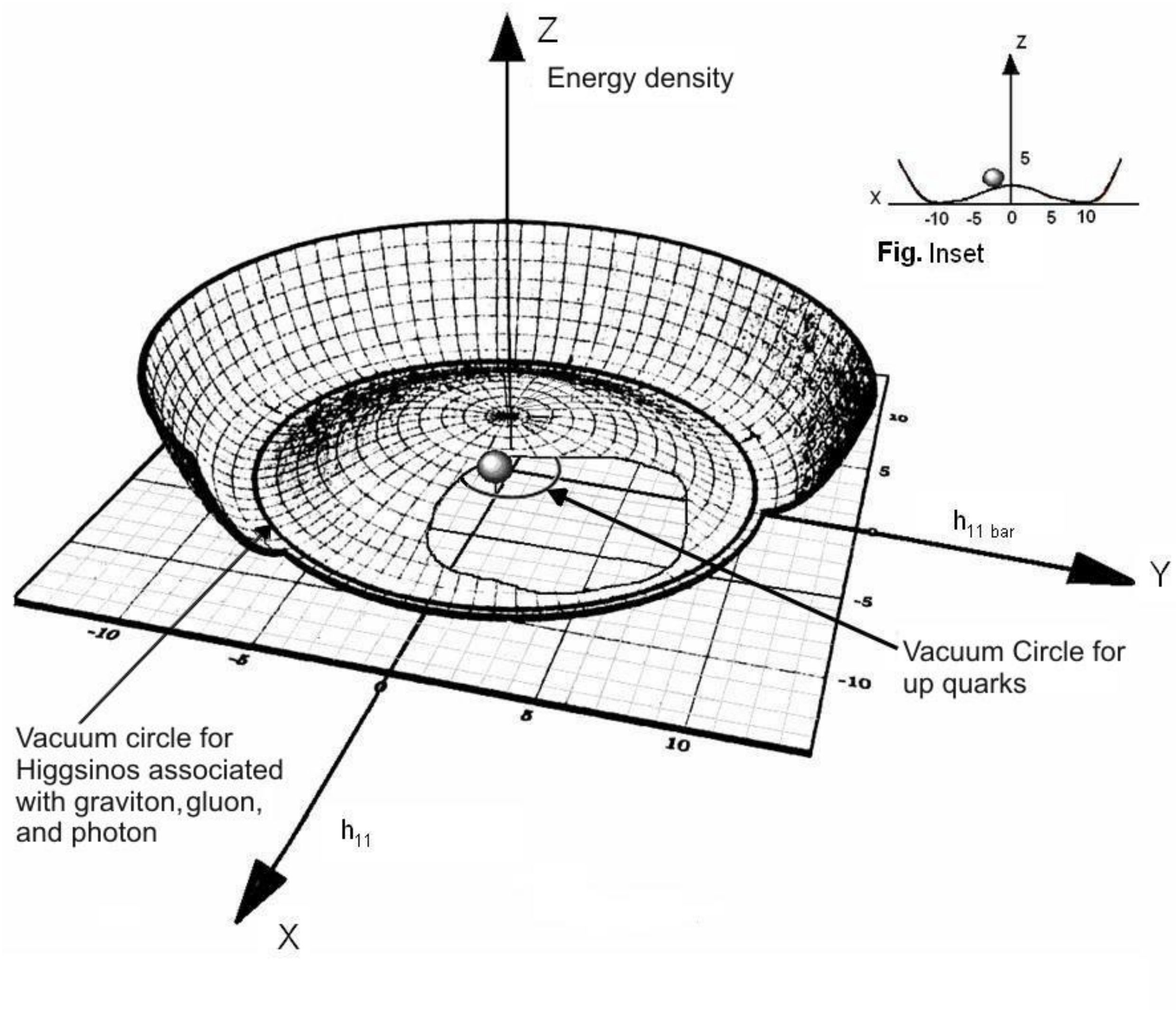

FIG. 5. Up quark baryogenesis and spontaneous symmetry breaking functions.

Following baryogenesis of each of nine transient matter particles, each decayed as follows. Decays were gauge mediated where heavier matter particles/Higgs forces decayed in a cascading process to lighter energy/mass matter particles/Higgs forces and intermediate force particles. Intermediate force particles were W/Z's for SM particles and winos for supersymmetric particles. For example, a transient SM bottom quark/Higgs force decayed to an up quark/Higgs force and a W^-/Higgs force. A transient superpartner (e.g., gravitino or gluino) decayed into a lower energy/mass superpartner and its intermediate force particle or wino. The wino decayed to SM particles/Higgs forces. The decay chain ended with zinos/Higgs forces and photinos/Higgs forces or the stable Lightest Supersymmetric Particles (LSP) and SM particles/Higgs forces. Stable LSPs or lightest neutralinos also included three permanent Higgsino types associated with gravitons, gluinos, and photons. Dark matter consisted of zinos, photinos, and three permanent Higgsino types [12] [13].

Following baryogenesis and decay of nine transient matter particles to eight permanent matter particles, baryogenesis and spontaneous symmetry breaking occurred for eight permanent matter particles and baryogenesis for three permanent Higgsinos. For the up quark, there were two key ball positions in Fig. 5. When the ball was in its peak position, up quark baryogenesis had not occurred. When the ball was in the Fig. 5 position, up quark baryogenesis had occurred and super force energy density had totally condensed to up quarks/Higgs forces. The z coordinate of the Fig. 5 ball position was the super force energy density condensed to up quark Higgs forces. The z coordinate of the peak ball position minus the z coordinate of the Fig. 5 ball position was the super force energy density condensed to up quarks. During the hadron era, the ball moved from its peak position to the Fig. 5 position. It took another 13.8 billion years for the ball to move vertically down to its current position just above the vacuum circle for up quarks. As the ball moved vertically down, the up quark's Higgs force (ball's x coordinate) remained constant whereas the up quark Higgs forces' energy density (ball's z coordinate) slowly decreased as our universe expanded.

