

(the short version* of the original article)

A Proposed SUSY Alternative (SUSYA) based on a new type of seesaw mechanism applicable to all elementary particles and predicting a new type of aether theory

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ABSTRACT

This paper proposes a potentially viable “out-of-the-box” alternative (called “SUSYA”) to the currently known supersymmetry (SUSY) theory variants: SUSYA essentially proposes a new type of *seesaw mechanism* (SMEC) applicable to all elementary particles (EPs) and named “Z-SMEC”; Z-SMEC is a new type of charge-based mass symmetry/“conjugation” between EPs which predicts the zero/non-zero rest masses of all known/unknown EPs, EPs that are “conjugated” in boson-fermion pairs sharing the same electromagnetic charge (EMC). Z-SMEC is actually derived from an *extended zero-energy hypothesis* (eZEH) which is essentially a *conservation principle applied on zero-energy* (assigned to the ground state of vacuum) that mainly states a general quadratic equation governing a form of *ex-nihilo creation* and having a pair of conjugate boson-fermion mass solutions for each set of given coefficients. eZEH proposes a general formula for all the rest masses of all EPs from Standard model, also indicating the true existence of the graviton and a possible bijective connection between the three types of neutrinos (all predicted to be actually *Majorana fermions*) and the massless bosons (photon, gluon and the hypothetical graviton), between the electron/positron and the W boson, predicting at least three generations of *leptoquarks* (LQs) (defined here as the “mass-conjugates” of the three known generations of quarks) and predicting two distinct types of *neutral massless fermions* (NMFs) (modelled as mass-conjugates of the Higgs boson and Z boson respectively) which may be plausible constituents for a hypothetical *lightest possible* (hot fermionic) *dark matter* (LPDM) or, even more plausible, the main constituents of a *superfluid fermionic vacuum/aether*, as also proposed by the notorious *Superfluid vacuum theory* (SVT) (in which the physical vacuum is modeled as a bosonic/fermionic superfluid). SUSYA also predicts two hypothetical bosons defined as the ultra-heavy bosonic mass-conjugates of the muon and tauon called here the “W-muonic boson” (Wmb) and the “W-tauonic boson” (Wtb) respectively: Wmb and Wtb are predicted much heavier than the W boson and the Higgs boson so that Wmb and Wtb can be regarded as ultra-heavy charged Higgs bosons with their huge predicted rest energies defining the energy scale at which the electroweak field (EWF) may be unified with the Higgs field (HF).

1. A ZERO-ENERGY HYPOTHESIS (ZEH) APPLIED ON VIRTUAL PARTICLE-ANTIPARTICLE PAIRS (VPAPs)

1.1 Introduction on supersymmetry (SUSY) theories

Supersymmetry (SUSY) is a *conjectured spacetime symmetry* defined as a *bijective pairing* between the two main groups of elementary particles (EPs): (spin-1) bosons and (spin-1/2) fermions. In SUSY, each EP from one group would have an associated EP in the other (called its “superpartner” [SP]), the spin of which differs by 1/2. The “standard” SUSY defines these SPs to be new and undiscovered EPs: for example, SUSY predicts the existence of a bosonic EP called “*selectron*” (defined as the SP of the electron) [1]; the hypothetical/predicted fermionic SPs of the known bosons are named with the “-ino” suffix (and are generically named “*bosinos*”, e.g. gluino is defined as the fermionic SP of the gluon). The simplest SUSY variants are the “unbroken”-SUSY variants which predict that any pair of SPs would share *the same mass* and the same internal quantum numbers (besides spin!):

however, the most viable/plausible SUSY variants are the *spontaneously broken SUSY variants* (SB-SUSY) allowing SPs to differ in their rest masses. There are also *extended SUSY variants* which allow at least two SPs for a given known fermionic/bosonic EP. Some SPs are predicted to have rest masses at least 3 orders of magnitude larger than their corresponding known EPs: that is why recreating these SPs in the present LHC would be a difficult task [2].

If ever proved to be valid, SB-SUSY variants may help solve many problems of the Standard model (SM), including the hierarchy problem, gauge coupling unification, dark matter etc.: however, none of the known SB-SUSY variants has any direct and/or indirect experimental evidence/support so far. If any SP (of any known EP) will ever be found in the future, its rest mass would indicate the scale at which SUSY is broken.

1.2 Motivating Points on this SUSY-alternative (SUSYA)

Although very appealing at first (and still quite interesting and seductive theory which may offer important explanations to

notorious problems in modern physics, like the hierarchy problem for example), the currently known SUSY variants have failed in gaining acceptance and lost a significant number of their initial supporters by the persistent failure in all the repetitive attempts to find experimental data supporting the true existence of any SP of any known EP.

This paper partially and briefly recapitulates and continues the work from another recently published article by the same author [3] by proposing a potentially viable “out-of-the-box” SUSY alternative (“SUSYA”) to the currently known SUSY variants: SUSYA a new type of charge-based mass symmetry/“conjugation” between EPs which predicts the zero/non-zero rest masses of all known/unknown EPs, EPs that are “conjugated” in boson-fermion pairs sharing the same electromagnetic charge (EMC). SUSYA is based on an *extended zero-energy hypothesis (eZEH)* which is essentially a *conservation principle applied on zero-energy (assigned to the ground state of vacuum)* that mainly states a general quadratic equation having a pair of conjugate boson-fermion mass solutions for each set of given coefficients. eZEH proposes a general formula for all the rest masses of all EPs from Standard model, also indicating the true existence of the graviton and a possible bijective connection between the three types of neutrinos and the massless bosons (photon, gluon and the hypothetical graviton), between the electron/positron and the W boson, predicting at least three generations of *leptoquarks (LQs)* (defined here as the “mass-conjugates” of the three known generations of quarks) and predicting two distinct types of *neutral massless fermions (NMFs)* (modelled as mass-conjugates of the Higgs boson and Z boson respectively) which may be plausible constituents for a hypothetical *lightest possible (hot fermionic) dark matter (LPDM)* or, even more plausible, the main constituents of a *superfluid fermionic vacuum/aether*, as also proposed by the notorious *Superfluid vacuum theory (SVT)* (with various variants in which the physical vacuum is modeled as a either a bosonic or fermionic superfluid).

1.3 A proposed zero-energy hypothesis (ZEH)

1.3.1. An introduction on ZEH and the main statement of ZEH

SUSYA is mainly based on a *zero-energy hypothesis (ZEH)* applied on any virtual particle-antiparticle pair (VPAP) popping out from the quantum vacuum at hypothetical length scales comparable to Planck scale: ZEH was already launched by the author in a previous article [3]. ZEH can be regarded as an extension of the notorious *zero-energy universe hypothesis (ZEUH)* which was actually first proposed by the German theoretical physicist Pascual Jordan (as recounted by the Russian-American theoretical physicist George Gamow in his autobiography called “*My World Line*” [4]) and first independently developed and published as a scientific article in Nature journal many years later by the American physicist Edward Tryon [5], assuming minimal curvature (thus an almost/practically flat spacetime) at Planck scale (like also presumed by Einstein’s General relativity [EGR] when calculating the equations of geodesics by calculus, a sine-qua-non condition for EGR to remain valid down to those scales). Presuming the gravitational and electrostatic inverse-square laws to be valid down to Planck scales and considering a VPAP composed from two electromagnetically-charged EPs (CEPs) each with non-zero rest mass m and energy $E_m = mc^2$, electromagnetic charge $\pm q$ and negative energies of

gravitational attraction $E_g = -Gm^2 / r$ [6] and electrostatic attraction $E_q = -k_e |q|^2 / r$, ZEH specifically states that:

$$2E_m + E_g + E_q = 0 \quad (1)$$

This equation (1) essentially governs (and quantizes) an *ex-nihilo creation process of VPAPs*. Defining the ratios $\phi_g = G / r$ and $\phi_e = k_e / r$ the previous equation is equivalent to the following simple quadratic equation with unknown $x (= m)$:

$$\phi_g x^2 - (2c^2)x + \phi_e q^2 = 0 \quad (2)$$

The previous equation is easily solvable and has two possible solutions which are both positive reals if $c^4 \geq \phi_g \phi_e q^2 \geq 0$:

$$m_{\pm} (= x_{\pm}) = \frac{c^2 \pm \sqrt{c^4 - \phi_g \phi_e q^2}}{\phi_g} \quad (3)$$

The realness condition $c^4 \geq \phi_g \phi_e q^2 \geq 0$ implies the existence of a minimum (and mass-independent!) distance between any two EPs (composing the same VPAP) $r_{\min} = q\sqrt{Gk_e} / c^2 \cong 10^{-1} l_{Pl}$ (for $q_{(\cong e)} \in \{e, \pm \frac{1}{3}e, \pm \frac{2}{3}e\}$ and with l_{Pl} being the Planck length): obviously, for distances lower than r_{\min} the previous equation has only imaginary solutions $x = m$ for any charged EP; by this fact, ZEH offers a *new interpretation of the Planck length, as being the approximate distance under which charged EPs cannot have rest masses/energies valued with real numbers*. For example and more specifically, for $q = e$,

$$r_{\min} / l_{Pl} = \sqrt{\alpha_0} \cong 11.71^{-1} \quad \text{with} \quad \alpha_0 = \frac{k_e e^2}{\hbar c} (\cong 137^{-1})$$

being the fine structure constant (FSC) (the value of the electromagnetic running coupling constant at rest).

Both generic $x = m$ conjugated solutions of the previous equation (3) indicate that, *because m has discrete values only, ϕ_g (and E_g implicitly) and ϕ_e (and E_q implicitly) should all have discrete values only*: however, ϕ_g and ϕ_e ratios can take discrete values *only if both their nominators (G and k_e respectively) and their common denominator (the length scale r) take only discrete values* (at scales relatively close to r_{\min})

a fact which, together with $r_{\min}(q)$ function, strongly suggests that *space is actually quantized/granular around Planck scale (PS) and allows only discrete distances between EPs (of the same VPAP) at those scales*.

Implicitly, SUSYA predicts a spacetime vacuum with two main essential features:

- (1) granular/quantized structure around PS and

(2) “*ex-nihilo*” creation of VPAPs at those same PS measured by $r_{\min}(q)$.

More interestingly, for neutral EPs (NEPs) with $q = 0(C)$ (which implies $\phi_g \phi_e q^2 = 0$) and $r \geq r_{\min} (> 0m)$, $x = m$ solutions may take *both*:

(1) non-zero positive values $m_+ = (c^2 + \sqrt{c^4}) / \phi_g = 2c^2 / \phi_g (> 0kg)$ (like in the case of all three types of neutrinos, the Z boson and the Higgs boson) AND

(2) zero values $m_- = (c^2 - \sqrt{c^4}) / \phi_g = 0kg$ (like in the case of the gluon and the photon which both have zero rest mass $m (= 0kg)$ and are assigned only relativistic mass/energy by the Standard model).

