New Physics Definition

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Abstract

"New Physics" is defined as physics requirements or specifications or descriptions which never previously existed. An example of "New Physics" approximately 60 years ago, was the Higgs/Englert requirement of the Higgs force (boson) giving mass to fundamental matter particles. Two "New Physics" definition concepts are the current astrophysics community's detection of "New Physics" in laboratories prior to analyses and my analyses of "New Physics" prior to detection in laboratories. The latter concept is the basis for a two-step Theory of Everything (TOE) physics solution, which defined 689 or 61% of all 1,134 TOE requirements as "New Physics" requirements. In contrast, the current astrophysics community has not defined a single "New Physics" requirement. Thus, this article describes "New Physics" definition and summarizes a two-step TOE physics solution.

Key words: New Physics, Higgs forces, Theory of Everything (TOE), stellar black holes

I. INTRODUCTION

The TOE is the most complex physics theory and my unique Systems Engineering background enabled the first and only TOE physics solution. A TOE unifies all known physics from the near infinitely small Planck cube scale (quantum gravity) to the near infinitely large stellar black hole scale (Einstein's General Relativity). The current astrophysics community's TOE does not exist with no hint of a solution after a century of attempts. In contrast, a two-step TOE physics solution is described by "A Theory of Everything Physics Solution using a Two-Step Integrated Physics/Mathematics Methodology – Version 2" [1].

Two astrophysics issue resolution methodologies are: the current astrophysics community's single-step mathematics and a new two-step consisting of a conceptual physics step and a second mathematics step. The single-step methodology provided spectacularly successful astrophysics achievements over the last century for single constituent theories such as Higgs forces and stellar black holes. Specifically for the latter, gravitational waves measured stellar black hole mergers. However, the single-step methodology is not applicable for multiple constituent theories such as a TOE, in contrast to the second methodology. Both methodologies are complementary and essential.

The conceptual physics step of a two-step TOE physics solution had three goals: define "Everything", answer all key outstanding TOE physics questions, and provide correct inputs to the second mathematics step. First, "Everything" was defined by the following 20 amplified and integrated "New Physics" constituent theories; superstring, particle creation, inflation, Higgs forces, spontaneous symmetry breaking, superpartner and Standard Model (SM) decays, neutrino oscillations, dark matter, universe expansions, dark energy, messenger particles, relative strengths of forces/Hierarchy problem, Super Universe (multiverse or parallel universes), stellar black holes (stars and galaxies), black hole entropy, arrow of time, cosmological constant problem, black hole information paradox, baryogenesis, and quantum gravity (mechanics). Second and most importantly, all 19 key outstanding TOE physics questions were explicitly defined and answered including what are: Higgs forces, the fundamental matter and force particles equivalent of Mendeleev's Periodic Table of elements, stellar black holes, inflation and spontaneous symmetry breaking potential field functions, quantum fluctuations of fundamental particles, physical and mathematical singularities, and the seven extra dimensions; what is: dark energy, dark matter, super supersymmetry (SSUSY) of Higgs particles, the border between quantum gravity and classical physics or Schrodinger wave function applicability, the boundary between quantum gravity and general relativity, our universe's implementation of the It from Qubit (IfQ) concept, and particle entanglement; and what caused: the start of our universe, hierarchy problem, black hole information paradox, baryogenesis, and the cosmological constant problem? Third, correct inputs were provided for the two-part second mathematics step which followed, an amplification of the existing SM mathematics or Beyond the Standard Model (BSM) solution for particles and an N-body galaxy simulation for cosmology.

A two-step TOE physics solution's conceptual physics step evolved as follows. Initially, the TOE was defined by a single superstring constituent theory as proposed by prominent astrophysicists. Superstring defined our universe's basic building blocks: fundamental matter particles (e.g., an electron) and force/energy particles (e.g., Higgs force). A superstring was visualized as a thin rubber band wrapped around a Planck-cube-sized beach ball. Each matter/force particle had a unique amplitude and frequency modulation to a perfectly circular superstring. Each universe object (e.g., a person) was uniquely defined by the object's volume of contiguous Planck cubes, each containing its constituent matter/force particle superstring. A visual model is a person composed of Lego blocks where the blocks are replaced by near infinitely small Planck cubes. However, superstring theory did not accommodate Higgs forces and dark energy theories, so the TOE was amplified to five constituent theories: Higgs forces, superstring, particle creation, inflation, and dark energy as shown in Fig. 1. A two-step TOE physics solution jigsaw puzzle. The center and key constituent theory was Higgs forces. The five theories were independent of each other and shown as five independent jigsaw puzzle pieces. Since these five were insufficient to answer all 19 key outstanding TOE questions (e.g., what is a stellar black hole?), the five were subsequently amplified to 20. The last two-step TOE physics solution's draft iteration stabilized the number of TOE constituent theories at 20, integrated all 20 constituent theories with each other, and answered all 19 key outstanding TOE physics questions.