There were eight baryogenesis and spontaneous symmetry breaking functions associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino). Each occurred at a temperature proportional to its energy/mass. Each had the same generic up quark Mexican hat shape of Fig. 5, but each had a different peak super force energy density (peak z coordinate) and Higgs force (ball x coordinate). By 100 s, only eight permanent matter particles/Higgs forces remained.

There was no spontaneous symmetry breaking for three permanent Higgsinos. However, three permanent Higgsinos associated with three SM force particles (graviton, gluon, and photon) experienced baryogenesis at creation times dependent on the permanent Higgsinos' energy/masses as follows. Higgsino baryogenesis was similar to up quark baryogenesis. Super force particles condensed into four particles (e.g., Higgsino and associated SM force, anti-Higgsino and associated SM force). During baryogenesis, the super force condensed totally to the Higgsino/SM force and none to the anti-Higgsino/SM force. By the end of Higgsino baryogenesis, the ball position in the Higgsino version of Fig. 5 was at x = -10, y = 0, z = 0 and on the vacuum circle for Higgsinos associated with the graviton, gluon, and photon. The vacuum was zero because no Higgs forces or dark energy were created. All a super force particle's energy condensed to a Higgsino and none to its associated zero energy force particle (graviton, gluon, or photon). In contrast to inseparable matter particles and their Higgs forces during the lifetime of our universe, the three permanent Higgsinos and their associated graviton, gluon, and photon forces became independent of each other following their associated creation. Thus by 100 s, eight permanent matter particles/Higgs forces and three permanent Higgsinos/associated forces (graviton, gluon, and photon) for a total of 22 permanent fundamental matter and force particles remained.

During matter creation (10^{-33} to 100 s), there were two time sequential false vacuum phases. First during baryogenesis for each of 17 matter particles, particle/anti-particle pairs condensed from and evaporated to the super force. As our universe expanded and cooled and after n of the condensation/evaporation cycles, this baryogenesis process was predominantly from energy to matter rather than to anti-matter. Particles/anti-particles were the intermediate, transient, or false vacuum state prior to the permanent matter/Higgs force or true vacuum state.

The second time sequential false vacuum phase occurred during the decay of nine transient matter particles to eight permanent matter particles and intermediate force particles. The super force condensed to a transient matter particle/Higgs force and bidirectionally evaporated back to the super force in the false vacuum state. Then, the super force condensed to lighter and stable matter particles/Higgs forces and intermediate force particles. This occurred for all nine transient matter particles. By 100 s, all nine transient matter particles/Higgs forces had condensed to eight permanent matter particles/Higgs forces. The true or permanent vacuum state consisted of space between matter particles, or the sum of eight permanent Higgs force energy densities.

Figure 2 shows total particle energy/masses of 64 matter and force particles designated as $P_1....P_{32}$ and $H_1....H_{32}$ where the symbols are described in Table I. These included gravitons (P_1), gluons (P_2), twelve fundamental matter particles ($P_3....P_{14}$), W/Z's (P_{15}), photons (P_{16}), 4 supersymmetric matter particles: gravitinos (P_{17}*), gluinos (P_{18}*), wino/zinos (P_{31}), photinos (P_{32}); and 12 superpartner force particles ($P_{19}....P_{30}$) energy/masses. The 32 super supersymmetric Higgs particles included 17 Higgs force energies ($H_3....H_{14}$, H_{17}, H_{18}, H_{31}, H_{32}, H_{15}) which were super force energy residuals following condensations of 12 fundamental matter, four supersymmetric matter, and W/Z's. There were also 15 Higgs matter particles (14 Higgsinos* and 1 Higgsino) energy/masses (H_1*, H_2*, H_{19}*....H_{30}*, H_{16}) for a total of 32 super supersymmetric Higgs particles. Sixty four anti-particles condensed at the same temperature and time as their identical energy/mass particles but were not explicitly shown in Fig. 2 because baryogenesis and inflation eliminated them.

A. Comparison between the current astrophysics spontaneous symmetry breaking and this article's descriptions

The current astrophysics spontaneous symmetry breaking description of matter creation in our early universe is ambiguously defined by Goldstone's "Mexican hat" potential with Z axis V(ϕ), X axis Re(ϕ), and Y axis Im(ϕ). The three axes are ambiguous because they are not related to our early universe's high energy particles such as the super force, up quark, and Higgs force. Also, no narrative is provided describing spontaneous symmetry breaking or its cause (temperature). In contrast, the three axes are explicitly defined in Fig. 5 with a narrative spontaneous symmetry breaking description. Therefore, the current astrophysics spontaneous symmetry breaking description will be compared to this article's detailed description to identify their differences.

There are three related astrophysics functions: inflation, baryogenesis, and spontaneous symmetry breaking listed in their correct time sequence. In the current astrophysics literature, baryogenesis is not defined. Furthermore, inflation and the ambiguously defined spontaneous symmetry breaking may have been incorrectly combined.

In this article, section IV described spontaneous symmetry breaking and inflation as similar but two separate functions. During matter creation, spontaneous symmetry breaking was the condensation of super force or mother particles to eight matter particles and their eight associated Higgs forces. Since inflation expanded space faster than the speed of light and matter particles could not travel faster than the speed of light, if matter particles were created before or during inflation they would not be uniformly distributed in space. This is contrary to the measured homogeneous and isotropic nature of matter in our universe on a large scale (490 million light year cube). The conclusion was no matter particles were created before or during inflation. In addition, if inflation and spontaneous symmetry breaking were combined in the current astrophysics description, this was incorrect.

