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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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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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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

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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**).

Keywords: Supersymmetry (SUSY); SUSY alternative (SUSYA); electromagnetic charge (EMC); charge-based mass symmetry/conjugation; extended zero-energy hypothesis (eZEH); conservation principle applied on zero-energy; elementary particles (EPs); "conjugated" boson-fermion pairs; leptoquarks (LQs); neutral massless fermions (NMFs); lightest possible (hot fermionic) dark matter (LPDM); superfluid fermionic vacuum/ether; Superfluid vacuum theory (SVT).

ABBREVIATIONS

AT : Aether theory
BB : Big Bang
BH(s) : Black Hole(s)
CBFP : Conjugated Boson-Fermion Pair
CE : Characteristic/Determinantal (quadratic) Equation (of a matrix / characteristic polynomial of a matrix)
CEP(s) : (Electromagnetically) Charged Elementary Particle(s)
CP : Characteristic Polynomial (of a matrix)
CPO : Composite (/non-elementary) physical object
DM : Dark Matter
EFE : Einstein's Field Equations
EGR : Einstein's General Relativity
EGSM : Electro-gravitational Seesaw Mechanism (Proposed by this SUSYA)
EGT(s) : Entropic Gravity Theory(ies)
eHUP : An Extension of Heisenberg's Uncertainty Principle (proposed by this SUSYA)
EMC : Electromagnetic Charge
EMF : Electromagnetic Field
en : Electron Neutrino
EP(s) : Elementary Particle(s)
ESR : Einstein's Special Relativity
EWF : Electroweak Field
eZEH : An Extended Zero-energy Hypothesis Proposed by This SUSYA
FSA : Fermionic Superfluid Aether
FSC : Fine Structure Constant (the Electromagnetic Running Coupling Constant at Rest)
FTG : Fatio/Le Sage theory of Gravitation
GF : gravitational Field
gl : Gluon
gr : A (hypothetical massless) Graviton (proposed by SUSYA
GU(T) : Grand Unification (theories)
GW(s) : Gravitational Wave(s)
Hb(s) : Higgs Boson(s)
Hf : "Higgs fermion" (the Mass-Conjugate of the Higgs Boson, as Defined by this SUSYA)
HF : Higgs Field
hMC(s) : heavier Mass-conjugate(s) as Defined by This SUSYA
HUP : Heisenberg's Uncertainty Principle

LA : *"Luminiferous Aether"*
LPDM : *Lightest Possible (hot fermionic) Dark Matter*
LQ(s) : *Leptoquark(s) of these types (proposed by SUSYA): uLQ (up-leptoquark), dLQ (down-leptoquark), cLQ (charm-leptoquark), sLQ (strange-leptoquark), tLQ (top-leptoquark) and bLQ (bottom-leptoquark)*
MBH(s) : *Micro(/ quantum) Black Hole(s)*
MC(s) : *Mass-Conjugate(s) as Defined by this SUSYA*
min : *Minimum (energetic minimum etc)*
MM : *Michelson–Morley (experiment)*
mn : *Muon Neutrino*
MN(s) : *Majorana Neutrino(s)*
MSSM : *Minimal Supersymmetric Standard Model*
NAPRF : *Non-absolute Preferred Reference Frame*
NDBD : *Neutrinoless Double Beta Decay*
NEP(s) : *(Electromagnetically) Neutral Elementary Particle(s)*
NMF(s) : *Neutral Massless Fermion(s)*
NMF-SV : *NMF-based Superfluid Vacuum/aether*
nzrm : *Non-Zero Rest Mass(es) (of Elementary Particles)*
ObU : *Observable Universe*
OMME : *Original Michelson–Morley experiment*
pBB(Q)S : *Pre-Big Bang (quasi-) singularity (as defined by this SUSYA)*
ph : *Photon*
PO(s) : *Physical Object(s)*
q : *Quark(s) of all Known Types: uq (up-quark), dq (down-quark), cq (charm-quark), sq (strange-quark), tq (top-quark) and bq (bottom-quark)*
QE : *Quantum Entanglement*
QED : *Quantum Electrodynamics*
QFT : *Quantum Field Theory*
QTE : *Quantum Tunnelling Effect*
SB : *Symmetry Breaking*
SB-SUSY : *Spontaneously Broken SUSY Variants*
SDM : *Scalar Dark Matter*
SFF : *Superfluid Fermionic Field*
SM : *The Standard Model of Particle Physics*
SMEC : *Seesaw Mechanism*
SMEC-1 : *Type-1 Seesaw Mechanism*
SP : *Superpartner Particle (as defined by SUSY)*
SRT : *Special Relativity Theory*
SUSY : *Supersymmetry (theories)*
SUSYA : *SUSY-alternative (a theory Alternative to the Currently known Supersymmetry Theories)*
SV : *Superfluid Vacuum/Aether*
SVT : *Superfluid Vacuum Theory*
tn : *Tau Neutrino*
ULDM : *Ultra-Light Dark Matter*
VEP(s) : *Virtual Elementary Particle(s)*
VPAP(s) : *Virtual Particle-Antiparticle Pair(s)*
VSGF : *Very Strong Gravitational Field (proposed/predicted by this SUSYA to manifest at Planck length scales)*
WILP(s) : *Weakly-Interacting Lightest Particle(s)*
Wmb : *(a hypothetical) "W-muonic boson" proposed by this SUSYA*
WPD : *wave-particle duality*
Wtb : *(a hypothetical) "W-tauonic boson" proposed by this SUSYA*
Zb(s) : *Z-boson(s)*
ZEH : *A Zero-Energy Hypothesis Proposed by This SUSYA*
ZEUH : *Zero-Energy Universe Hypothesis*
Zf : *"Z-fermion" (the mass-conjugate of the Z boson, as defined by this SUSYA)*
Z-SMEC : *a universal seesaw mechanism (as based on a Z matrix) proposed by this SUSYA*

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 (from few TeV up to hundreds of TeV) 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 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**). 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 (Majorana) 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 [Error! Bookmark not defined.]. ZEH can be egarded 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*:

$$2E_m + E_g + E_q = 0 \tag{1}$$

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 $x(=m)$:

$$\phi_g x^2 - \left(2c^2\right)x + \phi_e q^2 = 0 \tag{2}$$

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

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

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 $q_{(\cong e)} \in \{e, \pm 1/3\, e, \pm 2/3\, e\}$ 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 $q = e$, $r_{\min} / l_{Pl} = \sqrt{\alpha_0} \cong 11.71^{-1}$ with $\boxed{\alpha_0 = \frac{k_e e^2}{\hbar c}\left(\cong 137^{-1}\right)}$ 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*. More interestingly, for neutral EPs (**NEPs**) with $q = 0(\mathrm{C})$ (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 $m_+ = \left(c^2 + \sqrt{c^4}\right) / \phi_g = 2c^2 / \phi_g \,(>0\,kg)$ (like in the case of all three types of neutrinos, the Z boson and the Higgs boson) AND

(**2**) zero values $m_- = \left(c^2 - \sqrt{c^4}\right) / \phi_g = 0\,kg$ (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).