If interpreted as a non-coincidence, the previous equation (3) suggests/indicates that the non-zero mass (**nzrm**) of EPs (possessing nzrm) depends inverse-proportionally with the strength of the gravitational field (**GF**) (measured by big G scalar) at those r -scales (comparable to Planck scale) so that: a stronger GF (measured by larger big G values at r scales, thus larger $\phi_g (= G/r)$ ratios) “rips” photons in “lighter pieces” (allowing only smaller rest-masses for any EP with nzrm) AND a weaker GF allows larger nzrm for any EP at those same r scales (this simple principle also applies to macrocosm where the weak GF at large/macrocosmic scales allows for very large celestial bodies to exist and the predicted progressively stronger GF at microcosmic scales allows for only physical objects with very small mass to exist, like in the case of EPs); this fact also suggests that nzrm may have a “secret” geometrical meaning “encoded” in a possible quantum structure of spacetime vacuum at those r scales (as already explained and detailed in the previous article of the author [3]).

It is also very important to notice that the solutions (3) of the main equation (2) of ZEH strikingly resembles to the solutions proposed by *type-1 seesaw mechanism (SMEC-1)*

$$x_{\pm} = \frac{B \pm \sqrt{B^2 + 4M^2}}{2}, \text{ which are the conjugated solutions}$$

of the *characteristic/determinantal (quadratic) equation (CE)*

$$x^2 - xB - M^2 = 0 \text{ derived from the characteristic}$$

polynomial (CP) |A|(= x · I₂ - A) of the 2x2 symmetrical

$$\text{mass matrix of neutrinos } A = \begin{pmatrix} 0 & M \\ M & B \end{pmatrix} \text{ (with B being the}$$

Majorana mass component of the neutrinos and M being the Dirac mass component of the neutrinos) [7]. CP is the polynomial which is invariant under matrix similarity and has

the eigenvalues of A as roots; $I_2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ is the 2x2

identity matrix with 1-values on the main diagonal and 0-values on the secondary diagonal). This very important aspect of eZEH is detailed later on in the subsection of this paper dedicated to the three known generations of neutrinos.

1.3.2. A proposed *extended ZEH (eZEH)*, defined as the “core” of SUSYA

This more “ambitious” *extended ZEH (eZEH)* (proposed by SUSYA and defined as its “core”) is actually a stronger/stricter conjecture than ZEH because *eZEH assumes and applies the main equation of ZEH (3) not only on virtual particle-antiparticle pairs (VPAPs) but also on specific boson-fermion pairs which share the same zero/non-zero electromagnetic charge (EMC) and which are defined and coined by eZEH as “mass-conjugates” (MCs): these MCs (with distinct zero/non-zero rest masses, but sharing the same EMC) are the SUSYA-proposed alternative to the concept of partner-superpartner pair (or vice versa) used in SUSY. Furthermore, eZEH not only defines various MCs, but also states that the heavier MC can always decay into its lighter MC partner plus other EPs in respect to the energy conservation principle: however, the decay of a heavier MC (hMC) into its lighter MC is stated to not always be the single mode in which that hMC decays.*

eZEH additionally (co-)states/conjectures that: *if a specific bosonic EP is its own antiparticle (like in the case of the photon, the gluon, the Z boson and the Higgs boson) then its (mass-)conjugated fermionic partner is also its antiparticle, thus it is actually a Majorana fermion; in other words, “being its own antiparticle” is thus a property conjectured by eZEH/SUSYA to be shared by both MCs. eZEH establishes some interesting symmetries (called “conjugations”) between some known bosonic EPs and fermionic EPs, but also between some known bosonic EPs and some predicted still unknown fermionic EPs and between some known fermionic EPs and some predicted still unknown bosonic EPs.*

Similarly to SUSY, eZEH additionally states that *each pair of MCs actually resulted from a broken-symmetry of a (bosonic) field quantized by a boson with much higher rest energy-mass that the rest-masses/energies of those two MCs (composing that MCs pair).*

The $c^2 / \phi_g (= rc^2 / G)$ ratio is redefined as a “center” of mass-symmetry/conjugation between any two MCs proposed by SUSYA (as based on its eZEH), which “center” is mainly determined by $\phi_g (= G/r)$ ratio, thus by strength of the gravitational field (measured by a possibly variable/scale-dependent G scalar) possibly varying with the length scale r when approaching $r_{\min} (\cong 10^{-1} l_{Pl})$.

It is also important to notice that equation (3) of eZEH does not allow the existence of electromagnetically charged EPs with zero rest-mass, thus *doesn't allow the existence of elementary Weyl fermions.*

Important remark. In other words, formula (3) allows NEPs to be divided in two major families (NEPs with non-zero rest mass and NEPs possessing only relativistic mass) which is an indirect proof that m is a function of q (as requested/imposed by q) and *not* vice-versa, as if the q quantum also imposes fixed/discrete gradients $\Delta m = m_2 - m_1 (\geq 0kg) = f(q)$ between various types of generic EPs (“1” and “2”). eZEH additionally states that the two conjugated elementary mass solutions

$$m_{\pm} = (c^2 \pm \sqrt{c^4 - \phi_g \phi_e q^2}) / \phi_g \text{ (of eZEH's main equation)}$$

actually define a boson-fermion pair (with conjugated masses) called here “*conjugated boson-fermion pair*” (**CBFP**). eZEH

actually conjectures a new type of boson-fermion symmetry/"mass-conjugation" based on eZEH's main quadratic equation (with partially unknown coefficients): eZEH mainly predicts two distinct types of massless neutral fermions (modelled as conjugates of the Higgs boson and Z boson respectively) with zero charge and zero rest mass (which couple only gravitationally and thus may be plausibly the main constituents of *dark matter* or even the constituents of a hypothetical fermionic superfluid aether/vacuum), a bijective mass-conjugation between the three types of neutrinos and the massless bosons (gluon, photon and the hypothetical graviton), a relation of mass-conjugation between the electron/positron and the W^\pm boson and at least three generations of *leptoquarks* (LQs) (defined here as the "mass-conjugates" of the three known generations of quarks) (see next).

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For the beginning, let us start to estimate the values of ϕ_g for the known electromagnetically-neutral EP (NEP). For $q = 0(C)$, the conjugated solutions expressed by formula (3) simplify for any NEP such as $m_{NEP} = (c^2 \pm c^2) / \phi_g$, resulting $\phi_{g(NEP)} = (c^2 \pm c^2) / m_{NEP}$.

1.3.3(4). Two predicted types of neutral massless fermions (NMFs) proposed as candidate constituents of a predicted fermionic superfluid aether/vacuum (SV)

Focusing on Higgs boson and Z boson and their eZEH-predicted correspondent/conjugated neutral massless fermions (NMFs) which may compose a so-called (fermionic) superfluid aether/vacuum. In a first step and defining the unit of measure of $\phi_g (= 2c^2 / m)$ as $u = m^2 s^{-2} kg^{-1}$, eZEH

directly estimates ϕ_g for the Z boson (Zb) and Higgs boson (Hb) (with both Zb and Hb having non-zero rest energies) such as

$$\phi_{g(Zb)} (= 2c^2 / m_{Zb}) \cong 10^{42} u \quad \text{and}$$

$$\phi_{g(Hb)} (= 2c^2 / m_{Hb}) \cong 8 \times 10^{41} u. \text{ eZEH states that both Zb}$$

and Hb have two distinct correspondent/conjugated *massless neutral fermions* formally called the "Z fermion" (Zf) (which shares the same $\phi_{g(Zb)} (\cong 10^{42} u)$ with Zb) and the "Higgs

fermion" (Hf) (which shares the same $\phi_{g(Hb)} (\cong 8 \times 10^{41} u)$

with Hb) with zero rest masses

$$m_{Zf} = (c^2 - c^2) / \phi_{g(Zb)} (= 0 kg) \quad \text{and}$$

$$m_{Hf} = (c^2 - c^2) / \phi_{g(Hb)} (= 0 kg) \text{ (thus both moving with}$$

the speed of light in vacuum and *possessing only relativistic masses* instead of rest masses). Based on the previously defined

$$r_{\min} (\cong 10^{-1} l_{Pl}), \quad \text{we then obtain}$$

$$G_{Zb} (= \phi_{g(Zb)} r_{\min}) \cong G_{Hb} (= \phi_{g(Hb)} r_{\min}) \cong 2 \times 10^{16} G: \text{ based on}$$

these huge predicted lower bounds for big G values at Planck scales, eZEH states that E_g may reach the same magnitude as

$$E_q \left(E_g \cong E_q \Leftrightarrow \phi_g m^2 \cong \phi_e q^2 \right) \text{ at scales comparable to}$$

Planck scale, which implies a variable big G

$G_{\text{var}} \in [G, G_{Hb/Zb}]$ which may significantly increase (up to $10^{16} G$ and possibly larger values) with the drop of length scale down to $r_{\min} (\cong 10^{-1} l_{Pl})$.

Because Hb and Zb are their own antiparticles, their eZEH-predicted mass conjugates Hf and Zf are also defined (and predicted) by SUSYA to actually be their own particles thus to be massless Majorana fermions. Because Zb is a spin-1 vector boson, SUSYA also defines its mass-conjugate Zf as being a Majorana vector-fermion. Because Hb is a scalar boson, SUSYA also defines its mass-conjugate Hf as being a Majorana scalar-fermion. Being both fermions, Zf and Hf are also stated by SUSYA to obey Pauli's exclusion principle. Regarding the Zfs (vector-fermions), the left-handed Zfs are stated to form isospin doublets, while the right-handed Zf are stated to form isospin singlets (like all the other vector-fermions from the Standard Model).