In this article, section VI described both up quark baryogenesis and spontaneous symmetry breaking functions using Fig. 5. Baryogenesis occurred first in time followed by spontaneous symmetry breaking. In contrast to the current astrophysics spontaneous symmetry breaking ambiguously defined Goldstone's "Mexican hat" potential, this article's detailed Fig. 5 defines the three axes as follows. The Z axis represents super force energy density associated with the up quark/Higgs force, the X axis is the Higgs force (h_{11}) associated with an up quark, and the Y axis is the anti-up quark Higgs force (h_{11bar}). Spontaneous symmetry breaking shown for the up quark in Fig. 5, occurred for 8 permanent matter particles in sequence, at the temperature or energy/mass associated with the matter particle. That is, the heaviest energy/mass permanent matter particle (assumed to be a zino or photino) occurred first in time and the lightest energy/mass particle (electron-neutrino) occurred last. The eight permanent matter particles were (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) associated with eight Higgs forces.

Following baryogenesis but before spontaneous symmetry breaking, anti-up quarks and anti-up quark Higgs forces no longer existed. Therefore, the Y axis of Fig. 5 which represented anti-up quark Higgs force (h_{11bar}) was no longer required to describe spontaneous symmetry breaking. If the Y axis were compressed to zero, the result was the Fig. 5 inset. Figure 4 Single field inflation was similar to the right hand portion of the Fig. 5 inset which described spontaneous symmetry breaking. This may explain the incorrect combination of inflation and spontaneous symmetry breaking in the current astrophysics literature.

VII. CONSERVATION OF ENERGY/MASS ACCOUNTABILITY

All 128 matter and force particle types complied with conservation of energy/mass accountability. Accountability of our universe's total 10^{54} kg of energy by the end of matter creation at t = 100 s follows.

Nine transient matter particles (top quark, bottom quark, charm quark, strange quark, tau, muon, gravitino, gluino, and W/Z's) and their nine associated Higgs forces for a total of 18 particles accounted for 0%. By 100 s, these nine transient matter particles/Higgs forces evaporated and condensed or decayed to eight permanent matter particles/Higgs forces.

X bosons or inflatons consisted of 12 transient superpartner forces and their 12 associated Higgsinos for a total of 24 particles. X bosons or inflatons accounted for 0% because all their energy expanded our universe during inflation prior to t = 100 s.

By the end of matter creation at t = 100 s and at a temperature of 10^{10} K, all 64 anti-particles had been eliminated either by baryogenesis or inflation (12 anti-Higgsinos and their 12 associated superpartner forces) for a total of 64 particles.

From the above, there were 106 transient fundamental matter and force particles and only 22 permanent particles remained from the total 128. Three SM force particles (graviton, gluon, and photon) were permanent but accounted for 0%. For example, in transit photons contained radiation energies at t = 100 s, but these photons were assumed to contain zero energy. Transmitted radiation energies were allocated to transmitting particles until the radiation was received and then allocated to receiving particles.

Three types of matter and force particles, or 19 permanent fundamental matter and force particles with energy/masses remained at t = 100 s: atomic/subatomic matter, dark matter, and dark energy. However, because of significant photon radiation energy during the opaque era, constant energy/mass percentages of atomic/subatomic, dark matter, and dark energy did not occur at t = 100 s but at approximately 380,000 years. Atomic/subatomic matter or six permanent fundamental matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino) constituted 5% of our universe's energy/mass from approximately 380,000 years to the present time 13.8 billion years. Dark matter or the zino, photino, and three permanent Higgsino types constituted 26% of our universe's energy/mass. Dark energy or eight Higgs forces associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) constituted 69% of our universe's energy/mass. There was no quintessence or dynamic dark energy in our universe [1] [14] and these percentages remained constant for the next 13.8 billion years [15].

VIII. FUNDAMENTAL SM/SUPERSYMMETRIC/SUPER SUPERSYMMETRIC MATTER AND FORCE PARTICLES

The SM of Fig. 6 consists of twelve matter particles: six quarks (up, down, strange, charm, bottom, and top); six leptons (electron, muon, tau, electron-neutrino, muon-neutrino, and tau-neutrino); and four force particles (photon, W/Z's, gluon, and Higgs assuming the W and Z particles are combined into one). Although the SM is the gold standard of particle physics, it is inadequate because it: does not emphasize Higgs particles' supremacy; does not differentiate between more important permanent and less important transient fundamental particles; defines only a single Higgs force; and does not include the graviton, dark matter, dark energy, SUSY, and SSUSY of Higgs particles.

Figure 7 shows the Fundamental SM/supersymmetric/super supersymmetric matter and force particles which amplified the SM, resolved its inadequacies, and was a conceptual physics BSM solution. The figure consists of a circular area surrounded by an annular area. The circular area represents 22 permanent fundamental matter and force particles. The outer circular area clockwise from the top consists of: atomic/subatomic matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino) which constituted 5% of our universe's energy/mass between t = 380,000 years and 13.8 billion years; two of five dark matter components (zino and photino) or half of dark matter (26%) or approximately 13%; and the graviton, gluon, and photon forces or 0%. The inner circular area clockwise from the top consists of: dark energy or the sum of eight Higgs forces associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino or (69%); and three of five components of dark matter or three permanent Higgsinos associated with the graviton, gluon, and photon or approximately 13%. The large inner circular area consists of Higgs particles (eight permanent Higgs forces and three permanent Higgsinos) and emphasizes Higgs particles' supremacy because they constitute approximately 82% of our universe's energy mass.