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**) $\boxed{x_{\pm} = \frac{B \pm \sqrt{B^2 + 4M^2}}{2}}$, which are the conjugated solutions of the *characteristic/determinantal*

(quadratic) equation (**CE**) $\boxed{x^2 - xB - M^2 = 0}$ derived from the *characteristic polynomial* (**CP**) $|A'|\left(= x \cdot I_2 - A\right)$ of the 2x2 symmetrical matrix $A = \begin{pmatrix} 0 & M \\ M & B \end{pmatrix}$ (with B being the Majorana mass component of the neutrinos and M being the Dirac mass component of the neutrinos) [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, 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 $c^2 / \phi_g \left(= rc^2 / G\right)$ 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 $\phi_g \left(= G / \mathrm{r}\right)$ 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 $r_{\min} \left(\cong 10^{-1} l_{Pl}\right)$.

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 it *does not 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 $\Delta m = m_2 - m_1 \left(\geq 0\, kg\right) = f\left(q\right)$ between various types of generic EPs ("1" and "2"). eZEH additionally states that the two conjugated elementary mass solutions $m_{\pm} = \left(c^2 \pm \sqrt{c^4 - \phi_g \phi_e q^2}\right) / \phi_g$ (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 (Majorana) 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 plausibly be 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**).

1.3.3 The other equations of eZEH

The alternative variant of the main quadratic equation of eZEH and its implications. In the case of a virtual (charged) particle-antiparticle pair (**VPAP**) (with total rest mass $2m$ and total rest energy $2E_m = 2mc^2$) produced by a photon with wavelength λ and relativistic energy $E_{ph} = hc/\lambda = 2E_m$, equation (1) becomes:

$$E_{ph} + E_g + E_q = 0 \quad \left(\Leftrightarrow 2E_m + E_g + E_q = 0\right) \tag{1'}$$

Defining the same ratios $\phi_g = G/r$ and $\phi_e = k_e/r$ the previous equation is equivalent to an even simpler quadratic equation with unknown $x\left(=m\right)$:

$$\phi_g x^2 + \left(\phi_e q^2 - hc/\lambda\right) = 0 \tag{2'}$$

The previous equation is easily solvable and has two possible solutions which are both reals (with one being a positive real) only if $\boxed{hc/\lambda - \phi_e q^2 \geq 0}$:

$$m_{\pm}\left(=x_{\pm}\right) = \pm\sqrt{\frac{hc/\lambda - \phi_e q^2}{\phi_g}} \tag{3'}$$

From the previous formula (3') it is obvious that, for elementary rest masses m to take only discrete/quantized values, λ, ϕ_e and ϕ_g should all have only discrete values, at least in the interval of length scales close/comparable to $r_{\min} = q\sqrt{Gk_e}/c^2\left(\cong 10^{-1} l_{Pl}\right)$ (scales at which charged EPs are predicted to pop out from vacuum as VPAPs).

The realness condition $\boxed{hc/\lambda - \phi_e q^2 \geq 0}$ $\left(\Leftrightarrow hc/\lambda \geq k_e q^2/r\right)$ can be written as a function of the fine structure constant (**FSC**)/ alpha constant $\boxed{\alpha_0 = \frac{k_e e^2}{\hbar c}\left(\cong 137^{-1}\right)}$ (the value of the electromagnetic running coupling constant at rest) by succesive reduction of both terms (until obtaining α_0 as the right term of the inequality) to $\boxed{\frac{1}{\lambda} \geq \frac{\phi_e q^2}{hc}}$ <=> $\boxed{\frac{2\pi}{\lambda} \geq \frac{\phi_e q^2}{\hbar c}}$ <=> $\boxed{\frac{2\pi r}{\lambda} \geq \frac{k_e q^2}{\hbar c}}$ <=> $\boxed{\frac{2\pi r\left(\mathrm{q/e}\right)^2}{\lambda} \geq \frac{k_e e^2}{\hbar c}}$ up to:

$$\boxed{\frac{2\pi r\left(\mathrm{q/e}\right)^2}{\lambda} \geq \alpha_0} \tag{3''}$$

The previous equation (3'') offers a new interpretation of FSC $\left(\alpha_0\right)$ which can be redefined as the lower bound imposed by nature for the adimensional ratio $\phi_r = \frac{2\pi r\left(\mathrm{q/e}\right)^2}{\lambda}$ to allow the existence of elementary rest masses measured by real numbers, with $\phi_{r(\min)} = \alpha_0$. Although this last formula (3'') has the disadvantage to not allow the estimation of that minimum (and mass-independent!) distance between any two EPs (composing the same VPAP) $r_{\min} = q\sqrt{Gk_e}/c^2\left(\cong 10^{-1} l_{Pl}\right)$ (obtained from formula 3), but, instead, it offers a new important and fundamental interpretation of FSC indicating that FSC *has a profound important a gravitational/entropic significance also* (at least as interpreted by this eZEH-based SUSYA): *more specifically α_0 can be redefined as an adimensional threshold of vacuum which needs to be surpassed so that a high energy photon to can create fermionic mass (that can couple gravitationally and generate a negative E_g scalar) in form of charged VPAPs.* Furthermore (and for $q \cong e$), by replacing r with

$r_{\min}$ in formula (3'') we may easily obtain the approximate spectrum of minimum photonic wavelengths $\lambda_{\min} \in \left[r_{\min}, \lambda_e \right]$ that can create a charged VPAP in our universe:

$$\boxed{\begin{array}{l} \lambda_e = \dfrac{2\pi r_{\min} \left(\mathrm{q}/\mathrm{e}\right)^2}{\alpha_0} \Leftrightarrow \\ \Leftrightarrow \ \lambda_e \cong \dfrac{2\pi r_{\min}}{\alpha_0} \left(\cong 860 r_{\min} \cong 86 l_{Pl} \right) \end{array}} \quad (4)$$

with $\lambda_{\min} \in \left[r_{\min}, \lambda_e \right]$ <=>

<=> $\lambda_{\min} \in \left[10^{-1} l_{Pl}, 10^{2} l_{Pl} \right]$ (4')

and an average (**av**) minimum photonic wavelength:

$$\boxed{\lambda_{\min(\mathrm{av})} \cong l_{Pl} \left(\cong 10 r_{\min)} \right)} \quad (4'')$$

Based on the inequality (3''), eZEH also predicts that, for $q = 0C$, the generalized ratio $\phi_r\left(q, r, \lambda\right) = \dfrac{2\pi r \left(\mathrm{q}/\mathrm{e}\right)^2}{\lambda}$ is zero thus $\phi_r\left(0C, r, \lambda\right)\left(=0\right)$ doesn't satisfy the inequality (3'') $\phi_r\left(q, r, \lambda\right) \geq \alpha_0$: that is why, eZEH predicts/confirms that photons cannot create pairs of neutral fermions, but only pairs of charged fermions (which obviously couple electromagnetically): implicitly and as **a checkpoint conclusion**, photons are predicted by eZEH/SUSYA to can only generate pairs of EPs to which they can couple electromagnetically (thus only pairs of charged EPs).