My unique 42 years of Aerospace Systems Engineering background was in the design, integration, and test of ten, new, complex, electronic systems which never previously existed [e.g., Anti-Ballistic Missile System phased array radars, Manned Orbiting Laboratory, Global Positioning System (GPS), Federal Bureau of Investigation (FBI) Integrated Automated Fingerprint Identification System, etc.]. These systems were comparable in complexity to the Large Hadron Collider (LHC). New systems were designed and documented primarily via "A-level specifications" consisting of approximately 50% existing requirements (e.g., a radar transmitted an energy pulse and received the target's reflected signal) and 50% new requirements which never previously existed (e.g., a phased array antenna electronically formed and steered the beam rather than using a rotating mechanical antenna's beam). Since system components (e.g., transmitter, receiver, phased array antenna) were designed in parallel, their new requirements were not always compatible. An elaborate iterative documentation change control process enabled "A-level specification" compatibility via requirement modifications and integration. Similarly, astrophysics has existing requirements (e.g., conservation of energy/mass) and "New Physics" requirements which never previously existed. An example of "New Physics" approximately 60 years ago, was the Higgs/Englert requirement of the Higgs force (boson) giving mass to fundamental matter particles. Fifty years of search were still required to detect the elusive Higgs force. This attests to the complexities of both Higgs forces theory and the LHC. This is the primary justification for "New Physics" definition via analyses prior to their detection in laboratories like the LHC.

Hundreds of "New Physics" requirements are defined in a two-step TOE physics solution including; A permanent electron has an associated Higgs force which gives it mass, 17 matter particles (8 permanent and 9 transient) have 17 associated Higgs forces, and the sum of eight permanent Higgs force energies associated with eight permanent matter particles is dark energy. From Table I, 689 or 61% of the total 1,134 TOE requirements are "New Physics" requirements. These unfamiliar "New Physics" requirements shock astrophysicists, but are essential integrating requirements for a viable TOE. Compatibility of "New Physics" requirements was achieved over 16 years, by approximately 250 two-step TOE physics solution draft (i.e. A-level specification) iterations which modified and integrated the 20 TOE constituent theory requirements and answered all 19 key TOE questions.

The current astrophysics community's single-step TOE methodology was unsuccessful because TOE constituent theories were; never defined, not amplified by "New Physics" requirements, and not integrated with each other. Furthermore, all 19 key TOE physics questions were never systematically defined or answered. The conceptual physics step resolved these deficiencies as described by the three following examples, where "New Physics" requirements are identified by quotation marks. In the first single-step methodology deficiency, only one Higgs force existed. In contrast, the conceptual physics step defined "32 Higgs particles or 17 Higgs forces and 15 Higgsinos or Higgs matter particles." In the second example, stellar black hole constituents were never defined. In contrast, the conceptual physics step defined "as many as 22 fundamental permanent matter/force particles as constituents of any permanent universe object, including stellar black holes." Furthermore, "our universe started as a stellar black hole's doughnut physical singularity." In the third example, the SM or gold standard of particle physics, defined 16 matter/force particles. However, the SM included only a single Higgs force and excluded dark energy and dark matter. In contrast, the conceptual physics step defined "a BSM physics solution of 64 matter/force