	Matter			Force
Quarks	u up	c charm	t top	γ photon
	d down	s strange	b bottom	Z Z particle
Leptons	ν_e electon-neutrino	ν_μ muon-neutrino	ν_τ tau-neutrino	W W particle
	e electron	μ muon	τ tau	g gluon
				H Higgs force

FIG. 6. SM matter and force particles.

The annular area represents 44 transient matter and force particles, all of which were eliminated by 100 s after the big bang via particle decay (nine transient matter particles/Higgs forces decayed to eight permanent matter particles/Higgs forces) or inflation (twelve superpartner forces and their 12 associated Higgsinos or X bosons). The outer portion of the annular area clockwise from the top consists of: nine transient matter particles (top, bottom, charm, strange, tau, muon, gravitino, gluino, and W/Z's) and twelve transient force particles (stop, sbottom, stau, scharm, sstrange, smuon, stau-sneutrino, sdown, sup, selectron, smuon-sneutrino, and selectron-sneutrino). The inner portion of the annular area clockwise from the top consists of: nine transient super supersymmetric Higgs forces associated with nine transient matter particles and twelve transient super supersymmetric Higgsinos associated with twelve transient force particles.

Table II Fundamental SM/supersymmetric/super supersymmetric matter and force particles energy/mass, spin, and charge is an extension of Fig. 7 because it identifies the energy/mass, spin, and charge for each of the 64 fundamental matter and force particles shown in the figure. The first column of Table II defines particle symbol, where p_{xx} identifies one of 32 particles and h_{xx} identifies one of 32 super supersymmetric Higgs particles (force or matter particles). The second column defines particle name. The third column defines whether the particle is a matter (M) or force (F) particle. The fourth column defines SM, SUSY, or SSUSY Higgs particles. The first 16 rows are SM, the next 16 rows are SUSY, and the last 32 rows are SSUSY. The fifth column defines energy/mass. Energy/masses are described for all 16 SM particles. The only other energy/mass defined is the Higgs force h_{15} (125 GeV) associated with W/Z's. The observation of a 125 GeV boson by the Atlas and CMS collaborations is consistent with a SM Higgs boson [16]. The sixth column defines particle spin, described for all 64 particles. The seventh column defines electric charge, described only for the 16 SM particles.