In a checkpoint conclusion, Hf and Zf are thus massless Majorana fermions (aka massless Majorana neutrinos) which, like any massless neutrino in a 3+1-dimensional quantum field theory, can be described either as a theory of a massless four-component Majorana fermion [the zero mode of the Majorana fermion] or a theory of a two-component massless Weyl fermion: these two formulations are indistinguishable, as they arise from exactly the same Lagrangian when expressed in terms of two-component fermions; in other words, a massless neutrino can be modeled either as a Majorana neutrino or a Weyl neutrino [8]. In some variants of SUSY massless Majorana fermions (like Hf and Zf) are considered hypothetical "natural" superpartners of neutral spin-1 or spin-0 bosonic EPs, as also proposed by this SUSYA: since the three known generations of neutrinos have been found to have non-zero rest masses, Hf and Zf both partially save SUSY by replacing it with this SUSYA: furthermore (as explained in the next sections of this paper), *the three known generations of neutrinos are proposed by SUSYA to be actually the mass conjugates of the photon, the gluon and a hypothetical graviton.*

Zf and Hf are defined by SUSYA as "weakly-interacting lightest particles" ("WILPs") which are stated by SUSYA to interact only (and very weakly!) via gravitational force/field both locally and at distance (by their very low but non-zero relativistic energy which couples gravitationally) and possibly via weak interaction (locally).

An electron and such a massless Majorana neutrino (like Hf and Zf) can actually interact (but only locally) via charged-W exchange (as W boson has a very short mean lifetime and mediates only local interactions at very low length scales comparable to the size of a proton/neutron of about $10^{-15} m$). Note that in a Standard Model with a massless neutrino, there is no right-handed neutrino. The existence of a conserved lepton number in the theory with massless neutrinos is the reason one usually favors the Weyl over the Majorana form of the theory.

Like all Majorana fermions (which possess only positive/negative helicity which coincides with chirality for massless spinors), Hf and Zf are also stated by SUSYA to cannot possess intrinsic electric or magnetic moments, but *only toroidal moments* (a consequence of their helicity) and that is why they minimally interact with the electromagnetic field (which makes them potential candidates for *dark energy identified with a Hf/Zf-based superfluid aether* and even candidates for *cold dark matter* if/when agglutinating in larger clumps of Hfs and Zfs with co-centered circular trajectories) [9, 10].

SUSYA defines Hfs and Zfs to be maximally stable and to can not decay (thus with practically infinite lifetimes): more exactly, Hfs and Zfs are stated to be actually the final ultra-stable products of various possible decays of heavier EPs (mainly the decays of their heavier mass-conjugates). Furthermore, SUSYA retrodicts that the Big Bang would had mainly and firstly produced Hfs and Zfs (two types of very weakly interacting EPs) in huge quantities which compose a *superfluid aether (SA)* identified with our 3D non-empty space (as explained later in this section). In this way, SUSYA actually retrodicts a pre-Big-Bang singularity which may had generated both spacetime (identified with this Hf/Zf-based SA) and all EP-based physical objects (playing various “actor”-like “roles” on this aetherial spacetime “scene” identified with SA): this approach of SUSYA has some similarities with a special type of TOE (*theory of everything*) called “*Causal fermion system*” (firstly introduced by Felix Finster and collaborators) which derives both spacetime and the objects therein as secondary objects from the structures of an underlying *causal fermion system* [11].

Hf and Zf are stated by SUSYA to may even compose a hypothetical “*lightest possible (fermionic hot) dark matter*” (“**LPDM**”), which is even lighter than the so-called *ultra-light dark matter (ULDM)* which is a class of bosonic dark matter (**DM**) models where the hypothetical DM is stated to be composed of bosons with non-zero rest energies in the interval $\left[10^{-22} \text{ eV}, 1 \text{ eV}\right)$ (which bosons may form a Bose-Einstein condensate or a superfluid on galactic scales) [12]. LPDM was previously called “hot” because Zf and Hf are defined as being massless neutral fermions, thus moving at the speed of light in vacuum (from where the “hot” attributed comes from, in the sense of “very fast/mobile”).

Even more ambitiously, SUSYA proposes Zf and Hf as plausible main constituents of a *superfluid fermionic vacuum/aether*, as also proposed by the notorious *Superfluid vacuum theory (SVT)* (in which the physical vacuum is modeled as a bosonic/fermionic superfluid). Furthermore (and due to Pauli exclusion principle), this hypothetical (Zf&Hf-based) *fermionic superfluid aether (FSA)* (proposed by SUSYA) *may not be infinitely compressible* (to an infinite density) which suggests that a FSA-based pre-Big Bang singularity (**pBBS**), if it existed, *may not* had been a true gravitational singularity, but only a *gravitational quasi-singularity* with a large but finite density (as also detailed in the next sections of this paper).

The ultimate goal of SVT is to offer a common frame for unifying quantum mechanics with general relativity: that is why SVT can be regarded as both a candidate theory for quantum gravity and also an extension of the Standard Model (**SM**); SVT aims to model all known interactions and elementary particles (**EPs**) as different manifestations of the same *superfluid vacuum/aether*. However, SUSYA is slightly different from SVT, because SUSYA actually propose that there are actually EPs that “play the role” of standard/“actor”-EPs (composing both normal matter/radiation and dark matter: the “contained” compartment of our universe) and other EPs (like Hf and Zf) that play the role of non-standard/“scenic”-EPs (the “container” compartment, the “vacuum scene” of our universe).

The movement of any non-Hf/Zf EP (or of any composite physical body composed from such EPs) through this hypothetical superfluid Hf/Zf-based aether/sea would be practically frictionless, thus our universe may be actually a *perpetuum mobile of 3rd kind* (which *completely eliminates friction and other dissipative forces, to maintain motion forever due to its mass inertia*).

The initial concept of a “luminiferous aether” (**LA**) (as a medium conceived for the electromagnetic waves to exist at the first place at the “vibrations/oscillations of something”) was initially discarded after the negative results of the notorious Michelson–Morley (**MM**) experimental sessions (performed in 1887) and of other MM-like experiments that excluded aether in its initial definition of an “absolute reference frame” and sparked the advent of the *special relativity theory (SRT)*: however, MM and MM-like experiments *cannot* exclude a *non-absolute preferred reference frame (NAPRF)* which can exist in fact; the hypothetical “sea/ocean” composed of NMFs like Z-fermions (**Zfs**) and Higgs-fermions (**Hfs**) (moving at the speed of light, as proposed by SUSYA) may be indeed a plausible candidate for such NAPRF, as explained next.

It is often erroneously stated that the purpose of the original MM experiment (**OMME**) was to determine the existence of the aether: actually, Michelson assumed from the start that the aether existed, and was only attempting to measure the expected effects it would produce if it was indeed a static frame (however, the OMME failed to produce the expected results from a static aether). It is also erroneously reported (in many histories of physics) that the OMME and other MM-like experiments showed “no” changes in the speed of light in any direction: this first so-called “null” result actually “hid” some change in the interference pattern (as found in all MM-like experiments), but the effect was too small and interpreted as falling within experimental error (leading to this “null-results” interpretation). Actually, at those historical times (from 1887 to 1920 and even later), the inconclusive results of MM/MM-like experiments weren’t actually interpreted by the old physicists as the non-existence of aether but were generally (and indeed correctly!) interpreted as the aether, if it existed, couldn’t be a perfectly stationary medium (with moving Earth possibly dragging a certain amount of co-moving aether in its movement): some old physicists even emitted the hypothesis that maybe the act of Earth moving through the aether affected the measuring instruments (used in MM/MM-like experiments) -- in the 1890s Lorentz proposed the notorious Lorentz transformations, which describe the length-contraction of a moving object when viewed by an observer at various speeds. Even if Einstein’s special (and then general) relativity theories made it possible to consider the existence of a totally empty region of space, the quantum field theory (**QFT**) requires a non-empty vacuum (at least when measured at shortest time scales in which high-energy particles interact with the electromagnetic field): QFT actually treats vacuum as a place where a large variety of virtual (charged) particle-antiparticle pairs (**VPAPs**) may spontaneously and momentarily come into existence and then disappear (as allowed by the notorious *Heisenberg’s uncertainty principle*); furthermore, the propagation of electromagnetic or electroweak fields through “empty” space is facilitated by the *vacuum polarization* (resulting from the behavior of charged VPAPs).

However, Einstein’s special relativity (**ESR**) and general relativity (**EGR**) both had and have an essential contribution to the evolution of modern physics because they strongly supported the most probably correct hypothesis that our universe contained no fixed points and no stationary reference system (thus everything was in movement relative to each other), which is also the case of *an aether composed from the eZEH-proposed very low- interacting Zfs and Hfs moving in a Brownian-like manner at the speed of light*: thus, at least in principle, our proposed Zf/HF-based aether doesn’t contradict ESR nor EGR.

In 1982, the Romanian physicist and academician Ioan-Iovitz Popescu launched an article in which he defines the hypothetical aether as “*a form of existence of the matter [...]*”

which differs qualitatively from the common (atomic and molecular) substance or radiation (photons), and which is “governed by the principle of inertia” and which is composed of “some particles of exceedingly small mass, traveling chaotically at speed of light [...] called etherons.” [13].

The superfluid vacuum/aether theory (SVT). In 1951 P.A.M. Dirac published two papers where he pointed out that quantum fluctuations in the flow of the aether should taken into account [Error! Bookmark not defined., 14]: more specifically, Dirac applied the *Heisenberg’s uncertainty principle (HUP)* to the velocity of aether at any point of spacetime and demonstrated that the velocity isn’t a well-defined quantity, but distributed over various possible values (thus aether could be modeled by a wave function representing the perfect vacuum state for which all possible aether velocities in each spacetime point are equally probable). Inspired by these ideas of Dirac, Sinha, Sivaram and Sudarshan published in 1975 a series of papers in which they have proposed an aether modeled as *superfluid composed of fermion-antifermion pairs, describable by a macroscopic wave function* [15,16,17]. These authors have concluded that the superfluid vacuum/aether (SV) should be modeled as *relativistic matter* (ultra-light fermions/bosons moving at *ultrarelativistic* or even *relativistic speeds*) by putting it into the stress–energy tensor of the Einstein’s field equations (**EFE**): however, as subsequent authors have noted, this approach didn’t offer a description of relativistic gravity as a small fluctuation of SV. Actually, this approach has a very importance nuance/duality (which also has relevance in our SUSYA-proposed Zf/Hf-based SV): (1) an observer residing inside such a SV (and being capable of creating or measuring its *small fluctuations* with low momenta, below its excitation threshold) would observe those small fluctuations as relativistic objects (like Zfs and Hfs are): in this case, SV behaves like an ideal fluid and therefore, the MM-type experiments would observe no drag force from such a minimally-excited SV (explainable by those low-interacting Zfs and Hfs) thus would lead to “null” results (which cannot however exclude the existence of such a minimally-excited SV); (2) an observer residing inside such a SV (and being capable of creating or measuring its *large fluctuations* with large momenta, above its excitation threshold) would observe those large fluctuations as non-relativistic objects.