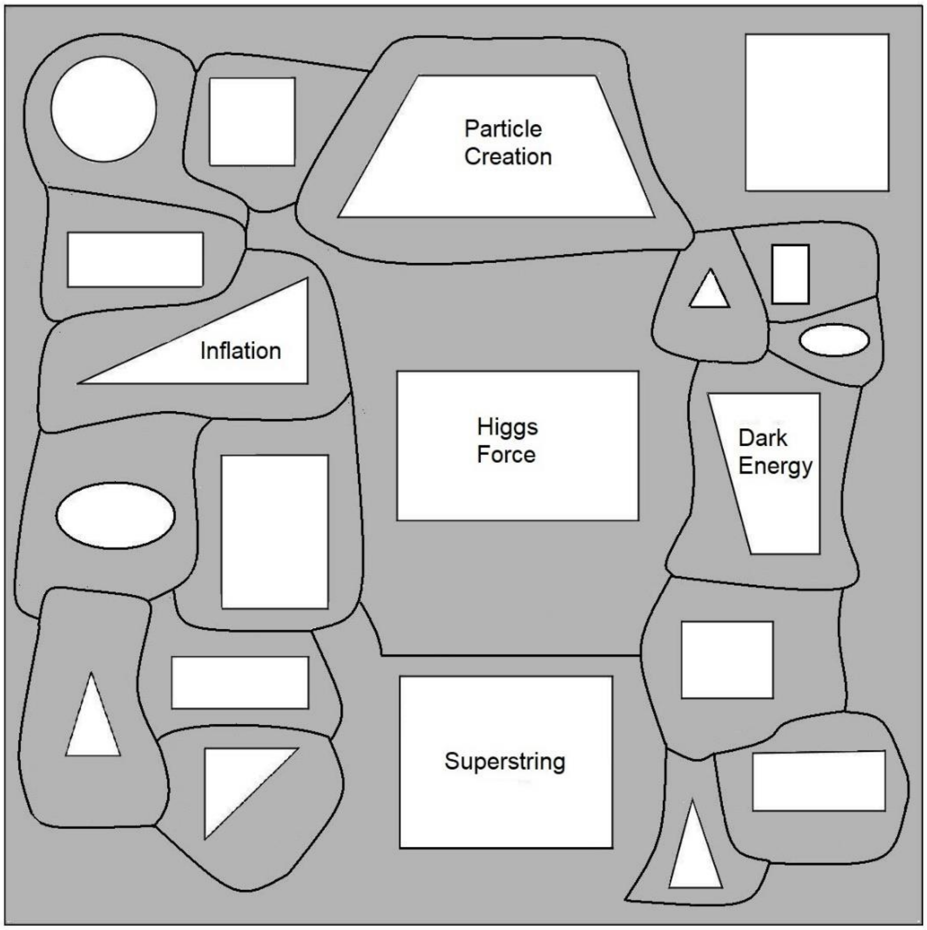

FIG. 1. A two-step TOE physics solution jigsaw puzzle.

particles. Dark energy was the sum of eight permanent Higgs force energies and dark matter was five permanent matter particles including three Higgsinos."

The 20 interrelated amplified constituent theories of a two-step TOE physics solution were modeled as 20 jigsaw puzzle pieces. Five independent theories (Higgs forces, superstring, particle creation, inflation, and dark energy) were modeled by five independent jigsaw puzzle pieces as shown in Fig. 1. The five theories were independent because physicists in each theory worked independently of each other. During the 250 two-step TOE physics solution iterations and 16 years, the number of independent existing jigsaw puzzle pieces stabilized at 20. A two-step TOE physics solution's basic premise was the 20 constituent theories were physically interrelated to each other and their relationships were defined by additional interrelated amplified requirements or "New Physics." In Fig. 1, the shaded areas surrounding the 20 unshaded jigsaw puzzle pieces represented "New Physics" requirements. For example, the unshaded area of the key Higgs forces jigsaw puzzle piece was amplified by its shaded area or "New Physics" requirements. Each of the 20 theories or equivalently each of 20 jigsaw puzzle pieces was selectively amplified without sacrificing the theory's integrity to provide 20 snuggly fitting interrelated amplified constituent theories of Fig. 1 and Table I "New Physics" and old physics requirements for 20 constituent theories.

The following section II. An amplified Higgs forces (bosons) and section III. An amplified stellar black holes (stars and galaxies) were extracted from reference 1. Higgs forces is the most important of the 20 TOE constituent theories and stellar black holes is an important TOE constituent theory. In this article, an example of reference 1's internal references is shown in section II, first paragraph, second sentence (see reference 1, Section XVI.A Einstein's General Relativity). Each requirement in the two sections was categorized as "New Physics" (NP), Old Physics/New Physics (OP/NP), Old Physics (OP), Duplicate (D) or Explanatory (E). Duplicate signifies repeated

TABLE I. "New Physics" and old physics requirements for 20 constituent theories.