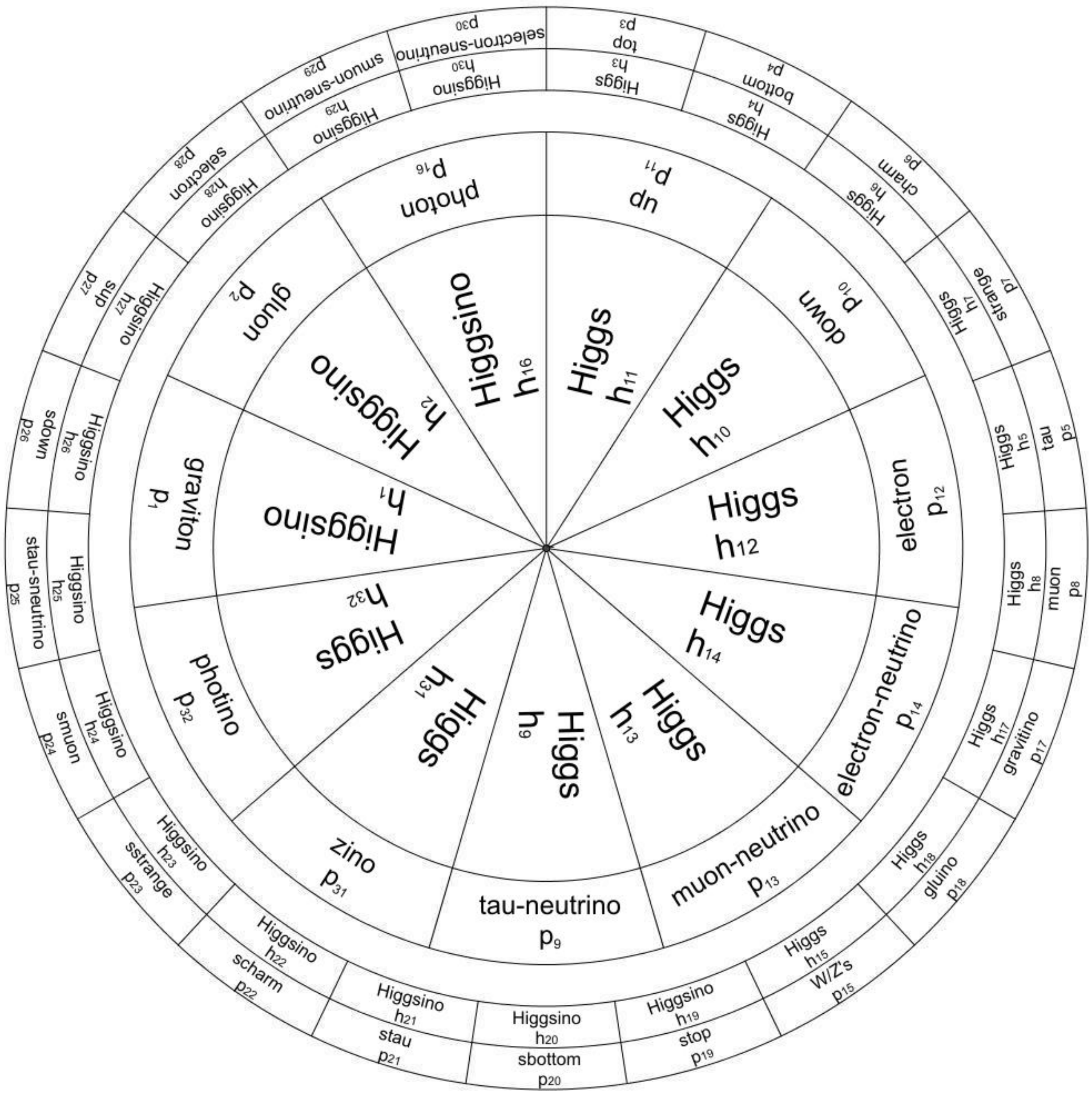

FIG. 7. Fundamental SM/supersymmetric/super supersymmetric matter and force particles.

TABLE II. Fundamental SM/supersymmetric/super supersymmetric matter and force particles energy/mass, spin, and charge.

Particle Symbol	Particle Name	Matter/ Force	SM/SUSY/ SSUSY	Energy/mass	Spin	Electric Charge
p_1	graviton	F	SM	0	2	0
p_2	gluon	F	SM	0	1	0
p_3	top quark	M	SM	172 GeV	1/2	+ 2/3
p_4	bottom quark	M	SM	4.2 GeV	1/2	-1/3
p_5	tau	M	SM	1.78 GeV	1/2	-1
p_6	charm quark	M	SM	1.29 GeV	1/2	+ 2/3
p_7	strange quark	M	SM	95 MeV	1/2	-1/3
p_8	muon	M	SM	105.7 MeV	1/2	-1
p_9	tau-neutrino	M	SM	Small, non-zero	1/2	0
p_{10}	down quark	M	SM	4.8 MeV	1/2	-1/3
p_{11}	up quark	M	SM	2.3 MeV	1/2	+ 2/3
p_{12}	electron	M	SM	.51 MeV	1/2	-1
p_{13}	muon-neutrino	M	SM	Small, non-zero	1/2	0
p_{14}	electron-neutrino	M	SM	Small, non-zero	1/2	0
p_{15}	W/Z's (hybrid)	M	SM	W 80, Z 91 GeV	1	W±1, Z 0
p_{16}	photon	F	SM	0	1	0
p_{17}	gravitino	M	SUSY		3/2	
p_{18}	gluino	M	SUSY		1/2	
p_{19}	stop squark	F	SUSY		0	
p_{20}	sbottom squark	F	SUSY		0	
p_{21}	stau	F	SUSY		0	
p_{22}	scharm squark	F	SUSY		0	
p_{23}	sstrange squark	F	SUSY		0	
p_{24}	smuon	F	SUSY		0	
p_{25}	stau-sneutrino	F	SUSY		0	
p_{26}	sdown squark	F	SUSY		0	
p_{27}	sup squark	F	SUSY		0	
p_{28}	selectron	F	SUSY		0	
p_{29}	smuon-sneutrino	F	SUSY		0	
p_{30}	selectron-sneutrino	F	SUSY		0	
p_{31}	wino/zinos	M	SUSY		1/2	
p_{32}	photino	M	SUSY		1/2	
h_1	Higgsino (graviton)	M	SSUSY		1/2	
h_2	Higgsino (gluon)	M	SSUSY		1/2	
h_3	Higgs force (top quark)	F	SSUSY		0	
h_4	Higgs force (bottom quark)	F	SSUSY		0	
h_5	Higgs force (tau)	F	SSUSY		0	
h_6	Higgs force (charm quark)	F	SSUSY		0	
h_7	Higgs force (strange quark)	F	SSUSY		0	
h_8	Higgs force (muon)	F	SSUSY		0	
h_9	Higgs force (tau-neutrino)	F	SSUSY		0	
h_{10}	Higgs force (down quark)	F	SSUSY		0	
h_{11}	Higgs force (up quark)	F	SSUSY		0	
h_{12}	Higgs force (electron)	F	SSUSY		0	
h_{13}	Higgs force (muon-neutrino)	F	SSUSY		0	
h_{14}	Higgs force (electron-neutrino)	F	SSUSY		0	
h_{15}	Higgs force (W/Z's) (hybrid)	F	SSUSY	125 GeV	0	
h_{16}	Higgsino (photon)	M	SSUSY		1/2	
h_{17}	Higgs force (gravitino)	F	SSUSY		0	

h_{18}	Higgs force (gluino)	F	SSUSY		0	
h_{19}	Higgsino (stop squark)	M	SSUSY		1/2	
h_{20}	Higgsino (sbottom squark)	M	SSUSY		1/2	
h_{21}	Higgsino (stau)	M	SSUSY		1/2	
h_{22}	Higgsino (scharm squark)	M	SSUSY		1/2	
h_{23}	Higgsino (sstrange squark)	M	SSUSY		1/2	
h_{24}	Higgsino (smuon)	M	SSUSY		1/2	
h_{25}	Higgsino (stau-sneutrino)	M	SSUSY		1/2	
h_{26}	Higgsino (sdown squark)	M	SSUSY		1/2	
h_{27}	Higgsino (sup squark)	M	SSUSY		1/2	
h_{28}	Higgsino (selectron)	M	SSUSY		1/2	
h_{29}	Higgsino (smuon-sneutrino)	M	SSUSY		1/2	
h_{30}	Higgsino (selectron-sneutrino)	M	SSUSY		1/2	
h_{31}	Higgs force (wino/zinos)	F	SSUSY		0	
h_{32}	Higgs force (photino)	F	SSUSY		0	

Table II information can be included into Fig. 7 if the latter is larger than the current page size. Each item in Fig. 7, for example the electron, could include its energy/mass, spin, and electric charge from Table II. The electron in Fig. 7 could appear as p_{12} electron followed by (.51 MeV, ½, -1).