Several SVT variants have been proposed (with various proposed structures and properties of the background SV): however, in absence of observational data (which would rule out some of them), these SVT variants are being pursued independently and SUSYA also proposes a *SV composed from these two types of neutral (Majorana) massless fermions (NMFs) (Zfs and Hfs) moving in a Brownian-like manner (in all directions) with a maximum allowed speed in our universe v_{\max} (approximated to the speed of light in vacuum)*: these SUSYA-proposed NMFs are stated to form a *superfluid fermionic field (SFF)* which is stated to also obey *Fermi–Dirac statistics* (governed by *Pauli’s exclusion principle* and by canonical anticommutation relations rather than the canonical commutation relations of bosonic fields). The FF-“prototype” is the Dirac field, which describes the collective behavior of spin-1/2 fermions with non-zero/zero rest mass (electrons, protons, quarks etc.) and which can be described as either a 4-component spinor (like in the case of *fermions with non-zero rest mass*) or as a pair of 2-component *Weyl spinors* (like in the case of *charged fermions with zero rest mass called “Weyl fermions”*).

Because both Hf and Zf are defined by SUSYA to be Majorana fermions, this SUSYA-proposed SFF can be described

as a dependent 4-component *Majorana spinor* or a single 2-component *Weyl-like (/pseudo-Weyl) spinor*. Being irreducible representations of the proper Lorentz group, Weyl fermions can actually be used as building blocks of any kind of fermionic field [8].

Furthermore, this NMFs-based SV (**NMF-SV**) behaves like an almost perfect (fermionic) ultrarelativistic gas (modeled as a fermionic condensate composed from Hfs and Zfs, possibly organized in Hf-Hf / Zf-Zf / Hf-Zf pairs analogously to Cooper pairs from the electron condensates) which expands progressively producing an accelerated cosmic inflation: other authors have also considered Big-Bounce-like *fermionic cosmologies* (in which a global fermionic field can behave as an accelerated-inflation field in the early universe, giving then place to a matter-dominated period characterized by cosmic decelerated inflation) [18].

Not only that Hf is (stated to be) the mass-conjugate of the Higgs boson (**Hb**) and Zf is (stated to be) the mass-conjugate of the Z boson (**Zb**) (as proposed by SUSYA), but SUSYA also proposes a profound connection between this NMF-based superfluid vacuum/aether (**NMF-SV**) and both the Higgs field (**HF**) (a very weak but subtle global coupling between NMF-SV and HF) and the electroweak Z-subfield (**ZF**) (a very weak but subtle local coupling between NMF-SV and ZF), with the possibilities that: (1) Hb may also produce one or more undetectable Hfs in its various types of decays; (2) Zb may also produce one or more undetectable Zfs in its various types of decays;

Pauli’s exclusion principle (prohibiting fermions from occupying the same quantum state and which principle apply to all fermions) may be also extended on Hfs and Zfs and, combined with *the principle of the minimum distance r_{\min} ($\cong e\sqrt{Gk_e}/c^2 \cong 10^{-1}l_{Pl}$)* (previously proposed by eZEH as the essential condition for any VPAP to possess a rest mass describable by a real number), may both explain why and how these Hfs/Zfs massless fermions create *the appearance of a 3D/4D empty space possessing a non-zero volume*. SUSYA thus predicts that the so-called “4D spacetime” used by Einstein’s General relativity (**EGR**) is not an abstract one, but is actually a 4D fermionic condensate/hyperfluid (composed from Hfs and Zfs) which may distort/bend/deform when excited by other sources of energy (like other physical fields and EPs): *gravitational waves (GWs)* are redefined as *collective distortions of the Hfs/Zfs trajectories composing this superfluid fermionic vacuum/condensate*.

Furthermore, this SUSYA-proposed NMF-based superfluid vacuum/aether (**NMF-SV**) rebrings into attention the *Fatio/Le Sage theory of gravitation (FTG)* (which never gained widespread acceptance until present) in which streams of NMFs impact all material objects from all directions: in this old theory of gravitation (firstly proposed in 1690 by Fatio and re-brought into attention in 1748 by Le Sage), any two material bodies partially shield each other from these impinging NMFs, resulting in a net imbalance in the pressure exerted by the impact of NMFs on the bodies, tending to drive the bodies together. In this way, SUSYA may be even compatible with the so-called *Modified Newtonian dynamics (MOND)* (which proposes a modification of Newton’s laws to account for observed properties of galaxies so that the gravitational force [GF] acting on a star in the outer regions of a galaxy is actually proportional to the square of its centripetal acceleration, or alternatively if GF actually varies inverse-proportionally with radius and not with the square of the radius).

Furthermore, SUSYA argues that FTG may be actually compatible with EGR, in the sense that EGR may be a 4D

geometrical variant of FGT, because this NMF-SV may actually “bend”/deform (and support “ripples” [identified with *gravitational waves* quantized by *the hypothetical graviton*] and “bubbles” [identified with black holes in which many types of EPs can remain “trapped” at least temporarily]) like any liquid/fluid (because it is actually a superfluid fermionic condensate) but may also contain streams of NMFs partially shielded by any material object (thus producing the gravitational effect described by FGT): in other words, SUSYA actually states that FGT and EGR are actually two “faces” of the same “coin”, to different ways to describe the same NMF-SV/aether. More ambitiously, SUSYA states that *entropic gravity theory* (EGT) (including Erik Verlinde’s version [19]) may be actually considered a third alternative variant in which the same NMF-SV phenomenology can be described without fundamentally contradicting or replacing EGR and FGT, but being merely the 3rd face of this same “coin”.

Because Hf is defined as a scalar neutral massless fermion (NMF) and the Zf is defined as a vectorial NMF, this fermionic SV/condensate/aether is thus defined by SUSYA as a “bilaminar” mix between two superposed scalar (Hf-based) and vectorial (Zf-based) fermionic fields: *fermionic scalar fields* are not a novelty per se [20]; the scalar Hf-based fermionic subfield (of this SUSYA-proposed aether) may be a candidate for a form of *scalar dark matter* (SDM) which is however quite distinct from the currently hypothesized forms of SDM composed from hypothetical (still unknown) EPs with rest masses between a few MeV’s and a few GeV’s [21].

This SUSYA-proposed NMF-based superfluid vacuum (NMF-SV) may explain many apparent paradoxes of quantum mechanics/world (listed below):

(1) NMF-SV may explain Heisenberg’s Uncertainty principle (HUP) and the wave-particle duality (WPD) (the “wavicle”-like character of any non-NMF EP) by the fact that any EP (or any EP-based composite physical object) produces ripples in this NMF-SV which may be identified with the so-called “*matter waves*” (firstly proposed by de Broglie).

(2) because NMFs are stated by SUSYA to can actually permeate any composite physical object (CPO), NMFs may also explain the *quantum tunnelling effect* (QTE) by a 2-steps “perforation” mechanism in which: (i) in a 1st step, a group of NMFs may shield any tunnelling (non-NMF-)EP and facilitate its transition through any CPO (energetic obstacle) which transition may be mediated (in a second step) by (ii) another group of NMFs which may create a tunnel-like structure through that energetic obstacle (CPO) so that to generate QTE;

(3) this NMF-SV is stated by SUSYA to interact very weakly with all the other (non-NMF-)EPs and CPOs but it is co-stated by SUSYA to also possess a self-interaction potential (as a function of the scalar and pseudo-scalar invariants) which may help explain many quantum effects like QTE (as previously detailed) and even quantum entanglement (QE) (as explained later in the paper);

Additionally, this Hfs/Zfs-based SV/aether (proposed by SUSYA) may at least partially explain *dark matter* and *dark energy* (including macrocosmic accelerated inflation of our observable universe) and even establish a profound connection between these two important physical concepts.

Other authors have also considered the “revival” of the aether concept to “save” EGR by solving its related paradoxes (and bringing EGR closer to quantum mechanics and concomitantly explaining *dark energy* and *dark matter*) starting from the “*Einstein aether theories*” which are concrete examples of theories with broken Lorentz invariance, initially popularized by Maurizio Gasperini in a series of papers in the 1980s [22]) and further developed by: (1) Jacobson, Mattingly and their

“*aethery*” (launched in 2000) [23]; (2) Heinicke et al. in 2005 [24]; (3) Złośnik et al. in 2018 [25]; (4) Battyte et al. in 2019 [26].

SUSYA predicts the real existence of the *hypothetical graviton* and defines it as a *bosonic excitation of this Hf/Zf fermionic superfluid “vacuum” (SV)/aether/condensate*. SUSYA not only predicts the existence of the graviton (as explained later on in this paper), but also predicts that, in contrast with the photon (which is stated by SUSYA to can only produce VPAPs composed from charged EPs which couple electromagnetically/with the electromagnetic field of the photon), only the graviton can produce VPAPs composed from neutral EPs, including pairs of neutrinos, Hfs and Zfs, depending on the energy of the graviton (**gr**), which may depend on its wavelength (λ) if modeled similarly to the photon so

that its energy would be $E_{gr} = h_{gr}c / \lambda$, with $h_{gr} (\ll h)$

being a Planck-like gravitonic constant measuring the quantum of the angular momentum of any graviton (which h_{gr} may actually inverse-proportionally vary with the length-scale λ explaining why G may also vary with λ in the same way).

Heisenberg’s Uncertainty principle (HUP) can be also extended on gravitons (and on all light neutral EPs that may be generated by the hypothetical graviton, in pairs/VPAPs) so that

$$\rho_x \rho_p \geq \hbar_{gr} / 2 (\ll \hbar / 2) \quad (\text{with a reduced gravitonic}$$

Planck-like constant defined as $\hbar_{gr} = h_{gr} / (2\pi)$): all these

known and predicted neutral EPs (Hfs, Zfs and all three known generations of neutrinos) are thus stated by SUSYA to be governed by this SUSYA-proposed extension of HUP (eHUP). Furthermore, this eHUP supports a realistic interpretation like the one recently proposed by Lindgren and Liukkonen [27].

These Hfs and Zfs may also explain *the physical time arrow* (flowing from the past to the future) by the irreversibility of Hf/Zf movements which *massless fermions are stated to cannot inversely describe any initial trajectory* (so that each of their trajectories of movement is unique and unrepeatable in the exactly inverse way).

This Hf/Zf-based SV (modeled as a fermionic condensate which may allow subtle resonance-like correlations between its distant regions) may also be a medium that allows and thus explains *quantum entanglement*.