TOE Constituent Theory	Number of New Physics (NP) Req'ts	Number of Old Physics/New Physics (OP/NP) Req'ts	Number of Old Physics (OP) Req'ts	Total Number of Req'ts (NP, OP/NP, OP)
Superstring	18	29	15	62
A. Universal rectangular coordinate system	26	10	0	36
B. Proposed SM/SUSY/SSUSY m/f particles	16	18	0	34
Particle creation	11	25	4	40
Inflation	9	16	2	27
A. Spontaneous symmetry breaking/inflation	3	16	0	19
Higgs forces	48	16	10	74
Spontaneous symmetry breaking	32	31	1	64
A. Comparison between……..description	3	19	5	27
B. Fundamental SM/SUSY/SSUSY…particles	16	21	9	46
Superpartner and Standard Model (SM) decays	2	13	1	16
Neutrino oscillations	1	4	2	7
Dark matter	1	1	6	8
Universe expansions	4	11	5	20
A. Superstring theory's 7th extra dimension	5	2	1	8
Dark energy	7	8	6	21
Messenger particles	23	11	10	44
Relative strengths of forces/Hierarchy problem	8	8	6	22
Conservation of energy/mass accountability	0	9	0	9
Super Universe (multiverse)	7	3	0	10
Stellar black holes	16	14	12	42
A. Einstein's General Relativity	19	22	16	57
B. Star factor products	0	4	0	4
Black hole entropy	5	3	2	10
Arrow of time	62	20	7	89
A. A new cosmology theory justification	5	4	3	12
Cosmological constant problem	58	34	10	102
A. Proof of parallel universes	5	9	2	16
B. Comparison of three multiverse theories	0	9	16	25
Black hole information paradox	5	20	12	37
Baryogenesis	2	14	9	25
Quantum gravity	3	4	0	7
A. Singularity characteristics	10	24	5	39
B. Quantum gravity interpretations	7	51	17	75
Total TOE requirements	437	503	194	1,134
Total TOE (NP and OP) requirements	689		445	1,134
Percent TOE requirements	61%	-	39%	100%

requirements and explanatory have no requirements. Duplicate and explanatory were ignored and the NP, OP/NP, and OP requirements summarized in Table I. Note that identical tables in this article and reference 1 have different numbers, Table I is Table VIII, Table II is Table V, and Table III is Table VII, respectively.

II. AN AMPLIFIED HIGGS FORCES (BOSONS)

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 (NP). 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 (see reference 1, Section XVI.A Einstein's General Relativity) (NP). The sum of eight Higgs force energies associated with eight permanent matter particles was dark energy and 69% of our universe's energy/mass (NP). Dark matter consisted of zinos, photinos, and three permanent Higgsino types (see reference 1, Section IX. An amplified dark matter) (OP/NP). Assuming three permanent Higgsino types were half of dark matter's energy/mass (26%), they were 13% of our universe's energy/mass (OP/NP). Eight Higgs force energies plus three permanent Higgsino types constituted approximately 69% + 13% = 82% of our universe's energy/mass (NP).

Amplifications to Higgs force theory ("New Physics") were key to a two-step TOE physics solution and are described as follows (NP). First, amplifications included 32 associated super supersymmetric Higgs particles, one for each of 32 SM and supersymmetric matter and force particle types (NP). These 32 Higgs particles defined a "Super supersymmetry (SSUSY)" (NP). If a SM/supersymmetric particle was a matter particle (e.g., up quark, gravitino), its associated Higgs particle was a Higgs force (NP). If a SM/supersymmetric particle was a force particle (e.g., graviton, sup squark), its associated Higgs particle was a Higgsino (NP). As described in reference 1, Section VI. An amplified spontaneous symmetry breaking, the super force condensed into eight permanent matter particles/Higgs forces (NP). During baryogenesis, the super force condensed into three permanent Higgsinos/associated forces (graviton, gluon, and photon) (NP).

In reference to quantum fluctuations and according to Carroll [2], 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 (OP). In the Minimal Supersymmetric Standard Model according to Randall [3], 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 (OP). Similarly, perhaps contributions of a SM or supersymmetric matter particle (e.g. up quark, gravitino) were exactly cancelled by equal and opposite contributions from their super supersymmetric Higgs force particles (e.g., Higgs force associated with up quark and Higgs force associated with the gravitino) before super supersymmetry was broken (NP). Under that assumption, the strength of four forces (strong, weak, electromagnetic, and gravitational) may have precisely met at the Planck time t = 5.4 x 10^{-44} s or 10^{19} GeV (OP/NP).

Matter creation included a super force particle's condensation to a matter particle/Higgs force (NP). Just as a permanent electron or up quark have permanent electric fields because of their electric charges, an electron or up quark also have permanent Higgs force fields because of their masses (NP). Reference 1, Fig. 13 shows an up quark with quantized Higgs force particles (NP). The 17 matter particles/Higgs forces (eight permanent and nine transient) were one and inseparable and created simultaneously (NP). They were modeled as an undersized porcupine (e.g., up quark Planck cube closed superstring or p_{11}) with overgrown spines (e.g., a three dimensional radial Higgs force field quantized into Higgs force Planck cube closed superstrings or h_{11}) (NP). The Higgs force was a residual super force which contained the mass, charges, and spin of its associated matter particle (NP). When a matter particle (e.g., up quark) condensed from the super force, the residual super force was the Higgs force associated with the matter particle (NP).