*

An important parenthesis. The author has also reported in a past article [8] that $\boxed{\alpha_0 \cong \log_2\left(\dfrac{\hbar c}{G m_x m_y} \right) \cdot \left(1 \pm 0.2\right)}$ (with m_x and m_y being the non-zero rest masses [**nzrm**] of any two identical or distinct EPs with nzrm) which, combined with inequality (**3''**) and applied to any VPAP (composed from two EPs with nzrm $m_x = m_y = m$), implies that:

$$\boxed{\frac{2\pi r \left(\mathrm{q}/\mathrm{e}\right)^2}{\lambda} \overset{\cong}{\geq} \log_2\left(\frac{\hbar c}{G m^2} \right)} \quad (4\text{-iii})$$

The previous inequality (4''') is actually equivalent to these ones:

$$\boxed{e^{2\pi r \left(\mathrm{q}/\mathrm{e}\right)^2 / \lambda} \overset{\cong}{\geq} \frac{\hbar c}{G m^2}} \quad (4\text{-iv})$$

$$\boxed{m^2 \overset{\cong}{\geq} \frac{\hbar c}{G e^{2\pi r \left(\mathrm{q}/\mathrm{e}\right)^2 / \lambda}}} \quad (4\text{-v})$$

$$\boxed{m \overset{\cong}{\geq} \sqrt{\frac{\hbar c}{G}} e^{-\pi r \left(\mathrm{q}/\mathrm{e}\right)^2 / \lambda}} \quad (4\text{-vi})$$

The exponential function represented by the right term of the previous inequality (**4-vi**) can be also regarded as the equation of a logarithmic spiral with radius $\boxed{R\left(u\right) = a \cdot e^{k \cdot u}}$ (with a and k being non-zero real constants) and with $R\left(u\right) = m\left[= f\left(\lambda\right) \right]$, $a = \sqrt{\dfrac{\hbar c}{G}}$, $k = -\left(\mathrm{q}/\mathrm{e}\right)^2$ and the variable angle (measured in radians) $u = \pi\left(r/\lambda\right)\left(\geq \dfrac{\alpha_0}{2\left(\mathrm{q}/\mathrm{e}\right)^2} \right)$.

If interpreted as a non-coincidence, the previous inequality (**4-vi**) suggests/indicates that the nzrm of EPs (with 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 $\phi_g\left(=G/r\right)$ 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 [Error! Bookmark not defined.]).

Returning to equation (**3'**) $m_{\pm}=\pm\sqrt{\dfrac{hc/\lambda-\phi_e q^2}{\phi_g}}$, because the elementary rest masses $m=f(\lambda)$ take only discrete/quantized values, the generalized (wave)length functions $r_{\min}(q)=q\sqrt{Gk_e}/c^2$ and $\lambda(q)=\dfrac{2\pi r_{\min}(q)\cdot(\mathrm{q}/\mathrm{e})^2}{\alpha_0}$ obviously can take only quantized values as long as the electromagnetic charge $q\in\{e,\pm 1/3\,e,\pm 2/3\,e\}$ is known to take only quantized values: these discretely-valued generalized (wave)length functions $r_{\min}(q)$ and $\lambda(q)$ strongly suggest that space is actually quantized/granular around Planck scale $\lambda_{\min}\in\left[10^{-1}l_{Pl},10^{2}l_{Pl}\right]$ 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 Planck scales and (**2**) "*ex-nihilo*" creation of VPAPs at those same Planck scales measure by $r_{\min}(q)$ and $\lambda(q)$.

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

1.3.4 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 $\phi_g\left(=2c^2/m\right)$ as $u=m^2s^{-2}kg^{-1}$, 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 $\phi_{g(Zb)}\left(=2c^2/m_{Zb}\right)\cong 10^{42}u$ and $\phi_{g(Hb)}\left(=2c^2/m_{Hb}\right)\cong 8\times 10^{41}u$ respectively. 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 $\phi_{g(Zb)}\left(\cong 10^{42}u\right)$ with Zb) and the "Higgs fermion" (**Hf**) (which shares the same $\phi_{g(\mathrm{H}b)}\left(\cong 8\times 10^{41}u\right)$ with Hb) with zero rest masses $m_{Zf}=\left(c^2-c^2\right)/\phi_{g(Zb)}\left(=0\,kg\right)$ and $m_{Hf}=\left(c^2-c^2\right)/\phi_{g(\mathrm{H}b)}\left(=0\,kg\right)$ (thus both moving with the speed of light in vacuum and *possessing only relativistic masses* instead of rest masses). Based on the previously defined $r_{\min}\left(\cong 10^{-1}l_{Pl}\right)$, we then obtain $G_{Zb}\left(=\phi_{g(Zb)}r_{\min}\right)\cong G_{Hb}\left(=\phi_{g(Hb)}r_{\min}\right)\cong 2\times 10^{16}G$: 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 $\left(E_g\cong E_q\Leftrightarrow\phi_g m^2\cong\phi_e q^2\right)$ *at scales comparable to Planck scale, which implies a variabile big G* $G_{\mathrm{var}}\in\left[G,G_{Hb/Zb}\right]$ *which may significantly increase (up to* $10^{16}G$ *and possibly larger values) with the drop of length scale down to* $r_{\min}\left(\cong 10^{-1}l_{Pl}\right)$.

Because Hb and Zb are their own antiparticles, their eZEH-predicted mass conjugates *Hf and Zf are also defined (and predicted) by SUSYA to be actually 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 Zfs 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 [9]. 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*.

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) [10,11].

SUSYA defines Hfs and Zfs to be maximally stable and to cannot 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 the spacetime-"scene" (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* [12].