The rest energy of Hf and Zf would be zero (as they are defined by SUSYA to possess only relativistic energy) and their relativistic energy of Hf and Zf would be the minimum (min) conceivable energy (E_{\min}) in our observable universe (ObU) which may be arbitrarily identified with the relativistic energy of a photon with wavelength equal to diameter of ObU ($D_{ObU} \cong 10^{27} m$) so that:

$$E_{Hf/Zf} = E_{\min} \cong hc / D_{ObU} \cong 10^{-33} eV \quad (5)$$

This predicted/estimated relativistic energy (E_{\min}) of Hf/Zf corresponds to a theoretical minimum rest mass (allowed in our universe) of $m_{Hf/Zf} = E_{Hf/Zf} / c^2 \cong 10^{-69} kg$ which is almost infinitesimal and may be reasonably

approximated to $m_{Hf/Zf} \cong 0kg$ (as predicted by the conjugated solutions of the main equation proposed by eZEH).

However, if the Planck-like gravitonic constant $h_{gr} (\ll h)$ (attributed to the hypothetical graviton) is

$$\text{estimated as } h_{gr} = h \cdot (\alpha_G / \alpha_0) \cong 10^{-43} h \quad (\text{with}$$

$\alpha \cong 137^{-1}$ being the value at rest of the *electromagnetic coupling constant* and $\alpha_G \cong 1.75 \times 10^{-45}$ being the value at rest of the *electromagnetic coupling constant*) then we may hypothesize an alternative gravitonic minimum energy-quantum

$$\text{of our ObU as } E_{\min(gr)} \cong h_{gr} c / D_{ObU} \cong 10^{-76} eV$$

(corresponding to a theoretical relativistic mass of the hypothetical graviton of $m_{gr} = E_{\min(gr)} / c^2 \cong 10^{-112} kg$).

A redefinition of the speed of light in vacuum (as based on Zf and Hf) and an explanation on the apparently paradoxal behavior of the superfluid vacuum/aether. Zfs and Hf (with zero rest mass or a finite and non-infinitesimal minimum rest mass $m_{\min} \cong 0kg$ allowed in our universe) can

actually be assigned a finite maximum allowed speed v_{\max} (for any EP to travel in our universe): the photon is redefined by SUSYA as an quantized oscillation of this Zf/Hf-based fermionic SV (composed from Zfs and Hfs moving at maximum speed v_{\max}), thus the photon can only travel in this fermionic SV at speeds $c \leq v_{\max}$ (so that the speed of a photon in

vacuum is inversely redefined as $c \cong v_{\max}$). Because the usually photon reaches speeds $c \cong v_{\max}$ in the “perfect SV the vacuum, this “sea” of Zfs and Hfs firmly opposes to any further acceleration of the photon, suddenly behaving like a very rigid/stiff solid-like elastic medium with a specific non-zero degree of elasticity (with huge energetic volumic density possibly approaching Planck density and a very large characteristic impedance of $c^3 / G \cong 4 \times 10^{35} kg/s$) in which the photon propagates as a *transverse wave* (like also the *gravitational [transverse] waves* and analogously to a sonic “boom”): that is how SUSYA explains why light behaves like a transverse wave (which commonly occur in elastic solids) in many types of specific experiments (like the Thomas Young’s double-slit experiment showing the diffraction of light); however, when any physical object (**PO**) travels in this Zf/Hf-based SV at low speeds $v (\ll v_{\max})$, SV opposes just a minimum (practically zero!) resistance to that movement, because Zfs and Hfs are very weakly interacting with any form of matter composing a PO. Furthermore, the solid-like resistance generated by the Zf/Hf-based SV at large/ultrarelativistic speeds v (a resistance highly opposing to the ultrarelativistic movement of any physical object [**PO**] with non-zero rest mass) may also explain the *Lorentz length compression factor*

$\gamma = 1 / \sqrt{1 - (v/c)^2}$ (applied as $l' = l / \gamma$ when the length of that PO is parallel to its direction of movement) and the phenomenon of relativistic mass dilation $m' = \gamma \cdot m$ (explained by a progressively larger number of Zfs and Hfs that may “precipitate” on and thus progressively increase the mass of any

PO moving at ultrarelativistic speeds v). In other words, SUSYA states that no other EP can surpass the speed of Hfs and Zfs ($v_{\max} \cong c$) simply because there is no EP lighter than Hfs and Zfs (composing SV): $v_{\max} (\cong c)$ is explained to be the same in all possible inertial reference-frames simply because SV is actually composed from these neutral massless fermions (Hfs and Zfs) which all travel at approximately the same speed $v_{\max} (\cong c)$ in a Brownian manner, in all possible conceivable directions of space, in all possible conceivable reference-frames.

The eZEH-predicted Zfs and Hfs have also some similarities to the so-called “etheron” proposed in an article from 1982 by the Romanian physicist Ioan-Iovitz Popescu which defined it as an elementary particle with “*exceedingly small [rest] mass, traveling chaotically at speed of light*” and estimated its rest mass as $m_0 = \frac{3}{2} \hbar H_0 / c^2 \cong 10^{-69} kg$ (with $H_0 \cong 70 (km/s) / Mpc$ being the Hubble constant) and rest

energy $E_0 = \frac{3}{2} \hbar H_0 (\cong 10^{-33} eV)$ [13]: note that E_0 is very close to the previous estimation of the Hf/Zf relativistic energy

$$E_{Hf/Zf} = E_{\min} (\cong 10^{-33} eV), \quad \text{because}$$

$c / H_0 (\cong 10^{-26} m)$ has a magnitude close to $D_{ObU} \cong 10^{27} m$, so that

$$E_0 \left(= \frac{3}{2} \hbar H_0 = \frac{\frac{3}{2} \hbar c}{c / H_0} \right) \cong E_{\min} \left(= \frac{hc}{D_{ObU}} \right) \cong 10^{-33} eV.$$

Important prediction. SUSYA also predicts that it is very possible for all the stars to produce (by hydrogen fusion to helium) large quantities of such neutral massless Majorana Higgs-fermions (**Hfs**) and Z-fermions (**Zfs**) which may progressively add volume to the current aether (identified with our apparently 3D empty space) and thus to produce an accelerated global expansion of our universe.

1.3.4(5). The proposed mass-conjugation between the three known types of neutrinos and the photon, gluon and the hypothetical graviton

Focusing on all three types of neutrinos, photon, gluon and hypothetical graviton. In a second step, eZEH estimates the lower bounds of ϕ_g for all known three neutrinos, as deduced from the currently estimated upper bounds of the non-zero rest energies of all three known types of neutrino: the electron neutrino (**en**) with $E_{en} < 1eV$ [28], the muon neutrino (**mn**) with $E_{mn} < 0.17MeV$ [29] and the tau neutrino (**tn**) with $E_{tn} < 18.2MeV$ [30, 31]: $\phi_{g(en)} > \cong 10^{53} u$, $\phi_{g(mn)} > \cong 6 \times 10^{47} u$ and $\phi_{g(tn)} > \cong 6 \times 10^{45} u$, with $\phi_{g(en)}$ being assigned a very large G_{var} upper bound $G_{en} (= \phi_{g(en)} r_{\min}) \cong 2 \times 10^{28} G$, so that $G_{var} \in [G, G_{en}]$ and thus strengthening the previously introduced (sub-)hypothesis $\phi_g m^2 \cong \phi_e q^2$ at scales close to Planck scale.

Remark. It is easy to observe that eZEH generally predicts

progressively larger “real” big G values for progressively smaller m : an additional explanation for this correlation shall be offered later in this paper. We must also remind that a specific virtual EP (**VEP**) may have a variable mass lower or equal to the mass m of the real “version” of the same EP ($m_{VEP} \leq m$) and that is why the “virtual” big G values assigned to the gravitational field acting between a virtual particle and its antiparticle (part of the same VPAP) may be even larger than the previously calculated ones.

eZEH cannot directly estimate the values of $\phi_{g(NEP)}$ for the massless photon (**ph**) $\phi_{g(ph)}$ and the gluon (**gl**) $\phi_{g(gl)}$ due to the division-by-zero error/paradox. However, eZEH additionally states that $\phi_{g(ph)}$ and $\phi_{g(gl)}$ may have very large values coinciding with $\phi_{g(en)}$, $\phi_{g(mn)}$ and $\phi_{g(tn)}$. More specifically, eZEH speculates that $\phi_{g(ph)} > \phi_{g(gl)}$ and that there also exists a massless graviton (**gr**) defined by

$\phi_{g(gr)} > \phi_{g(ph)} (> \phi_{g(gl)})$ so that: $\boxed{\phi_{g(gr)} = \phi_{g(en)}}$,

$\boxed{\phi_{g(ph)} = \phi_{g(mn)}}$ and $\boxed{\phi_{g(gl)} = \phi_{g(tn)}}$. **In other words,**

SUSYA actually predicts these *three pairs of mass-conjugates (MCs)*: (gr , en), (ph , mn) and (gl - tn). Furthermore and accordingly to eZEH, because the hypothetical gr (**hgr**), ph and gl are their own antiparticles (as generally considered in the Standard Model), *this eZEH-based SUSYA predicts that en, mn and tn (defined as the MCs of hgr, ph and gl respectively) are also their own antiparticles, thus they are predicted to be actually elementary Majorana fermions (EMFs) (aka Majorana neutrinos*, because Majorana fermions are electromagnetically neutral by definition, otherwise they couldn't be their own antiparticles). More ambitiously (and also based on the same eZEH), SUSYA also predicts that, because hgr is the MC of the en, a sufficiently high-energy hgr may produce (or “decay to”) an en-pair: the same for ph (which may produce a mn-pair) and for gl (which may produce a tn-pair). SUSYA also predicts the multiple possibility that: **(1)** en to decay to a (hgr, Hf/Zf) pair, **(2)** mn to decay to a (ph, Hf/Zf) pair, **(3)** tn to decay to a (gl, Hf/Zf) pair.

Like all EMFs (including the hypothetical Hf and Zf) en, mn and tn are also stated by SUSYA to not possess intrinsic electric or magnetic moments, but only *toroidal moments* (produced by their *helicity*) which allows only minimal interactions with electromagnetic fields (thus making them plausible candidates for *cold dark matter*). Also, like all EMFs, en, mn and tn are also stated by SUSYA to *violate the conservation of lepton number and even to violate the difference between the baryon number (B) and the lepton number (L)* (the so-called “B - L”/ “bee minus ell”): thus, SUSYA predicts that, even if it hasn't been observed yet in nature (nor in various experiments), neutrinoless double beta decay (**NDBD**) is possible, because NDBD can be viewed as two ordinary beta decays whose resultant antineutrinos immediately annihilate with each other (an annihilation that is only possible if neutrinos are their own antiparticles).