Extremely high temperatures between 10^{25} and 10^{10} K in our early universe caused matter creation via spontaneous symmetry breaking and baryogenesis (OP/NP). The Higgs force was a product not the cause of spontaneous symmetry breaking (NP). The super force condensed into 17 matter particles/Higgs forces at 17 different temperatures (NP). 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) (OP/NP). The zino and photino were dark matter particles (OP/NP). Spontaneous symmetry breaking was similar to the three condensation phases of H_2O from steam, to water, to ice as temperature decreased from 212º to 32º F (OP/NP). 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 (NP). There was an intimate relationship between matter creation time and the matter particle's energy/mass or temperature (NP). 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) (NP). The earlier the matter creation time, the greater was the matter particle's temperature or energy/mass (NP).

Ice also evaporated or melted to water which then evaporated to steam as temperature increased from 32^o to 212^o F (OP). Similarly, particle creation and spontaneous symmetry breaking were bidirectional (NP). For example, as temperature increased, the down quark/Higgs force evaporated back to the super force (see stellar black hole evaporation in reference 1, Section XVIII. An amplified arrow of time) (NP).

Therefore, the super force condensed into a matter particle/Higgs force or a matter particle/Higgs force evaporated to the super force (NP). In Beta minus decay, the down quark decayed to an up quark and a W^- (OP). The W^- then decayed to an electron and an anti-electron-neutrino (OP). 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 (OP/NP).

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 (NP). In the Beta minus decay with Higgs force amplification or "New Physics," the down quark/Higgs force evaporated to a super force particle (NP). 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 (NP). 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 (OP/NP). The super force then condensed into an electron/Higgs force and an anti-electron-neutrino/Higgs force (NP). Since the W/Z's were reclassified as transient (hybrid) matter particles, this produced the asymmetrical number 17 instead of 16 matter particles, that is, 9 transient and 8 permanent matter particles (NP). 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 (OP/NP). The latter included the: up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, photino and their eight Higgs force energies or dark energy (NP).

Mass was given to a matter particle by its Higgs force and gravitons or gravitational force messenger particles (see reference 1, section XII.A Gravitational/electromagnetic) (OP/NP). Graviton requirements were amplified to include embedded clocks/computers (NP). 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 (NP). Permanent Higgs forces give mass to their permanent associated matter particles (NP). Transient Higgs forces (e.g., the 125 GeV Higgs associated with W^-) cannot give mass to permanent matter particles (e.g. up quark) because the former exist for only 10^{-25} s (NP).

By the end of matter creation or t = 100 s, only 22 permanent fundamental matter and force particle types remained of the total 129 (NP). Atomic/subatomic matter or six permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino) constituted 5% of our universe's energy/mass (OP/NP). Dark matter consisted of the zino and photino (13%) each associated with a Higgs force and three permanent Higgsinos (13%) (NP). Dark energy or eight permanent Higgs force energies associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) constituted 69% (D). Three SM force particles (graviton, gluon, and photon) accounted for 0% (OP/NP).

The following is according to Kane [4] (OP). Masses of SM matter particles: six quarks, six leptons, and W/Z's are provided by Higgs forces (OP). The number of Higgs forces is unknown (OP). Particle masses that interact with Higgs forces are proportional to their Higgs forces (OP). Kane's 13 SM matter particles consisted of six permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, and tau-neutrino) and seven transient matter particles (top quark, bottom quark, strange quark, charm quark, muon, tau, and W/Z's) (OP).

The relationship of a permanent matter particle's (e.g., up quark p_{11}) energy/mass to its associated permanent Higgs force (h_{11}) energy was $p_{11} = (c)(h_{11})$ (NP). This fundamental particle relationship was the counterpart of atomic/subatomic matter energy/mass plus dark matter energy/mass associated with Higgs forces divided by dark energy in any large scale 490 million light year cube in our universe, or $c = (5 + 13)/69 = 0.26$ (NP). Thus, a permanent up quark's energy/mass of 2.2 MeV was approximately 0.26 of its associated permanent Higgs force energy or 8.5 MeV (NP). The permanent Higgs force energy (18.1 MeV) associated with the permanent down quark, permanent Higgs force energy (8.5 MeV) associated with the permanent up quark, and permanent Higgs force energy (2.0 MeV) associated with the permanent electron were added to reference 1, Table II [5] (NP). Permanent Higgs force energies associated with the permanent electron-neutrino, muon-neutrino, and tau-neutrino were left blank in reference 1, Table II because the energy/masses of three permanent neutrinos were small, non-zero, and unknown (OP/NP). Permanent Higgs force energies associated with the permanent zino and photino were left blank in reference 1, Table II because the energy/masses of those two permanent particles were unknown (OP/NP).