These eZEH-predicted neutral massless (Majorana) fermions (**NMFs**) Zf and Hf are also quite distinct (and almost the "opposite") from the so-called *neutralinos* predicted by a SUSY variant known as the Minimal Supersymmetric Standard Model (**MSSM**) which defines neutralinos as ultra-heavy superpartners of the Zb and Hb with rest masses between 300GeV and 1TeV: this is another main difference (in predictions) between SUSYA and SUSY/MSSM. Zf and Hf are actually the opposite of the so-called WIMPs (weakly-interacting massive particles, as neutralinos were also defined by MSSM and were standardly regarded in the past as plausible constituents of the dark matter [13]): by contrast, Zf and Hf are actually defined by SUSYA as "weakly-interacting lightest particles" ("**WILPs**") which are stated by SUSYA to interact only (and very weakly!) via gravitational force/field (by their very low but non-zero relativistic energy which couples gravitationally).

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 $\left[10^{-22}\,\mathrm{eV}, 1eV\right)$ (which bosons may form a Bose-Einstein condensate or a superfluid on galactic scales) [14]. 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*).

Because light was proved since the nineteenth century to be an *electromagnetic transverse wave* with many other interesting wave-like properties (refraction, diffraction etc), many old physicists believed that, to understand light, it was necessary to understand the special characteristics of the light "medium" (called "luminiferous aether" [**LA**]) without which the movement of the "light-wave" appeared as unconceivable (and still appears as such to many physicists today). Many old physicists developed complex models in order to explain this LA with special and apparently contradictory qualities (which models were unsuccessful however): LA had to be very thin and elastic (a "jelly"-like medium that would allow solid objects to pass through it without resistance) but, at the same time, it had to be very dense (a solid-like medium with high elasticity so that to allow the transmission of light as transverse wave at such high speeds); actually, in the last two decades of the nineteenth century, the best minds in physics from that time intensively brainstormed in their attempt to accurately describe LA.

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 “hided” 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.

Some important historical mentions of the aether. In 1920 Einstein gave a speech entitled "Aether and Relativity Theory" to an audience in Germany: “*We may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an Aether. According to the general theory of relativity space without Aether is unthinkable; for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time (measuring-rods and clocks), nor therefore any space-time intervals in the physical sense. But this Aether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time. The idea of motion may not be applied to it.*” [15].

Paul Dirac also wrote in 1951: "*Physical knowledge has advanced much since 1905, notably by the arrival of quantum mechanics, and the situation [about the scientific plausibility of Aether] has again changed. If one examines the question in the light of present-day knowledge, one finds that the Aether is no longer ruled out by relativity, and good reasons can now be advanced for postulating an Aether ... We have now the velocity at all points of space-time, playing a fundamental part in electrodynamics. It is natural to regard it as the velocity of some real physical thing. Thus, with the new theory of electrodynamics [vacuum filled with virtual particles] we are rather forced to have an Aether.*" [16].

In 1986, when interviewed by Paul Davies in "The Ghost in the Atom" John Bell suggested that an Aether theory might help resolve the EPR paradox by allowing a reference frame in which signals go faster than light. He also suggested that Lorentz contraction may be consistent with relativity (and could produce an aether theory perfectly consistent with the OMME). Bell also suggested that the aether was wrongly rejected mainly on purely philosophical grounds: "*what is unobservable does not exist*" [p. 49]. Einstein found the non-aether theory simpler and more elegant, but, in Bell’s opinion, that doesn't rigorously rule out the existence of the aether [17].

Gerard 't Hooft also regards quantum (field) theory (**QFT**) not as a complete field theory (but only an emergent phenomenon arising from a deeper level of possibly subquantum dynamics) and conjectured in 2002 that: "*We should not*

forget that quantum mechanics does not really describe what kind of dynamical phenomena are actually going on, but rather gives us probabilistic results. To me, it seems extremely plausible that any reasonable theory for the dynamics at the Planck scale would lead to processes that are so complicated to describe, that one should expect apparently stochastic fluctuations in any approximation theory describing the effects of all of this at much larger scales. It seems quite reasonable first to try a classical, deterministic theory for the Planck domain. One might speculate then that what we call quantum mechanics today, may be nothing else than an ingenious technique to handle this dynamics statistically [18]."

In one of his latest published articles, the famous physicist Louis de Broglie also expressed his opinion on a hypothetical subquantum aether: "*If a hidden sub-quantum medium is assumed, knowledge of its nature would seem desirable. It certainly is of quite complex character. It could not serve as a universal reference medium, as this would be contrary to relativity theory. […] Quantum mechanics only gives statistical information, often correct, but in my opinion incomplete [19].*"

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 [20].*"

The potential advantages of "resurrecting" the famous "aether". An *aether theory* (**AT**) may allow solving some serious problems of modern physics:

(**1**) AT presents the gravitational field as a condensed matter theory on a 2D Euclidean/plane background: however, such theories have to be quantized thus impose quantum gravity, which implies that aether is *not truly continuous* (at any length scale) but probably quantized below a specific length-scale (a "granular/atomized" aether) and that is what SUSYA also states by defining the minimum length allowed $r_{\min} \cong e\sqrt{Gk_e}/c^2 \cong 10^{-1} l_{Pl}$ (as also detailed in a previous paper of the author [Error! Bookmark not defined.]).

(**2**) Quantum theory is non-local (a consequence of Bell's theorem), which shows that Bell's inequality must hold in any Einstein-causal realistic theory. On the other hand, *quantum entanglement* (**QE**) appears to violate Einstein causality: however, if one gives up Einstein causality (the base of Einsteinian "realism"), one essentially has to go back to the AT proposed by Lorentz, and to find an extension of it applicable to gravity.

(**3**) The equations of Einstein's general relativity (**EGR**) generate singularity-type solutions which indicate an intrinsic flaw in EGR: AT has the potential to eliminate the main singularities (unavoidable for the current form of EGR): the pre-Big-Bang singularity and the black holes. The aether is considered complete if it is defined for all coordinates. A solution of AT is considered complete if it is defined for all values of the preferred coordinates: in contrast, a solution of EGR is considered complete only if the metric is geodetically complete.

(**4**) EGR has also a major conceptual problem with energy and momentum conservation: the conserved *stress–energy–momentum pseudotensor* of EGR (which behaves as tensor *only* with respect to *restricted coordinate transformations*) doesn't allow a physical interpretation in the standard spacetime interpretation of EGR (where *all* physical fields should to be *tensor fields*). In contrast with EGR, AT has standard local densities of energy and momentum also for the gravitational field.