Table III summarizes the number of SM, SUSY, and SSUSY particles in Table II. The SM consists of 13 matter and 3 force particles. The reason for the asymmetric numbers 13 and 3, is W/Z's are reclassified as hybrid matter/force particles because they are primarily transient matter particles associated with transient Higgs forces but have force particle spins of 1. SUSY consists of 4 matter and 12 force particles. SSUSY consists of 15 Higgsino matter and 17 force particles. SM/SUSY/SSUSY consists of 32 matter and 32 force particles for a total of 64 matter and force particles. Detection of a SM particle's (e.g. up quark) SSUSY particle [e.g. Higgs force (up quark)] is independent of detection of a SM particle's (e.g. up quark) SUSY particle (e.g. sup squark).

A. Fundamental SM/supersymmetric/super supersymmetric matter and force particles ramifications

There were four fundamental SM/supersymmetric/super supersymmetric matter and force particles ramifications: A BSM solution, Higgs particles as associate God particles, definition of a permanent black hole's constituents, and a proposed BSM mathematics solution.

First and foremost, Fig. 7 Fundamental SM/supersymmetric/super supersymmetric matter and force particles resolved all SM inadequacies and was a conceptual physics BSM solution.

Second, Higgs particles were associate God particles. Super force particles were God particles because they constituted 100% of our universe's total energy/mass between t = 0 s and the start of matter creation at t = 10^{-33} s. During matter creation from t = 10^{-33} to 100 s, super force particles condensed and decayed to 22 permanent fundamental matter and force particles. Higgs particles were associate God particles because they constituted approximately 82% of our universe's total energy/mass between the start of recombination at approximately 380,000 years and 13.8 billion years. The sum of eight Higgs force energies associated with eight permanent matter particles was dark energy and 69% of our universe's energy/mass. Dark matter consisted of zinos, photinos, and three permanent Higgsino types associated with the graviton, gluon, and photon. Assuming three permanent Higgsino types were half of dark matter's energy/mass (26%), they were 13% of our universe's energy/mass. Eight Higgs forces plus three permanent Higgsino types constituted approximately 69% + ½(26%) = 82% of our universe's energy/mass.

Third, a permanent black hole's constituents were defined. The 22 permanent fundamental matter and force particles in the Fig. 7 circular area were constituents of all objects in our universe including all: solar systems, galaxies, and permanent stellar black holes. All permanent stellar black holes consisted of 22 permanent fundamental matter and force particles, in sharp contrast to current astrophysics theory which states stellar black holes have unknown constituents. Specifically, the current astrophysics theory states nothing can be seen inside a black hole's event horizon. One type of permanent stellar black hole is a supermassive quark star (matter)

TABLE III. Number of SM, SUSY, and SSUSY particles.

	Matter (M)	Force (F)	Total
SM	13	3	16
SUSY	4	12	16
SSUSY	15	17	32
Total	32	32	64

which contains 10^6 to 10^{10} solar masses and consists of 22 permanent fundamental matter and force particles, each a closed string in a Planck cube. A supermassive quark star (matter) exists at the center of each of our universe's 100 billion galaxies. Population III stars containing hydrogen, helium, and lithium first formed approximately 200 million years after the start of our universe. These first generation stars contained up to 100 times more gas than the sun, had short lives, and created over 100 billion neutron stars or quark stars (matter) and their supernova or quark-nova remnants or protogalaxies. Over the next 13.6 billion years, by accretion of stars/matter and merger with other galaxies, approximately 100 billion supermassive quark stars (matter) and their 100 billion galaxies formed in our universe. That is, over the last 13.6 billion years, approximately 10^6 to 10^{10} solar masses were swallowed by these supermassive quark stars (matter) [1].

Fourth, a BSM mathematics solution is proposed. SM mathematics is a gauge group SU(3) x SU(2) x U(1), where the groups are associated with the strong, weak, and electromagnetic forces. The proposed BSM mathematical solution is an amplification of this existing SM mathematics as follows.

There are six time periods in our universe containing different fundamental matter and force particle types. These six time periods are prioritized and each separately mathematically analyzed. The first four periods are shown in Fig. 2. The six periods are: Start of our universe at t = 0 to the beginning of inflation or 5×10^{-36} s; the inflationary period between 5×10^{-36} and 10^{-33}; matter creation between 10^{-33} and 100 s; nucleosynthesis between 100 and 200s; the opaque era from 200 s to 380,000 years; and 380,000 years to 13.8 billion years. During the first period, our universe consisted of super force particles or their derivatives (e.g., gravitons and gluons) in a doughnut or spherical singularity. During the second inflationary period, our universe consisted of individual super force, gravitons, and gluon force particles each in their Planck cubes. During the third matter creation period, our universe consisted of super force condensations and decays, creating a time varying plasma of 129 fundamental matter and force particles each in their Planck cubes. Only 22 permanent fundamental matter and force particles remained by 100 s. SM mathematics must be amplified to include 22 permanent fundamental matter and force particles in the BSM mathematics solution. During the fourth nucleosynthesis period, neutrons converted into protons until the proton/neutron ratio was seven to one. During the fifth opaque period, our universe consisted of 22 permanent fundamental matter and force particles and radiation energy (photons). During the sixth period, our universe consisted of 22 permanent fundamental matter and force particles.