Eight permanent Higgs force fields associated with eight permanent matter particles, multiplied by the number of each particle type (e.g., approximately10^{80} electrons) in our universe, produced the permanent Higgs force field or the vacuum (dark energy) density of space between galaxies, stars, and filament matter particles (NP). A single transient Higgs force of 125 GeV or 10^{11} eV cannot produce permanent dark energy of .69 x 10^{90} eV (OP/NP). Furthermore, the Higgs field vacuum expectation value (VEV) or $2M_w/g$ ~ 246 GeV is invalid for the permanent vacuum in space because the W boson mass (M_w) and its associated Higgs force are transient (10^{-25} s) (NP). In contrast, eight permanent Higgs force energies associated with eight permanent matter particles produced permanent dark energy and the permanent vacuum or dark energy density of space (NP).

In summary, there were six Higgs force theory amplifications or "New Physics" requirements (D). First, Higgs particles were associate God particles because they constituted approximately 82% of our universe's total energy/mass (D). The sum of eight permanent Higgs force energies associated with eight permanent matter particles (up quark, down quark, electron, electron-neutrino, muon-neutrino, tau-neutrino, zino, and photino) was dark energy (D). Dark matter consisted of zinos, photinos, and three permanent Higgsinos associated with the graviton, gluon, and photon (D). Second, matter creation via spontaneous symmetry breaking and baryogenesis created: eight permanent matter particles and their eight associated permanent Higgs forces; and three permanent Higgsinos and their three permanent associated forces (D). Third, perhaps unification of four forces (strong, weak, electromagnetic, and gravitational) required quantum fluctuation contributions of 32 SM/supersymmetric matter/force particles to be exactly cancelled by equal and opposite contributions from their 32 super supersymmetric Higgs particles (D). The latter consisted of 17 Higgs forces (eight permanent and nine transient) and 15 Higgsinos (three permanent and twelve transient) (D). Fourth, each of eight permanent matter particles and their eight permanent associated Higgs forces were one and inseparable (D). For example, the permanent electron had three permanent fields: a gravitational field; an electric field; and a Higgs force field (D). Fifth, mass was given to each of eight permanent matter particles by their eight permanent associated Higgs forces (D). Transient Higgs forces (e.g., the 125 GeV Higgs associated with W^-) could not give mass to permanent matter particles (e.g. electron) because the former existed for only 10^{-25} s (D). Sixth, eight permanent Higgs force fields associated with eight permanent matter particles produced the permanent Higgs force field or the vacuum (dark energy) density of space (D). A single transient Higgs force of 125 GeV or 10^{11} eV cannot produce permanent dark energy of .69 x 10^{90} eV (D). In contrast, eight permanent Higgs force fields associated with eight permanent matter particles multiplied by the number of each particle type (e.g., approximately10^{80} electrons) in our universe, produced the vacuum (dark energy) density of space (D).

Higgs forces contained 48 NP, 16 OP/NP, and 10 OP requirements as shown in Table I (E).

This integrated Higgs forces with superstring, particle creation, spontaneous symmetry breaking, superpartner and SM decays, neutrino oscillations, dark matter, universe expansions, dark energy, messenger particles, arrow of time, baryogenesis, and quantum gravity theories (see Table III) (NP).

III. AN AMPLIFIED STELLAR BLACK HOLES (STARS AND GALAXIES)

Stellar black hole theory was amplified to include quark stars (matter) and black holes (energy) (E).

Currently a stellar black hole is defined as a spacetime region where gravity is so strong not even light can escape and having no support level below neutron degeneracy pressure (OP). The black hole spacetime region is a three dimensional sphere which appears as a two dimensional hole just as our three dimensional sun appears as a two dimensional disk (OP/NP). An inconsistency in black hole definitions exists (NP). A stellar black hole contains a physical singularity having minimum area and volume whereas the same stellar black hole has maximum entropy with maximum event horizon area as defined by Bekenstein or maximum volume as defined in reference 1, Section XVII. An amplified black hole entropy (NP).

Stellar black hole theory was thus amplified to include a quark star (matter) and black hole (energy), both of which were "black" (NP). Their differences were a quark star (matter) had mass, volume, near zero temperature in accordance with the black hole temperature equation, permanence, and maximum entropy (NP). In contrast, its associated black hole (energy) had super force energy, a minimum volume doughnut physical singularity at a Planck cube center, near infinite temperature, transientness, and minimal entropy (NP).