The weak points of an aether theory (AT). The harmonic condition of an AT (which is a physical equation) is not an Euler-Lagrange equation (and not derived from a Lagrange formalism): in contrast, EGR in its spacetime interpretation is preferable, because it has a Lagrange formalism (defined by the Hilbert-Einstein Lagrangian). The fact that AT hasn't got a Lagrange formalism generates some other problems too, especially the fact that Noether's theorem cannot be used to derive energy and momentum conservation laws: this issue is also very problematic in the EGR spacetime interpretation where there is no local energy and momentum density for the gravitational field, but only a pseudotensor (which does not allow for a physical interpretation in EGR). The lack of Lagrange formalism in AT also makes quantization more difficult:

quantization would have been much simpler if there would be a local energy density to define the Hamilton operator.

SUSYA solves at least in part the problem of spacetime/gravitational quantization by introducing a minimum length allowed in our universe $r_{\min} \cong e\sqrt{Gk_e} / c^2 \cong 10^{-1} l_{Pl}$ (derived from the main equation of eZEH).

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.**, 21]: more pecifically, 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* [22,23,24]. 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 [**Error! Bookmark not defined.**].

*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) [25].

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* $r_{\min}\left(\cong e\sqrt{Gk_e}/c^2 \cong 10^{-1}l_{Pl}\right)$ (previously proposed by eZEH as the esential 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. 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 [26]) 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 "bilaminary" mix between two superposed scalar (Hf-based) and vectorial (Zf-based) fermionic fields: *fermionic scalar fields* are not a novelty per se [27]; 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 [28].

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 temporarily cover 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 [29]) and further developed by: (**1**) Jacobson, Mattingly and their "*aetheory*" (launched in 2000) [30]; (**2**) Heinicke et al. in 2005 [31]; (**3**) Złośnik et al. in 2018 [32]; (**4**) Battye et al. in 2019 [33].

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 $\boxed{E_{gr} = h_{gr} c / \lambda}$, with $h_{gr} (<< h)$ 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 $\boxed{\rho_x \rho_p \geq \hbar_{gr} / 2 (<< \hbar / 2)}$ (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 [34].

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 an 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:

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

This predicted/estimated relativistic energy $(E_{\min})$ of Hf/Zf corresponds to a theoretical

minimum rest mass (allowed in our universe) of $\boxed{m_{Hf/Zf} = E_{Hf/Zf} / c^2 \cong 10^{-69} kg}$ which is almost infinitesimal and may be reasonably approximated to $\boxed{m_{Hf/Zf} \cong 0kg}$ (as predicted by the conjugated solutions of the main equation proposed by eZEH).

If the total mass of the ordinary matter (**om**) (including ration/bosonic matter and estimated at $\boxed{M_{om} \cong 10^{53} kg}$) represents only about 5% (=1/20) of the total mass of the observable universe (**ObU**) (with total mass estimated as $\boxed{M_{ObU} \cong 20 \times M_{om} \cong 2 \times 10^{54} kg}$) and the dark energy (**de**) plus dark matter(**dm**) both represent 95% of ObU (thus having a mass of $\boxed{M_{de\&dm} \cong 0.95 \times M_{ObU} \cong 1.9 \times 10^{54} kg}$) then: if $M_{de\&dm}$ is attributed to this predicted Hf/Zf-based aether only, the minimum number of Hfs/Zfs per unit of volume in ObU (with total volume $V_{ObU} \cong 3.6 \times 10^{80} m^3$) would be $\boxed{\frac{M_{de\&dm} / m_{NMF}}{V_{ObU}} \cong 2 \times 10^{42} NMFs / m^3}$ (with "**NMFs**" being the abbreviation for "neutral massless fermions" like Hfs and Zfs are and $\boxed{m_{NMF} = m_{Hf/Zf} \cong 10^{-69} kg}$): this minimum density is equivalent to about $10^{13} NMFs$ per each volume of a hydrogen atom (**H**) (with volume $V_H \cong 10^{-30} m^3$) which is a relatively huge number of NMFs (defining a kind of spatial/aetherial "volumic resolution" of a hydrogen atom).

However, if the Planck-like gravitonic constant $h_{gr} \left(<< h \right)$ (attributed to the hypothetical graviton) is estimated as $\boxed{h_{gr} = h \cdot \left(\alpha_G / \alpha_0 \right) \cong 10^{-43} h}$ (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 of our ObU as $\boxed{E_{\min(gr)} \cong h_{gr} c / D_{ObU} \cong 10^{-76} eV}$ (corresponding to a theoretical relativistic mass of the hypothetical graviton of $\boxed{m_{gr} = E_{\min(gr)} / c^2 \cong 10^{-112} kg}$: based on these attributes of the hypothetical graviton and *redefining* $\boxed{m_{NMF} \left(= m_{Hf/Zf} \right) \cong m_{gr} \cong 10^{-111} kg \left(\cong 0kg \right)}$, we have $\boxed{\frac{M_{de\&dm} / m_{NMF}}{V_{ObU}} \cong 9 \times 10^{84} NMFs / m^3}$ which is equivalent to about $10^{55} NMFs$ per each volume of a hydrogen atom (**H**) which is a really large number of NMFs (defining a huge spatial/aetherial "volumic resolution" of a hydrogen atom).

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 $c \le v_{\max}$ (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

$v\left(<<v_{\max}\right)$, 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* $\gamma = 1/\sqrt{1-\left(v/c\right)^2}$ (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" /deposit 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 $\left(v_{\max} \cong c\right)$ simply because there is no EP lighter than Hfs and Zfs (composing SV): $v_{\max}\left(\cong c\right)$ 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 $v_{\max}\left(\cong c\right)$ 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 $E_0 = \frac{3}{2}\hbar H_0 \left(\cong 10^{-33} eV\right)$ [**Error! Bookmark ot defined.**]: note that E_0 is very close to the previous estimation of the Hf/Zf relativistic energy $\boxed{E_{Hf/Zf} = E_{\min}\left(\cong 10^{-33} eV\right)}$, because $c/H_0\left(\cong 10^{-26} m\right)$ has a magnitude close to $D_{ObU} \cong 10^{27} m$, so that $E_0\left(=\frac{3}{2}\hbar H_0 = \frac{\frac{3}{2}\hbar c}{c/H_0}\right) \cong E_{\min}\left(=\frac{hc}{D_{ObU}}\right) \cong 10^{-33} eV$.

The eZEH-predicted Zfs and Hfs have also some similarities to the so-called "*microleptons*" (**MLs**) proposed by the Russian physicist Anatolij Fedorovich Ohatrin which defined them as superlight fermions with rest masses estimated to be in the interval $\left[10^{-44}, 10^{-39}\right] kg$ (and stated to surround and fill/permeate "all the composite physical objects [**CPOs**] of the material world", with "no physical barriers"). These MLs are also stated to possess inherent torsion, axial and spin fields and to globally form *a very weak fermionic field* called "*microleptonic gas*" (**MLG**) which has a specific contribution to the inertial/rest mass of any CPO (a contribution also depending on the density and temperature of this MLG) [35].