In this new light of SUSYA, *the hypothetical aether components Hf and Zf may be actually considered a “0th” (4th) (still undetected) generation of (Majorana) neutrinos.*

In a checkpoint conclusion, by predicting en, mn and tn to be all EMFs (additionally to the SUSYA-predicted hypothetical aether components Hf and Zf which are also defined as EMFs),

SUSYA is in agreement with the currently most-favored explanation of the smallness of neutrino mass, the *seesaw mechanism (SMEC)* (in which the neutrino is “naturally” a Majorana fermion).

SMEC may naturally explain why the observed neutrino rest-masses are so small. There are several types of hypothetical SMECs (index as type 1, 2 etc), each proposed as a possible extension of the Standard Model (SM). Type-1 SMEC (**SMEC-1**) is the simplest variant of SMEC and assumes two or more additional right-handed neutrino fields inert under the electroweak interaction (the so-called “sterile neutrinos”), and the existence of a very large mass scale identifiable with the postulated scale of grand unification (**GU**). More specifically, SMEC-1 produces both a light neutrino and a very heavy one (yet to be observed) for each of the three known neutrino flavors. SMEC-1 is actually based on a simple mathematical principle following property of the symmetric 2x2 mass matrix

for the neutrinos of the form $A = \begin{pmatrix} 0 & M \\ M & B \end{pmatrix}$ (with B being the

Majorana mass component of the neutrinos and M being the *Dirac mass component* of the neutrinos) with a *characteristic polynomial (CP)* $|A'|$ (a polynomial which is invariant under

matrix similarity and has the eigenvalues of A as roots), with *eigenvector matrix*

$$A' = x \cdot I_2 - A = x \cdot \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0 & M \\ M & B \end{pmatrix} = \begin{pmatrix} x & -M \\ -M & x-B \end{pmatrix} \quad (\text{with}$$

$$I_2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \text{ being the 2x2 identity matrix with 1-values on}$$

the main diagonal and 0-values on the secondary diagonal): the determinant $|A'|$ (defining the CP) can be easily estimated as

$$|A'| = \begin{vmatrix} x & -M \\ -M & x-B \end{vmatrix} = x(x-B) - (-M)^2 \quad \text{and} \quad \text{the}$$

characteristic/determinantal (quadratic) equation (**CE**)

$$|A'| = 0 \Leftrightarrow \boxed{x^2 - xB - M^2 = 0}. \text{ Noting the coefficient of}$$

this CE with $a = 1$, $b = -B$ and $c = -M^2$, the x_{\pm} solutions of CE are actually the eigenvalues of matrix A and can be

$$\text{easily determined as } x_{\pm} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \text{ which is}$$

$$\text{equivalent to } \boxed{x_{\pm} = \frac{B \pm \sqrt{B^2 + 4M^2}}{2}}, \text{ with product}$$

$$\boxed{x_+ \cdot x_- = -M^2} : \text{ as one may easily note from these } x_{\pm}$$

solutions, if one of the eigenvalues (x_+) goes up, the other (x_-) goes down (and vice versa) and that is why SMEC was

coined as “seesaw” mechanism. In applying SMEC-1 to neutrinos, the *Majorana mass component B* (which is defined as comparable to the GU energy-scale and violating lepton number) is taken to be much larger (\gg) than *Dirac mass component M* of the neutrinos (which is comparable to the much smaller electroweak energy-scale), which implies that $B^2 + 4M^2 \cong B^2$ (because $4M^2 \ll B^2$): that is why

$x_+ \left(\cong \frac{B + \sqrt{B^2}}{2} \right) \cong B$ and the smaller eigenvalue (x_-) is

approximated from the previously mentioned equality ($x_+ \cdot x_- = -M^2$) to $x_- \left(\cong \frac{-M^2}{x_+} \right) \cong \frac{-M^2}{B} \cong 0$ [7] [32, 33, 34].

That is how SMEC-1 explains why the neutrino masses (corresponding to the x_- solution) are so small ($\sim 1\text{eV}$), which is in relative agreement with the most recent experiments that estimate the rest energy-masses of the three known generations of neutrinos: this (relative) agreement is sometimes regarded as supportive evidence for the framework of GU theories.

The conjugated solutions $x_{\pm} \left(= \frac{B \pm \sqrt{B^2 + 4M^2}}{2} \right)$

(proposed by SMEC-1) have striking similarity with the solutions (3) of the main equation (2) of eZEH

$m_{\pm} = \frac{c^2 \pm \sqrt{c^4 - \phi_g \phi_e q^2}}{\phi_g}$ (presented in the first sections of

this paper); to exactly resemble x_{\pm} solutions, the m_{\pm} solutions (proposed by eZEH) can be rewritten as:

$$m_{\pm} = \frac{\frac{2c^2}{\phi_g} \pm \sqrt{\frac{4c^4}{\phi_g^2} - \frac{2\phi_e q^2}{\phi_g}}}{2} \quad (5)$$

According to this similarity (invoked by SUSYA), $(2c^2 / \phi_g) (= 2rc^2 / G)$ corresponds to B , $-(2\phi_e q^2 / \phi_g)$ corresponds to $4M^2$, thus $\sqrt{\frac{-2\phi_e q^2}{4\phi_g}} \left(= \frac{q}{2} \sqrt{\frac{-2\phi_e}{\phi_g}} \right) = \frac{q}{2} \sqrt{\frac{-2k_e}{G}}$ corresponds to M).

The 2x2 symmetrical mass matrix with m_{\pm} solutions as eigenvalues would be:

$$Z = \begin{pmatrix} 0 & \frac{q}{2} \sqrt{\frac{-2k_e}{G}} \\ \frac{q}{2} \sqrt{\frac{-2k_e}{G}} & \frac{2rc^2}{G} \end{pmatrix} \quad (6)$$

The equation (2) of eZEH may be thus redefined as the *characteristic equation* (derived from the *characteristic polynomial* by equaling it to zero) of this Z mass matrix.

The $a_{2,2}$ element $2rc^2 / G$ (of the previous mass matrix Z) is actually a *Majorana mass component* B and may be written as a variable (**var**) real mass component

$m_{\text{var}}(r) = 2rc^2 / G$ (which takes only real-number values

for $r \geq r_{\min}$): $m_{\text{var}}(r)$ is a simple linear function of $r (\geq r_{\min})$, which takes the value of $2m_{Pl}$ for distance $r = l_{Pl}$ (with $m_{Pl} = \sqrt{\hbar c / G} \cong 2.18 \times 10^{-8} \text{kg}$ being the Planck mass and $l_{Pl} = \sqrt{\hbar G / c^3} \cong 1.62 \times 10^{-35} \text{m}$ being the Planck length) and progressively larger values (in a linear manner) for larger r values. However, G is also stated by SUSYA to vary with the length (thus energy) scale r (as previously calculated from the various values of ϕ_g for various

pairs of mass-conjugates and r_{\min} , as $G_{\min(x)} = \phi_{g(x)} r_{\min}$)

and that is why $m_{\text{var}}(r)$ can be generalized as $m_{\text{var}}(r) = 2rc^2 / G(r)$: exponentially larger $G(r)$ values with decreasing length scale r (as predicted by SUSYA) would allow elementary rest masses much lower than m_{Pl} for r -scales comparable to $r_{\min} (\cong 10^{-1} l_{Pl})$ as all known EPs actually have.

The $a_{1,2} (= a_{2,1})$ double element $(q/2) \sqrt{-2(k_e / G)}$ (of the same previous mass matrix Z) is actually a *Dirac mass component* M and may be written as a variable (**var**) imaginary mass component $m_{\text{var}(i)}(q) = (q/2) \sqrt{-2(k_e / G)}$ (which takes only imaginary values if both k_e and G remain positive reals at any length/energy scale $r \geq r_{\min}$): for example,

$m_{\text{var}(i)}(e) \cong 1.3i \times 10^{-9} \text{kg}$ (an imaginary undetectable mass which may be approximated with 0kg); thus SUSYA extends this simple 2x2 B-M symmetrical mass matrix A (applied by SMEC-1 to neutrinos only) to all known/unknown EPs (including neutrinos) as a more general mass matrix Z , so that the *Majorana mass component* B of any EP is predicted (by SUSYA) to be generally much larger than the *Dirac mass component* M of that same EP.

However, because k_e (which is directly-proportional to the *electromagnetic coupling constant* $\alpha(R)$ increasing with decreasing r -scale) and G are both stated by SUSYA to vary with the length r -scale (as $k_e(R)$ and $G(R)$), $m_{\text{var}(i)}(q)$ can be generalized as

$m_{\text{var}(i)}(q, r) = (q/2) \sqrt{-2k_e(r) / G(r)}$. This

generalized mass-function has imaginary-number values, but may have real-number values only if the variable gravitational constant scalar $G(r)$ would invert its sign and become negative (so that the $-2k_e(r) / G(r)$ ratio would become positive): in this case, the gravitational field (**GF**) may become very strongly repulsive for infinitesimal length scales $r < r_{\min}$ and that may explain why our universe doesn't allow r scales smaller than r_{\min} (because a very strongly repulsive GF under

r_{\min} would simply prevent any collapse to scales smaller than r_{\min}). Based on this predicted repulsive GF (for scales $r < r_{\min}$), SUSYA thus predicts that our universe doesn't actually allow true gravitational singularities, but only gravitational quasi-singularities: that is how SUSYA tries to solve the singularity paradox of Einstein's General Relativity (EGR).

A negative-valued $G(r)$ (for $r < r_{\min}$) would also imply a negative (real-numbered) *Majorana mass component*

$$m_{\text{var}}(r) = 2rc^2 / G(r) \quad \text{for } r < r_{\min} : \text{hypothetical EPs}$$

with negative rest mass-energy are not a novelty per se in physics, as they were also considered much earlier by other physicists: in 1928, Paul Dirac's theory of EPs (part of the current Standard Model [SM]) firstly included negative solutions [35]; quantum electrodynamics (QED) (the "core" of SM) also works with the concept of negative mass-energy.

The previously introduced Z mass matrix may be now redefined as:

$$Z(q, r) = \begin{pmatrix} 0 & m_{\text{var}(i)}(q, r) \\ m_{\text{var}(i)}(q, r) & m_{\text{var}}(r) \end{pmatrix} \quad (6')$$

The equation (2) of eZEH may be thus re-redefined as the *characteristic equation* (derived from the *characteristic polynomial*) of this Z mass matrix.