Twenty two permanent fundamental matter and force particles are constituents of all objects in our universe including: all solar systems, galaxies, and permanent stellar black holes as described in reference 1, Section VI.B. Fundamental SM/supersymmetry (SUSY)/super supersymmetry (SSUSY) matter and force particles (NP). All permanent stellar black holes or quark stars (matter) consist of 22 permanent fundamental matter and force particles (see reference 1, Fig. 14a), which is in sharp contrast to the unknown constituents of stellar black holes according to current astrophysics theory (NP).

Stars are formed via molecular cloud gravitational collapse, star accretion, and star merger (OP/NP). Molecular cloud gravitational collapse occurs when internal energy is insufficient to resist the star's own gravity and is stopped by Pauli's exclusion principle degeneracy pressure (OP). If the star's mass is less than 8 solar masses, it gravitationally collapses to a white dwarf star supported by electron degeneracy pressure (OP). The discrepancy between the initial 8 solar masses and approximately 1.39 solar masses or Chandrasekhar limit is due to solar winds (OP). If the star is between 8 and 20 solar masses, it gravitationally collapses to a neutron star supported by neutron degeneracy pressure with a supernova explosion (OP/NP). If the star is between 20 and 100 solar masses, it gravitationally collapses to a quark star (matter) supported by Planck cube matter degeneracy pressure (e.g., up quark) with a quark-nova explosion (OP/NP). According to Leahy and Ouyed, the quark star (matter) forms with a quark-nova's nuclear binding energy release (OP). The delayed (10 - 40 days) secondary quark-nova explosion follows a neutron star's primary supernova explosion (see reference 1, Section XXIV. Validation of a TOE physics solution using a two-step integrated physics/mathematics methodology, Leahy and Ouyed) (OP).

Six types of Super Universe stellar black holes were: supermassive quark star (matter), quark star (matter), super supermassive quark star (matter), its associated super supermassive black hole (energy), super super supermassive quark star (matter), and its associated super super supermassive black hole (energy) (NP). The first two types, supermassive quark stars (matter) and quark stars (matter) existed in universes (OP/NP). The second two types, super supermassive quark stars (matter) and their associated super supermassive black holes (energy) existed in precursor universes and created universes (NP). The third two types, super super supermassive quark stars (matter) and their associated super super supermassive black holes (energy) existed in the Super Universe and created precursor universes (NP).

The first type or a supermassive quark star (matter) contains 10^6 to 10^{10} solar masses [6] (OP/NP). They may be "fossil quasars" with masses proportional to their host galaxies' masses (OP). According to Carilli, galaxy to central black hole mass ratio was 30:1 in our early universe and 700:1 now [7] (OP). Population III stars containing hydrogen, helium, and lithium first formed approximately 200 million years after the start of our universe (OP). 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) with their supernova or quark-nova remnants [8] (OP/NP). Over the next 13.6 billion years, by accretion of stars/matter and merger with galaxies, approximately 100 billion supermassive quark stars (matter) and their 100 billion galaxies formed in our universe (OP/NP). 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) (OP/NP). Another method, direct-collapse black holes (DCBHs) with 10^4 to 10^5 solar masses, may have formed a portion of the approximately 100 billion supermassive quark stars (matter) and their 100 billion galaxies in our universe (OP). That is, over the last 13.6 billion years, approximately 10^2 to 10^5 solar masses were swallowed by these DCBHs (OP). The latter were born a few hundred million years after the big bang and bypassed the optimum Eddington feeding rate for black hole growth [9] (OP).

The second type or quark star (matter) contains between several and 10^6 solar masses (OP/NP). Quark stars (matter) having several solar masses were initially created by first generation star collapses (OP/NP). Their sizes were augmented by accretion of stars/matter and merger with neutron stars or quark star (matter) galaxies during the next 13.6 billion years (OP/NP).

The third type or a super supermassive quark star (matter) contains approximately 10^{24} solar masses (NP). In our

TABLE II. Relationships between stellar black hole types and precursor universes, universes, and galaxies.

Stellar black hole types	Stellar black hole sizes (solar energy/mass)	Creation of precursor universes, universes, galaxies
Super super supermassive quark stars (matter)/black holes (energy)	>> 10^{24}	Precursor universes
Super supermassive quark stars (matter)/black holes (energy)	~ 10^{24}	Universes
Supermassive quark stars (matter)	10^{6} – 10^{10}	Galaxies
Quark stars (matter)	Several - 10^{6}	Small galaxies

precursor universe, a super supermassive quark star (matter) which consisted of a cold quark-gluon plasma [10], increased in size via accretion of stars/matter and merger with galaxies (OP/NP). At the 10^{24} solar mass threshold or our universe's energy/mass, Planck cube matter degeneracy pressure was insufficient to stop further gravitational collapse (NP). The super supermassive quark star (matter) instantaneously evaporated, deflated, and gravitationally collapsed to the fourth type or its associated super supermassive black hole (energy) which created our universe's "big bang" (white hole) and a bubble of zero-point energy (NP). A zero-point energy bubble is completely empty (i.e., a perfect vacuum) whereas a true vacuum contains dark energy or Higgs force energies (OP/NP).