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.

1.3.5 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 deducted from the currently estimated upper bounds of the non-zero rest energies of all three known types of neutrino: the electron neutrino (**en**) with $E_{en} < 1eV$ [36], the muon neutrino (**mn**) with $E_{mn} < 0.17MeV$ [37] and the tau neutrino (**tn**) with $E_{tn} < 18.2MeV$ [38,39]: $\phi_{g(en)} > \cong 10^{53} u$, $\phi_{g(mn)} > \cong 6\times 10^{47} u$ and $\phi_{g(tn)} > \cong 6\times 10^{45} u$, with $\phi_{g(en)}$ being assigned a very large G_{var} upper bound $G_{en}\left(=\phi_{g(\text{en})} r_{\min}\right) \cong 2\times 10^{28} G$, so

that $G_{\text{var}} \in \left[G, G_{\text{en}}\right]$ and thus strengthening the previously introduced (sub-)hypothesis $\boxed{\phi_g m^2 \cong \phi_e q^2}$ 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 $\left(m_{VEP} \le m\right)$ 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 $\phi_{g(gr)} > \phi_{g(ph)} \left(> \phi_{g(gl)}\right)$ 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 2×2 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* $A'=x\cdot I_2-A=x\cdot\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}-\begin{pmatrix} 0 & M \\ M & B \end{pmatrix}=\begin{pmatrix} x & -M \\ -M & x-B \end{pmatrix}$ (with $I_2=\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ 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 $|A'|=\begin{vmatrix} x & -M \\ -M & x-B \end{vmatrix}=x(x-B)-(-M)^2$ and the characteristic/determinantal (quadratic) equation (**CE**) $|A'|=0\Leftrightarrow\boxed{x^2-xB-M^2=0}$. 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 easily determined as $x_\pm=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$, which is equivalent to $\boxed{x_\pm=\frac{B\pm\sqrt{B^2+4M^2}}{2}}$, with product $\boxed{x_+\cdot x_-=-M^2}$: 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 (>>) 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 $4M^2<<B^2$): 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 $x_-\left(\cong\frac{-M^2}{x_+}\right)\cong\frac{-M^2}{B}\cong 0$ [Error! Bookmark ot defined.] [40,41,42].

That is how SMEC-1 explains why the neutrino masses (corresponding to the x_- solution) are so small (~1eV), 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:

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

According to this similarity (invoked by SUSYA), $\left(2c^2/\phi_g\right)\left(=2rc^2/G\right)$ corresponds to B, $-\left(2\phi_e q^2/\phi_g\right)$ 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 matrix with $m_\pm$ solutions as eigenvalues would be:

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

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 matrix.

The $a_{2,2}$ element $2rc^2/G$ (of the previous matrix Z) is actually a *Majorana mass component B* and may be written as a variable (**var**) real mass component $\boxed{m_{\text{var}}(r)=2rc^2/G}$ (which takes only real-number values for $r\geq r_{\min}$): $m_{\text{var}}(r)$ is a simple linear function of $r\left(\geq r_{\min}\right)$, which takes the value of $2m_{Pl}$ for distance $r=l_{Pl}$ (with $m_{Pl}=\sqrt{\hbar c/G}$ $\cong 2.18\times10^{-8}kg$ being the Planck mass and $l_{Pl}=\sqrt{\hbar G/\mathrm{c}^3}$ $\cong 1.62\times10^{-35}m$ 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 $\boxed{G_{\min(\mathrm{x})}=\phi_{g(\mathrm{x})}r_{\min}}$) and that is why $m_{\text{var}}(r)$ can be generalized as $\boxed{m_{\text{var}}(r)=2rc^2/G(r)}$: 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 $r_{\min}\left(\cong 10^{-1}l_{Pl}\right)$ as all known EPs actually have.

The $a_{1,2}\left(=a_{2,1}\right)$ double element $(q/2)\sqrt{-2(k_e/G)}$ (of the same previous matrix Z) is actually a *Dirac mass component M* and may be written as a variable (**var**) imaginary mass component $\boxed{m_{\text{var}(i)}(q)=(q/2)\sqrt{-2(k_e/G)}}$ (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, $m_{\text{var}(i)}(e)\cong 1.3i\times10^{-9}kg$ (an imaginary undetectable mass which may be approximated with $0kg$); thus SUSYA extends this simple 2x2 B-M symmetrical matrix A (applied by SMEC-1 to neutrinos only) to all known/unknown EPs (including neutrinos) as a more general 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 $\boxed{m_{\text{var}(i)}(q,r)=(q/2)\sqrt{-2k_e(r)/G(r)}}$. 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 $\boxed{m_{\mathrm{var}}(r)=2rc^2/G(r)}$ for $r<r_{\min}$: 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 [43]; quantum electrodynamics (**QED**) (the "core" of SM) also works with the concept of negative mass-energy.

The previously introduced Z matrix may be now redefined as:

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

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

1.3.6 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 $m_e=\left(c^2-\sqrt{c^4-\phi_{g(W/e)}\phi_{e(W/e)}q_e{}^2}\right)/\phi_{g(\mathrm{W/e})}$ and $m_W=\left(c^2+\sqrt{c^4-\phi_{g(W/e)}\phi_{e(W/e)}q_e{}^2}\right)/\phi_{g(\mathrm{W/e})}$. 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 $m_e+m_W=2c^2/\phi_{g(\mathrm{W/e})}$, from which their common/shared $\phi_{g(\mathrm{W/e})}$ ratio can be reversely estimated as $\boxed{\phi_{g(\mathrm{W/e})}=2c^2/(m_e+m_W)\cong 1.25\times10^{42}u}$, which is relatively close to $\phi_{g(Zb)}\left(\cong10^{42}u\right)$ and $\phi_{g(\mathrm{H}b)}\left(\cong8\times10^{41}u\right)$, thus we have an estimated $\boxed{G_{W/e}\left(=\phi_{g(\mathrm{W/e})}r_{\min}\right)\cong G_{Zb}\cong G_{Hb}\cong2\times10^{16}G}$. The other $\phi_{\mathrm{e(W/e)}}$ ratio can be also reversely estimated from both m_W (or m_e) and $\phi_{g(\mathrm{W/e})}$ as $\boxed{\phi_{\mathrm{e(W/e)}}\cong6.4\times10^{24}F^{-1}}$.

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 Hf and Zf 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*.