SUSYA additionally predicts that the length domain $r < r_{\min}$ may be "populated" by "exotic" EPs with negative and/or imaginary rest mass-energies (which may be regarded as the "shadows" of the known positive-mass EPs) which are coined as "shadow"-EPs (shEPs) in this paper: furthermore, SUSYA also predicts that the core of any black hole (BH) may also be populated by such shEPs which may conserve all the physical information (stored on all "normal"/"standard" EPs) absorbed by any BH (thus solving the *BH information paradox*) and may be regarded as an "empty"/"shadowy" BH-core.

In a checkpoint conclusion, both concepts of *imaginary mass-energy* and *negative mass-energy* are very important in this eZEH-based SUSYA which proposes $Z(q, r)$ -based SMEC (**Z-SMEC**) as a *universal seesaw mechanism* (organizing all EPs in specific pairs of mass-conjugates, analogously/similarly to the neutrinos as standardly modeled by SMEC-1) applicable not only to neutrinos, but to all the EPs of the Standard Model (SM) of particle physics and far beyond SM.

1.3.5(6). The proposed mass-conjugation between the electron and the W boson; two proposed bosonic mass-conjugates for the muon and the tauon

Focusing on the electron-W boson conjugated pair, but also on the muon and tauon which are predicted to have ultra-heavy charged bosonic mass-conjugates. In a third step, eZEH additionally states that the W boson and the electron may also form a conjugate boson-fermion pair with rest masses

$$m_e = \left(c^2 - \sqrt{c^4 - \phi_{g(W/e)} \phi_{e(W/e)} q_e^2} \right) / \phi_{g(W/e)} \quad \text{and}$$

$$m_e = \left(c^2 - \sqrt{c^4 - \phi_{g(W/e)} \phi_{e(W/e)} q_e^2} \right) / \phi_{g(W/e)} \quad \text{and}$$

$$m_W = \left(c^2 + \sqrt{c^4 - \phi_{g(W/e)} \phi_{e(W/e)} q_e^2} \right) / \phi_{g(W/e)}. \quad \text{The}$$

common term $\sqrt{c^4 - \phi_{g(W/e)} \phi_{e(W/e)} q_e^2}$ of both rest masses (m_e and m_W) disappears when summing

$$m_e + m_W = 2c^2 / \phi_{g(W/e)}, \text{ from which their common/shared}$$

$\phi_{g(W/e)}$ ratio can be reversely estimated as

$$\phi_{g(W/e)} = 2c^2 / (m_e + m_W) \cong 1.25 \times 10^{42} u, \text{ which is}$$

relatively close to $\phi_{g(Zb)} (\cong 10^{42} u)$ and

$\phi_{g(Hb)} (\cong 8 \times 10^{41} u)$, thus we have an estimated

$$G_{W/e} (= \phi_{g(W/e)} r_{\min}) \cong G_{Zb} \cong G_{Hb} \cong 2 \times 10^{16} G. \text{ The other } \phi_{e(W/e)}$$

ratio can be also reversely estimated from both m_W (or m_e)

$$\text{and } \phi_{g(W/e)} \text{ as } \phi_{e(W/e)} \cong 6.4 \times 10^{24} F^{-1}.$$

In the case of the muon (**m**) and tauon (**t**) (which are currently considered two distinct excited states of the electron) eZEH predicts that they may be conjugated with two predicted hypothetical bosons (which are analogously considered two distinct excited (ultra-heavy) states of the W boson) called here the "*W-muonic boson*" (**Wmb**) and the "*W-tauonic boson*" (**Wtb**) respectively, which Wmb and Wtb are probably much heavier than the W boson and the Higgs boson: Wmb and Wtb can be also regarded as *ultra-heavy charged Higgs bosons* with their rest energies defining the energy scale at which the electroweak field (**EWf**) may be unified with the Higgs field.

Furthermore, Wtb is predicted by SUSYA to be the heaviest possible EP (allowed in our universe) that may decay to many other lighter EPs (including decaying into leptoquarks, as explained later): also, the muon and the tauon may be produced not only by the decay of their heavier mass-conjugates (MCs) Wmb and Wtb, but also by the decay of leptoquarks (as also explained later in this paper). **In a checkpoint conclusion**, the Wtb-tauon pair of MCs is retrodicted by SUSYA to be actually the 1st step (/level/type) of symmetry breaking (**SB**) in our universe, which may have had occurred immediately after Big Bang (**BB**) or even right in the BB moment: *all the other lighter EPs* (from the leptoquarks domain down to the lowest-energy domain dominated by the massless Majorana neutrinos H_f and Z_f predicted to compose a so-called superfluid aether) *are thus redefined by SUSYA to be actually just the final products of this 1st step of SB.*

1.3.6(7). The proposed mass-conjugation between the three known generations of quarks and three predicted generations of fractional-charge bosons (known as "leptoquarks")

Focusing on a proposed mass conjugation between the three known generations of quarks and three predicted generations of fractional-charge bosons (leptoquarks). eZEH also predicts that the six known quarks may have as mass-conjugates a set of six fractional-(electromagnetic)charge bosons known as *leptoquarks* (**LQs**) (hypothetical EPs that

would carry information between each generation of quarks and a correspondent generation of leptons, thus allowing quarks and leptons to interact). LQs were first predicted by various extensions of the Standard Model, such as *technicolor theories* and *Grand unified theories (GUTs)* based on *Pati–Salam model*, *SU(5)* or *E6*, etc

LQs were predicted to be considerably unstable and heavy EPs (nearly as heavy as an atom of lead) that may only be produced in LHC at very high energies of collisions: the quantum numbers (like spin, fractional electromagnetic charge [EMC] and weak isospin) vary among theories. *However, eZEH specifically predicts that LQs (the mass-conjugates of quarks) also organize in three generations AND can only have the same fractional EMC as quarks (an essential eZEH-imposed condition for being “mass-conjugates” of those known quarks), so that and given $\phi_{g(\text{Hb})} (= 2c^2 / m_{\text{Hb}})$:*

(1a) A so-called 1st generation LQ named “*up-leptoquark*” (**uLQ**) with rest mass $m_{\text{uLQ}} (> m_{\text{Hb}})$,

$$\phi_{g(\text{uLQ})} = \frac{2c^2}{m_{\text{uq}} + m_{\text{uLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$+2/3 e$ (the mass-conjugate of the up quark sharing the same EMC $+2/3 e$) may decay (by conserving its EMC, however) into an up quark (with the same EMC $+2/3 e$) and an electron neutrino/antineutrino **OR** may decay into a down quark (with emc $-1/3 e$) and a positron (with EMC $+e$);

(1b) A so-called 1st generation LQ named “*down-leptoquark*” (**dLQ**) with rest mass $m_{\text{dLQ}} (> m_{\text{uLQ}} > m_{\text{Hb}})$,

$$\phi_{g(\text{dLQ})} = \frac{2c^2}{m_{\text{dq}} + m_{\text{dLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$-1/3 e$ (the mass-conjugate of the down quark sharing the same EMC $-1/3 e$) may decay into a down quark (with the same EMC $-1/3 e$) and an electron neutrino/antineutrino **OR** may decay into an up quark (with EMC $+2/3 e$) and an electron (with EMC $-e$);

(2a) A so-called 2nd generation LQ named “*charm-leptoquark*” (**cLQ**) with rest mass $m_{\text{cLQ}} (> m_{\text{Hb}})$,

$$\phi_{g(\text{cLQ})} = \frac{2c^2}{m_{\text{cq}} + m_{\text{cLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$+2/3 e$ (the mass-conjugate of the charm quark sharing the same EMC $+2/3 e$) may decay (by conserving its EMC, however) into a charm quark (with the same EMC $+2/3 e$) and a muon neutrino/antineutrino **OR** may decay into a strange quark (with emc $-1/3 e$) and an antimuon (with emc $+e$);

(2b) A so-called 2nd generation LQ named “*strange-leptoquark*” (**sLQ**) with rest mass $m_{\text{sLQ}} (> m_{\text{Hb}})$,

$$\phi_{g(\text{sLQ})} = \frac{2c^2}{m_{\text{sq}} + m_{\text{sLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$-1/3 e$ (the mass-conjugate of the strange quark sharing the same EMC $-1/3 e$) may decay into a strange quark (with the same

EMC $-1/3 e$) and a muon neutrino/antineutrino **OR** may decay into a charm quark (with EMC $+2/3 e$) and a muon (with EMC $-e$);

(3a) A so-called 3rd generation LQ named “*top-leptoquark*” (**tLQ**) with rest mass $m_{\text{tLQ}} (> m_{\text{Hb}})$,

$$\phi_{g(\text{tLQ})} = \frac{2c^2}{m_{\text{tq}} + m_{\text{tLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$+2/3 e$ (the mass-conjugate of the top quark sharing the same EMC $+2/3 e$) may decay (by conserving its EMC, however) into a top quark (with the same EMC $+2/3 e$) and a tauon neutrino/antineutrino **OR** may decay into a bottom quark (with emc $-1/3 e$) and an antitauon (with EMC $+e$);

(3b) A so-called 3rd generation LQ named “*bottom-leptoquark*” (**bLQ**) with rest mass $m_{\text{bLQ}} (> m_{\text{Hb}})$,

$$\phi_{g(\text{bLQ})} = \frac{2c^2}{m_{\text{bq}} + m_{\text{bLQ}}} \left(< \phi_{g(\text{Hb})} \right) \text{ and fractional EMC}$$

$-1/3 e$ (the mass-conjugate of the bottom quark sharing the same EMC $-1/3 e$) may decay into a bottom quark (with the same EMC $-1/3 e$) and a tauon neutrino/antineutrino **OR** may decay into a top quark (with EMC $+2/3 e$) and a tauon (with EMC $-e$);

The three generations of LQs could actually explain the reason for the three generations of matter (three generations of quarks plus three generations of leptons), why the same number of quarks and leptons exist and many other similarities between the quark and the lepton sectors. At high energies, at which leptons (which are not affected by the strong nuclear field [SNF]) and quarks (that cannot be separately observed because of SNF) become one: this could form a more fundamental particle and describe a higher symmetry (so that there would be three kinds of LQs, each decaying into the leptons and quarks of each generation in part). LQs may be demonstrated in the medium future by the so-called *LHeC project*, which will be built in the future by adding an electron ring to collide bunches with the existing LHC proton ring.

As anticipated, it is clear that eZEH doesn't allow to directly estimate the ϕ_g and ϕ_e ratios for each LQ-quark pair

but estimates that $\phi_{g(\text{LQs})} < \phi_{g(\text{Hb})}$ and $\phi_{e(\text{LQs})} > \phi_{e(W/e)}$:

the possible existence of LQs obviously implies the possible existence of *additional “exotic” fundamental physical forces/fields quantized by LQs (still unknown in the present)* indicating the approximate energy scale at which SNF and electroweak field (EWF) can be unified (by the so-called Grand unified theories [GUTs]).