Following is the BSM mathematics solution plan. The first, second, and fourth periods contain the least important particle types, are relatively simple to analyze in comparison to the three other periods, and are temporarily ignored. Of the remaining three periods, the sixth is the most comprehensive but simplest to analyze and is selected to be analyzed first.

The sixth period has 22 permanent fundamental matter and force particles which include SM, SUSY, and SSUSY particles. That is, between 380,000 years and our universe's current age of 13.8 billion years or approximately 99.99% of our universe's lifetime, 22 permanent fundamental matter and force particles existed to define our universe's evolution. The SM consists of 16 matter and force particles or: six permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino); six transient matter particles (charm quark, strange quark, top quark, bottom quark, muon, and tau); two permanent force particle (photon and gluon); and two transient force particles (W/Z's and Higgs). The BSM solution consists 22 permanent matter and force particles or: 11 permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, photino, and three permanent Higgsinos); and 11 permanent force particles (eight permanent Higgs forces associated with eight permanent matter particles and the graviton, gluon, photon associated with three permanent Higgsinos). SM mathematics or gauge group SU(3) x SU(2) x U(1) must be amplified to include 22 permanent fundamental matter and force particles. There are difference in the BSM mathematics solution for the third and sixth periods. In the third period, transient particles (e.g., top quark/Higgs force decay to lower energy/mass quarks/Higgs forces) were a significant portion of the third period's total energy/mass. In the sixth period, transient particles (e.g., W^- from radioactive decay and muons produced by cosmic rays) were an insignificant portion of the sixth period's total energy/mass (10^{54} kg distributed as atomic/subatomic 5%, dark matter 26%, and dark energy 69%). Thus, the incomplete conceptual physics SM must first be amplified by defining for example, a viable replacement for the existing ambiguous spontaneous symmetry breaking function and how a transient Higgs force gives mass to permanent matter particles. Answers to both examples were described in this article. Second, SM mathematics must be amplified to include the proposed BSM mathematics solution.

The fifth period is analyzed next because it consists of the sixth period's 22 permanent fundamental matter and force particle types, and radiation energy (photons). The third period is analyzed last because it consists of a complex time varying plasma of 129 matter and force particles.

IX. VALIDATION OF A BSM SOLUTION USING A TWO-STEP INTEGRATED PHYSICS/MATHEMATICS METHODOLOGY

There were four existing and two proposed validations. The four existing independent validations agreed with this article's conclusions as follows. Leahy and Ouyed measured a quark nova or an explosive transition from a neutron star to a quark star in their article "Supernova SN2006gy as a first ever Quark Nova?" [17]. The origin of the doughnut physical singularity at a Planck cube center at t = 0 was described in section III An amplified particle creation. The singularity occurred when a maximum entropy super supermassive quark star (matter) instantaneously evaporated, deflated, and gravitationally collapsed to its associated minimum entropy super supermassive black hole's (energy) doughnut physical singularity which created our universe. The singularity's creation was described in section 18 Arrow of time in a Two-Step Integrated Theory of Everything" [1]. Morandi and Sun in their article "Probing dark energy via galaxy cluster outskirts" [18] concluded there was no quintessence or dynamic dark energy in our universe as described in section VII Conservation of energy/mass accountability. Edmonds et. al. in their article "Testing Modified Dark Matter with Galaxy Clusters" concluded a relationship existed between the cosmological constant and dark matter [19]. Dark energy was defined in section V An amplified Higgs forces (bosons). The cosmological constant lambda (Λ) was proportional to the vacuum or dark energy density (ρ_Λ), or $\Lambda = 8\pi G\rho_\Lambda$, where G is the gravitational constant. Since dark energy was a constant, dark energy density and the proportional cosmological constant decreased in time as our universe expanded. That is, the cosmological constant was not a constant, in contrast to current astrophysics theory. Since the zino and photino dark matter particles had associated Higgs forces or dark energy components, there was a relationship between the cosmological constant and dark matter. This was described in section 11 Dark energy of a Two-Step Integrated Theory of Everything" [1]. Finally, Longo stated our universe was born spinning in his article "Detection of a Dipole in the Handedness of Spiral Galaxies with Redshifts z ~ 0.04" [20]. The doughnut physical singularity at a Planck cube center at t = 0 was defined in section III An amplified particle creation. This singularity and its relationship via conservation laws of energy/mass, charge, and angular momentum with the atoms, stars, and galaxies in our universe were described in section 22.2 Quantum gravity clarification of a Two-Step Integrated Theory of Everything" [1]. The above four existing independent validations provided a 10% estimated validation to this article and gave it credibility.

The first proposed validation used "A Two-Step Integrated Theory of Everything – Revision B" [1] as a benchmark. The latter defined the TOE as 20 interrelated amplified theories and their intimate physical relationships with each other. The 20 included the 4 theories of this article (superstring, particle creation, Higgs forces or bosons, and spontaneous symmetry breaking). The 20 TOE theories were; superstring, particle creation, inflation, Higgs forces, spontaneous symmetry breaking, superpartner and SM decays, neutrino oscillations, dark matter, universe expansions, dark energy, messenger particles, relative strengths of forces/Hierarchy problem, Super Universe (multiverse), stellar black holes (stars and galaxies), black hole entropy, arrow of time, cosmological constant problem, black hole information paradox, baryogenesis, and quantum gravity. All key outstanding TOE conceptual physics questions were answered including what are: Higgs forces, the fundamental matter and force particles equivalent of Mendeleev's Periodic Table of elements, stellar black holes, spontaneous symmetry breaking and inflation functions, quantum fluctuations of fundamental particles, physical and mathematical singularities, the seven extra dimensions, etc.; What is: dark energy, dark matter, SSUSY of Higgs particles, the boundary between quantum gravity and classical physics or Schrodinger wave function applicability, the boundary between general relativity and quantum gravity, our universe's implementation of the It from Qubit (IfQ) concept, particle entanglement, etc.; and what caused: the start of our universe, hierarchy problem, black hole information paradox, baryogenesis, cosmological constant problem, etc.? If a critical peer review agrees with these answers, both "A Two-Step Integrated TOE" and this article are validated. This critical peer review requires an estimated several weeks if the two-step integrated theories are proven incorrect. Several months are required for the critical peer review to prove the two-step integrated theories are correct. If the two-step integrated theories are peer reviewed to be correct, this provides an estimated 80 to 90% validation.