1.3.7 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* $\phi_{g(\mathrm{Hb})}\left(=2c^2/m_{Hb}\right)$:

(**1a**) A so-called 1st generation LQ named "*up-leptoquark*" (**uLQ**) with rest mass $m_{uLQ}\left(>m_{Hb}\right)$, $\phi_{g(\mathrm{uLQ})}=\dfrac{2c^2}{m_{uq}+m_{uLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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 $m_{dLQ}\left(>m_{uLQ}>m_{Hb}\right)$, $\phi_{g(\mathrm{dLQ})}=\dfrac{2c^2}{m_{dq}+m_{dLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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 $m_{cLQ}\left(>m_{Hb}\right)$, $\phi_{g(\mathrm{cLQ})}=\dfrac{2c^2}{m_{cq}+m_{cLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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

$m_{sLQ}\left(>m_{Hb}\right)$, $\phi_{g(\mathrm{sLQ})}=\dfrac{2c^2}{m_{sq}+m_{sLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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 $m_{tLQ}\left(>m_{Hb}\right)$, $\phi_{g(\mathrm{tLQ})}=\dfrac{2c^2}{m_{tq}+m_{tLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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 $m_{bLQ}\left(>m_{Hb}\right)$, $\phi_{g(\mathrm{bLQ})}=\dfrac{2c^2}{m_{bq}+m_{bLQ}}$ $\left(<\phi_{g(\mathrm{Hb})}\right)$ 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 $\phi_{g(\mathrm{LQs})}<\phi_{g(\mathrm{Hb})}$ and $\phi_{\mathrm{e(LQs)}}>\phi_{e(W/e)}$: 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

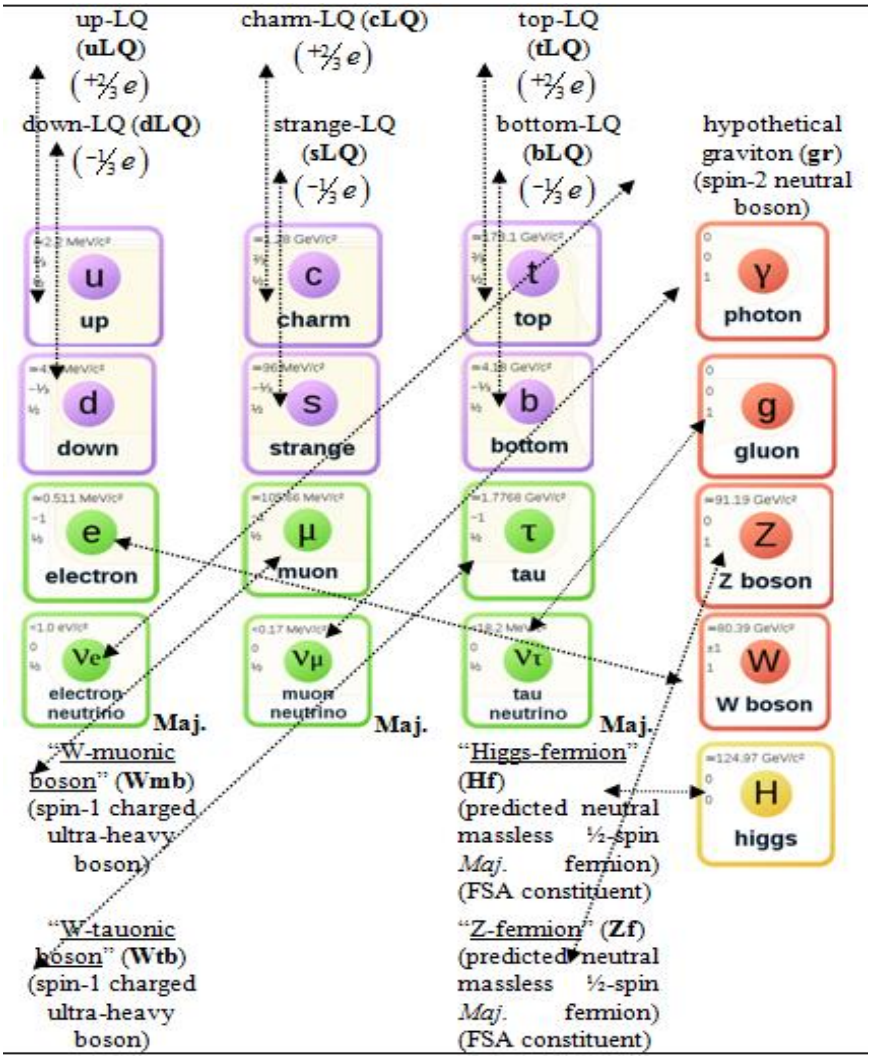
All the proposed pairs of EP-conjugates (as stated by the eZEH-based SUSYA) are also illustrated in the **next tables**: as it can be seen from these tables, eZEH transforms the already "classical" 2D table of EPs (from the Standard model of particle physics) in a 3D structure/table in which EPs are 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 $Z(q,r)$ 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**) (*Majorana* neutrino)	$\phi_{g(gr)}=\phi_{g(en)}$ $\left(>1.1\times10^{53}u\right)$ $G_{gr/en}>2.1\times10^{27}G$	$\phi_{e(\mathrm{gr})}$ **=?** $k_{e(\mathrm{g}r)}$ **=?**
photon (**ph**) (spin-1 neutral boson)	muon neutrino (**mn**) (*Majorana* neutrino)	$\phi_{g(ph)}=\phi_{g(mn)}$ $\left(>6\times10^{47}u\right)$ $G_{ph/mn}>1.2\times10^{22}G$ (the same for all photons, no matter their frequency)	$\phi_{e(\mathrm{ph})}$ **=?** $k_{e(\mathrm{ph})}$ **=?**
gluon (**gl**) (spin-1 neutral boson, with color charge only)	tauon neutrino (**tn**) (*Majorana* neutrino)	$\phi_{g(gl)}=\phi_{g(tn)}$ $\left(>5.6\times10^{45}u\right)$ $G_{gl/tn}>1.2\times10^{20}G$	$\phi_{e(\mathrm{gl})}$ **=?** $k_{e(\mathrm{gl})}$ **=?**
Z boson (**Zb**) (spin-1 neutral boson)	"Z-fermion" (**Zf**) (predicted neutral massless ½-spin *Majorana* fermion/ neutrino) (proposed as vector constituent of a fermionic superfluid aether (**FSA**)	$\phi_{g(Zb)}\left(=\phi_{g(Zf)}\right)\cong10^{42}u$ $G_{Zb/Zf}\cong2.1\times10^{16}G$	$\phi_{e(\mathrm{Zb})}$ **=?** $k_{e(\mathrm{Zb})}$ **=?**
Higgs boson (**Hb**) (spin-0/scalar neutral boson)	"Higgs-fermion" (**Hf**) (predicted neutral massless ½-spin *Majorana* fermion/neutrino) (proposed as scalar constituent of a FSA)	$\phi_{g(Hb)}\left(=\phi_{g(Hf)}\right)\cong8\times10^{41}u$ $G_{Hb/Hf}\cong1.7\times10^{16}G$	$\phi_{e(\mathrm{Hb})}$ **=?** $k_{e(\mathrm{Hb})}$ **=?**
W boson (**Wb**) (spin-1 charged boson)	electron (**e**)	$\phi_{g(\mathrm{W/e})}\cong1.25\times10^{42}u$ $G_{\mathrm{W/e}}\cong2.6\times10^{16}G$	$\phi_{e(\mathrm{W/e})}\cong6.4\times10^{24}F^{-1}$ $k_{e(\mathrm{W/e})}\cong10^{-21}k_e$