2. A synthesis of SUSYA [3]

All the proposed pairs of EP-conjugates (as stated by the eZEH-based SUSYA) are also illustrated in the **next tables**: as it can be seen from these tables, eZEH transforms the already “classical” 2D table of EPs (from the Standard model of particle physics) in a 3D structure/table in which EPs are grouped *not only* in boson and fermion families/subfamilies, BUT they are also grouped and inter-related by an “underneath” relation of boson-fermion mass-conjugation, all based on the same simple

semi-empirical quadratic equation proposed by eZEH as derivable from this proposed universal seesaw mechanism based

on the $Z(q,r)$ mass matrix and applicable to all known and unknown EPs.

Table 1. The pairs of conjugated EPs (predicted by the eZEH-based SUSYA)

Boson (/correspondent conjugate boson of a known fermion)	Fermion (/correspondent conjugate fermion of a known boson)	Common/ shared ϕ_g ratio of a conjugated boson-fermion pair and the predicted big G values (assigned to each type of EP) $G_{pr} = \phi_{g(pr)} r_{\min}$	Common/ shared ϕ_e ratio of a conjugated boson-fermion pair and the predicted Coulomb's constant values $k_{e(pr)} = \phi_{e(pr)} r_{\min}$
Non-quark EPs as treated by the eZEH-based SUSYA			
hypothetical graviton (gr) (spin-2 neutral boson)	electron neutrino (en) (<i>Majorana</i> neutrino)	$\phi_{g(gr)} = \phi_{g(en)}$ ($> 1.1 \times 10^{53} u$) $G_{gr/en} > 2.1 \times 10^{27} G$	$\phi_{e(gr)} = ?$ $k_{e(gr)} = ?$
photon (ph) (spin-1 neutral boson)	muon neutrino (mn) (<i>Majorana</i> neutrino)	$\phi_{g(ph)} = \phi_{g(mn)}$ ($> 6 \times 10^{47} u$) $G_{ph/mn} > 1.2 \times 10^{22} G$ (the same for all photons, no matter their frequency)	$\phi_{e(ph)} = ?$ $k_{e(ph)} = ?$
gluon (gl) (spin-1 neutral boson, with color charge only)	tauon neutrino (tn) (<i>Majorana</i> neutrino)	$\phi_{g(gl)} = \phi_{g(tn)}$ ($> 5.6 \times 10^{45} u$) $G_{gl/tn} > 1.2 \times 10^{20} G$	$\phi_{e(gl)} = ?$ $k_{e(gl)} = ?$
Z boson (Zb) (spin-1 neutral boson)	“ Z-fermion ” (Zf) (predicted neutral massless 1/2-spin <i>Majorana</i> fermion/neutrino) (proposed as vector constituent of a fermionic superfluid aether (FSA))	$\phi_{g(Zb)} (= \phi_{g(Zf)}) \cong 10^{42} u$ $G_{Zb/Zf} \cong 2.1 \times 10^{16} G$	$\phi_{e(Zb)} = ?$ $k_{e(Zb)} = ?$
Higgs boson (Hb) (spin-0/scalar neutral boson)	“ Higgs-fermion ” (Hf) (predicted neutral massless 1/2-spin <i>Majorana</i> fermion/neutrino) (proposed as scalar constituent of a FSA)	$\phi_{g(Hb)} (= \phi_{g(Hf)}) \cong 8 \times 10^{41} u$ $G_{Hb/Hf} \cong 1.7 \times 10^{16} G$	$\phi_{e(Hb)} = ?$ $k_{e(Hb)} = ?$
W boson (Wb) (spin-1 charged boson)	electron (e)	$\phi_{g(W/e)} \cong 1.25 \times 10^{42} u$ $G_{W/e} \cong 2.6 \times 10^{16} G$	$\phi_{e(W/e)} \cong 6.4 \times 10^{24} F^{-1}$ $k_{e(W/e)} \cong 10^{-21} k_e$
“W-muonic” boson (Wmb) (very heavy spin-1 charged boson)	muon (m)	$\phi_{g(Wmb)} = ? (< \phi_{g(Hb)})$ $G_{Wmb} = ? (< G_{Hb})$	$\phi_{e(Wmb)} = ? (> \phi_{e(W/e)})$ $k_{e(Wmb)} = ? (> k_{e(Hb)})$
“W-tauonic” boson (Wtb) (ultra-heavy spin-1 charged boson)	tauon (t)	$\phi_{g(Wtb)} = ? (< \phi_{g(Hb)})$ $G_{Wtb} = ? (< G_{Hb})$	$\phi_{e(Wtb)} = ? (> \phi_{e(W/e)})$ $k_{e(Wtb)} = ? (> k_{e(Hb)})$

Quark-leptoquark (LQ) pairs of mass-conjugates as treated and predicted by the eZEH-based SUSYA			
up quark (uq)	up-LQ (uLQ)	$\phi_g(\text{uLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{uLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{uLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{uLQ})} = ? \left(> k_{e(Hb)} \right)$
down quark (dq)	down-LQ (dLQ)	$\phi_g(\text{dLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{dLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{dLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{dLQ})} = ? \left(> k_{e(Hb)} \right)$
charm quark (cq)	charm-LQ (cLQ)	$\phi_g(\text{cLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{cLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{cLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{cLQ})} = ? \left(> k_{e(Hb)} \right)$
strange quark (sq)	strange-LQ (sLQ)	$\phi_g(\text{sLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{sLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{sLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{sLQ})} = ? \left(> k_{e(Hb)} \right)$
top quark (tq)	top-LQ (tLQ)	$\phi_g(\text{tLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{tLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{tLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{tLQ})} = ? \left(> k_{e(Hb)} \right)$
bottom quark (bq)	bottom-LQ (bLQ)	$\phi_g(\text{bLQ}) = ? \left(< \phi_g(Hb) \right)$ $G_{\text{bLQ}} = ? \left(< G_{Hb} \right)$	$\phi_e(\text{bLQ}) = ? \left(> \phi_e(W/e) \right)$ $k_{e(\text{bLQ})} = ? \left(> k_{e(Hb)} \right)$

scale so that $\boxed{|E_g| \cong |E_q| \Leftrightarrow \phi_g m^2 \cong \phi_e q^2}$ and a very large-valued universal gravitational constant around Planck length scale $G_{Pl} \geq G_{gr} (> 2.1 \times 10^{27} G)$ (with G_{gr} being the big G assigned to the hypothetical graviton as shown in the 1st row of **Table 1**).

Because both G and k_e are stated to vary with the length scale $r (\geq r_{\min})$ thus to take the forms $G_{\text{var}}(r)$ and $k_e(r)$ respectively, the variable ϕ_g and ϕ_e ratios can be also rewritten as $\phi_{g(\text{var})(r)}$ and $\phi_{e(\text{var})(r)}$ respectively: SUSYA

thus predicts a global/universal electro-gravitational seesaw mechanism (**EGSM**) in which, when the electromagnetic field (**EMF**) increases in strength (at macroscopic scales) the gravitational field (**GF**) decreases in strength (at the same macroscopic scales) AND when EMF decreases in strength at microscopic scales (down to r_{\min} scales comparable to the Planck-length scale), the GF increases in strength at the same microcosmic Planck-like scale; the equation (2) of eZEH can

be also rewritten as $\phi_g(r)x^2 - (2c^2)x + \phi_e(r)q^2 = 0$, with

$$\text{solutions } m_{\pm} = \frac{c^2 \pm \sqrt{c^4 - \phi_{g(r)}\phi_{e(r)}q^2}}{\phi_{g(r)}}.$$

The r-scale-dependent $G_{\text{var}}(r)$ (variable) function transforms the classical Planck mass $m_{Pl} = \sqrt{\hbar c / G}$ in a

Planck mass series $\boxed{m_{Pl(\text{var})}(r) = \sqrt{\hbar c / G_{\text{var}}(r)}}$ which may

offer a very interesting new glimpse in the domain of quantum/micro black holes (as explained next). The huge $G_{Pl} (> 2.1 \times 10^{27} G)$ has many important implications indicating that micro(/ quantum) black holes (**MBHs**) usually assigned a size comparable to Planck length $l_{Pl} (= \sqrt{\hbar G / c^3}) (\cong 1.62 \times 10^{-35} m)$ and a mass equal to

the Planck mass $m_{Pl} = \sqrt{\hbar c / G} \cong 2.18 \times 10^{-8} kg$ (which is currently considered the approximate smallest mass of any MBH) may actually have much smaller masses of

$$\boxed{m_{MBH} = \sqrt{\hbar c / G_{Pl}} (< 10^{-22} kg) (< 10^5 GeV / c^2)}$$
 which

relatively superposes to the mass-domain of the known EPs (with the heaviest known EP namely the top-quark with rest mass $m_{tq} \cong 174 GeV / c^2$): by emphasizing this much

smaller $m_{MBH} (< 10^5 GeV / c^2)$, SUSYA strongly suggests

that all EPs may be actually non-extreme stable (quantum) MBHs defined as non-point-like gravitational quasi-singularities (with very small but non-zero and non-infinitesimal 3D/4D volumes) generated by a very strong gravitational field (**VSGF**) (measured by the scalar

$G_{Pl} > 2.1 \times 10^{27} G$) acting close to $r_{\min} (\cong 10^{-1} l_{Pl})$ scales: if all EPs are truly MBHs (as SUSYA predicts), then EPs should have non-zero radii relatively close to r_{\min} (this possibility of EPs being actually MBHs was also previously considered in a past article of the author [36]). **VSGF may also explain the almost perfect spherical shape of the cloud of evanescent VPAPs covering / shielding any electron (as recently demonstrated).**

The largeness of $G_{Pl} (> 2.1 \times 10^{27} G)$ may also indicate the existence of possible large/bulk 4th (/5th etc.) extra-dimensions of our universe in which the hypothetical graviton may escape (immediately after being emitted by these MBH-equivalent EPs), explaining why gravity is measured as being much weaker at large macrocosmic scales compared to scales comparable to Planck scales (r_{\min}).

Some other important implications and predictions of SUSYA were already presented in a past article [3].

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5. COMPETING INTERESTS

Author has declared that no competing interests exist.

1. See his Research Gate page: www.researchgate.net/profile/Thomas_Buckholtz

2. See his Research Gate page: www.researchgate.net/profile/Gary_Warren2

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