The second proposed validation requires an updated Snowmass estimate [21]. The first Snowmass estimated supersymmetric particles' energy/masses between 100 and 1,500 GeV. Since no supersymmetric particles were detected at the Large Hadron Collider (LHC), an updated Snowmass estimate is required. Dependent on the updated supersymmetric particles energy/mass estimates, either the LHC or an advanced collider detector should detect the 16 supersymmetric particles. The additional 32 super supersymmetric Higgs particles proposed in this article may be detected with equipment simpler than a LHC. This is because detection of a SM particle's (e.g. up quark) SSUSY particle [e.g. Higgs force (up quark)] is independent of detection of a SM particle's (e.g. up quark) SUSY particle (e.g. sup squark). Emphasis should be detection of permanent Higgs forces, not just the 125 GeV transient Higgs force. The second proposed validation is formidable, requiring an estimated 5 to 50 years dependent on whether the LHC is powerful enough to detect supersymmetric particles or a new accelerator is required. This second proposed validation provides 100% validation.

X. CONCLUSIONS

The two-step integrated physics/mathematics methodology was justified because it provided solutions for integrated theories such as a TOE and a BSM. In contrast, the prevailing single primarily mathematics step methodology provided near zero results for those two integrated theories after a century and half century, respectively. However, the prevailing single step methodology was applicable to single independent theories and provided most if not all of the spectacularly successful astrophysics achievements over the last century. Both the prevailing single primarily mathematics step and the two-step integrated physics/mathematics methodologies were complementary and essential for future astrophysics achievements. The single step defined the leaves, trunk, branches, bark, and roots of a specific tree whereas the equally important two-step defined the forest.

Four theories (superstring, particle creation, Higgs forces or bosons, and spontaneous symmetry breaking) were initially independent of each other. Each of those four theories' requirements were selectively amplified to integrate them with the other three without sacrificing the independent theories' integrities. The results of the four independent theory amplifications were four snuggly fitting interrelated amplified theories.

Figure 7 Fundamental SM/supersymmetric/super supersymmetric matter and force particles resolved all SM inadequacies and was a conceptual physics BSM solution. Figure 7 was also the fundamental matter particle counterpart of Mendeleev's Periodic Table of elements. The circular area of Fig. 7 described a TOE solution as the intimate relationship between atomic/subatomic matter, dark matter, and dark energy as defined by their constituent 22 permanent fundamental matter and force particles. Between t = 380,000 years and 13.8 billion years, atomic/subatomic matter consisted of the: up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino or 5% of our universe's energy/mass. Dark matter consisted of the: zino, photino, and three permanent Higgsinos associated with the graviton, gluon, and photon or approximately 26%. Dark energy consisted of the sum of eight permanent Higgs forces associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) or 69%.

Super force particles were God particles because they constituted 100% of our universe's total energy/mass between the start of our universe and the start of matter creation. Higgs particles were associate God particles because they constituted approximately 82% of our universe's total energy/mass between the start of recombination at approximately 380,000 years and 13.8 billion years. Dark energy or eight permanent Higgs forces plus ½ of dark matter or three permanent Higgsino types constituted approximately 69% + ½(26%) = 82% of our universe's energy/mass.

The 22 permanent fundamental matter and force particles were constituents of all objects in our universe including all: solar systems, galaxies, and permanent stellar black holes. All permanent stellar black holes consisted of these 22 permanent fundamental matter and force particles, in sharp contrast to current astrophysics theory which states stellar black holes have unknown constituents. Specifically, nothing can be seen inside a black hole's event horizon.

The proposed BSM mathematics solution was an amplification of the existing SM mathematics. There were six time periods in our universe containing different fundamental matter and force particle types. The sixth period where our universe consisted of 22 permanent fundamental matter and force particles, was selected to be analyzed first. SM mathematics or gauge group SU(3) x SU(2) x U(1) must be amplified to include the proposed BSM mathematics solution consisting of 22 permanent fundamental matter and force particles.

There were four existing and two proposed validations for this article. Four existing independent validations agreed with this article's conclusions and gave this article credibility. The first proposed validation used "A Two-Step Integrated Theory of Everything – Revision B" as a benchmark. The latter defined the TOE as 20 interrelated amplified theories which answered key outstanding TOE conceptual physics questions. If a critical peer review of "A Two-Step Integrated Theory of Everything – Revision B" agreed with those answers, both that article and this article were validated.

The second proposed validation required an updated Snowmass estimate of supersymmetric particles' energy/masses (100 – 1500 GeV). Dependent on the updated estimates, either the Large Hadron Collider or an advanced collider detector was required to detect the 16 supersymmetric particles. The additional 32 super supersymmetric Higgs particles proposed in this article may be detected with equipment simpler than a LHC. The second validation is formidable even if the Large Hadron Collider is powerful enough to detect the 16 supersymmetric particles and significantly more formidable in time and money, if a new accelerator is required.

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