In the Super Universe, the fifth type or a super super supermassive quark star (matter) contained >> 10^{24} solar masses and instantaneously evaporated, deflated, and gravitationally collapsed to the sixth type or its associated super super supermassive black hole (energy) and created a precursor universe (NP). Table II shows the relationships between stellar black hole types and precursor universes, universes, and galaxies (NP).

Stellar black holes contained 16 NP, 14 OP/NP, and 12 OP requirements as shown in Table I (E).

This integrated stellar black holes with superstring, particle creation, dark energy, black hole entropy, arrow of time, cosmological constant problem, black hole information paradox, baryogenesis, and quantum gravity theories, (see Table III) (NP).

IV. CONCLUSIONS

Table I shows "New Physics" and old physics requirements for 20 constituent theories from reference 1, including Higgs forces and stellar black holes sections from this article. Also included in Table I are requirements for all sections of the 20 constituent theories, for example, section A. Einstein's General Relativity under stellar black holes. Each TOE requirement in the 20 constituent theories was categorized as "New Physics" (NP), Old Physics/New Physics (OP/NP), Old Physics (OP), Duplicate (D) or Explanatory (E). Duplicate and explanatory were ignored. Half of the OP/NP requirements were allocated to new physics and half to old physics requirements. There were 1,134 total TOE, 689 (61%) new physics, and 445 (39%) old physics requirements. In contrast, the current astrophysics community has not defined a single "New Physics" requirement. ***The single-step mathematics TOE methodology is "dead in the water" because 689 of all TOE requirements were "New Physics" requirements which never previously existed, and were not incorporated in the single-step mathematics TOE methodology.***

This article describes "New Physics" definition and summarizes a two-step TOE physics solution. The complete "New Physics" definition and a two-step TOE physics solution is available in reference 1.

TABLE III. Primary interrelationships between 20 interrelated amplified 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	Super Universe	Stellar black holes	Black hole entropy	Arrow of time	Cosmological constant problem	Black hole information paradox	Baryogenesis	Quantum gravity
Superstring	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Particle creation	x	x	x	x	x	x	x	x	x	x		x		x	x			x	x	x
Inflation	x	x	x						x											x
Higgs forces	x	x		x	x	x	x	x	x	x	x					x			x	x
Spontaneous symmetry breaking	x	x		x	x	x	x	x	x	x									x	x
Superpartner and SM decays	x	x		x	x	x														x
Neutrino oscillations	x	x		x	x		x	x												x
Dark matter	x	x		x	x		x	x	x	x							x		x	x
Universe expansions	x	x	x	x	x			x	x	x		x								x
Dark energy	x	x		x	x			x	x	x			x	x		x	x		x	x
Messenger particles	x			x							x									x
Relative strengths of forces	x	x							x			x								x
Super Universe	x									x			x							x
Stellar black holes	x	x								x				x	x	x	x	x	x	x
Black hole entropy	x	x												x	x	x	x	x	x	x
Arrow of time	x			x						x				x	x	x	x	x	x	x
Cosmological constant problem	x							x		x				x	x	x	x			x
Black hole information paradox	x	x												x	x	x		x	x	x
Baryogenesis	x	x		x	x			x		x				x	x	x		x	x	x
Quantum gravity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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[5] The assumed rest masses of all SM particle may require future revisions because all matter particles have associated Higgs forces. For example, when an electron annihilates with its anti-particle (positron), the total released energy is twice the assumed electron's rest mass of 0.51 MeV. Since an electron is always associated with its Higgs force, electron annihilation released energy (0.51 MeV) may be the sum of the electron's rest mass plus its associated Higgs force. Thus, the electron's rest mass may be .11 MeV and its associated Higgs force .40 MeV for a total of 0.51 MeV. The latter maintains the relationship p_{11} = (c) (h_{11}). The concept is similar to a proton's total energy/mass of 938 MeV. The latter consists of rest masses of two up quarks (4.4 MeV) and one down quark (4.7 MeV) or only one percent of the proton's energy/mass, with the remaining 99% being binding energy.

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