"W-muonic" boson (**Wmb**) (very heavy spin-1 charged boson)	muon (**m**)	$\phi_{g(\mathrm{Wmb})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{Wmb}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{Wmb})} = ?\left(> \phi_{e(\mathrm{W/e})}\right)$ $k_{e(\mathrm{Wmb})} = ?\left(> k_{e(Hb)}\right)$
"W-tauonic" boson (**Wtb**) (ultra-heavy spin-1 charged boson)	tauon (**t**)	$\phi_{g(\mathrm{Wtb})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{Wtb}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{Wtb})} = ?\left(> \phi_{e(\mathrm{W/e})}\right)$ $k_{e(\mathrm{Wtb})} = ?\left(> k_{e(Hb)}\right)$
Quark-leptoquark (LQ) pairs of mass-conjugates as treated and predicted by the eZEH-based SUSYA			
up quark (**uq**)	up-LQ (**uLQ**)	$\phi_{g(\mathrm{uLQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{uLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{uLQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(\mathrm{uLQ})} = ?\left(> k_{e(Hb)}\right)$
down quark (**dq**)	down-LQ (**dLQ**)	$\phi_{g(d\,\mathrm{LQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{dLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{dLQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(\mathrm{dLQ})} = ?\left(> k_{e(Hb)}\right)$
charm quark (**cq**)	charm-LQ (**cLQ**)	$\phi_{g(c\,\mathrm{LQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{cLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{cLQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(\mathrm{cLQ})} = ?\left(> k_{e(Hb)}\right)$
strange quark (**sq**)	strange-LQ (**sLQ**)	$\phi_{g(\mathrm{sLQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{sLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(s\,\mathrm{LQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(s\,\mathrm{LQ})} = ?\left(> k_{e(Hb)}\right)$
top quark (**tq**)	top-LQ (**tLQ**)	$\phi_{g(\mathrm{tLQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{tLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(t\,\mathrm{LQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(\mathrm{tLQ})} = ?\left(> k_{e(Hb)}\right)$
bottom quark (**bq**)	bottom-LQ (**bLQ**)	$\phi_{g(\mathrm{bLQ})} = ?\left(< \phi_{g(Hb)}\right)$ $G_{\mathrm{bLQ}} = ?\left(< G_{Hb}\right)$	$\phi_{e(\mathrm{bLQ})} = ?\left(> \phi_{e(W/e)}\right)$ $k_{e(\mathrm{bLQ})} = ?\left(> k_{e(Hb)}\right)$

Table 2. The pairing of conjugated EPs predicted by the eZEH-based SUSYA and marked by interconnecting arrows. Source of image extracts: en.wikipedia.org/wiki/File:Standard_Model_of_Elementary_Particles.svg ◄┈┈► (marks each pair of conjugates stated by eZEH) Additional abbreviation: Maj. (*Majorana neutrino*)



In a checkpoint conclusion, SUSYA essentially proposes *a universal seesaw mechanism* (abbreviated as Z-SMEC and previously expressed by the $Z(q,r)$ matrix) applicable to all known/unknown EPs. Z-SMEC actually replaces the "superpartner" notion (of SUSY) with the concept of (charge-based) "mass-conjugate" or simply "conjugate" of a known EP, which conjugate may be actually an already known EP: in this way SUSYA more-"economically" predicts only 28 *known plus hypothetical EPs in contrast with SUSY which predicts at least 34 distinct types of EPs (the double of the 17 known types of EPs);* SUSYA explains *the non-zero rest masses of 28 known and hypothetical EPs (14 pairs of eZEH-predicted mass-conjugates, not counting their antiparticles which almost doubles this number: (**1**)Zb & Zf, (**2**)Hb & Zf, (**3**)gr & en, (**4**)ph & mn, (**5**)gl & tn, (**6**)Wb & electron, (**7**)Wmb & muon, (**8**)Wtb & tauon, (**9**)uq & uLQ, (**10**)dq & dLQ, (**11**)cq & cLQ, (**12**)sq & sLQ, (**13**)tq & tLQ and (**14**)bq & bLQ) by only 14 discrete ϕ_g ratios (associated with their bijectively-correspondent ϕ_e ratios)*: (**1**) $\phi_{g(Zb)}\left(=\phi_{g(Zf)}\right)$, (**2**)

$\phi_{g(Hb)}\left(=\phi_{g(Hf)}\right)$, (**3**) $\phi_{g(gr)}\left(=\phi_{g(en)}\right)$, (**4**) $\phi_{g(ph)}\left(=\phi_{g(mn)}\right)$, (**5**) $\phi_{g(gl)}\left(=\phi_{g(tn)}\right)$, (**6**) $\phi_{g(W)}\left(=\phi_{g(e)}=\phi_{g(\mathrm{W/e})}\right)$, (**7**) $\phi_{g(Wmb)}\left(=\phi_{g(m)}\right)$, (**8**) $\phi_{g(Wtb)}\left(=\phi_{g(\mathrm{t})}\right)$, (**9**) $\phi_{g(\mathrm{uq})}\left(=\phi_{g(\mathrm{uLQ})}\right)$, (**10**) $\phi_{g(\mathrm{dq})}\left(=\phi_{g(\mathrm{dLQ})}\right)$, (**11**) $\phi_{g(\mathrm{cq})}\left(=\phi_{g(\mathrm{cLQ})}\right)$, (**12**) $\phi_{g(\mathrm{sq})}\left(=\phi_{g(\mathrm{sLQ})}\right)$, (**13**) $\phi_{g(t\mathrm{q})}\left(=\phi_{g(\mathrm{tLQ})}\right)$ and (**14**) $\phi_{g(t\mathrm{q})}\left(=\phi_{g(\mathrm{tLQ})}\right)$.

The heavier conjugate of any pair can decay to its lighter conjugate (or a sufficiently energetic bosonic conjugate may produce particle-antiparticle pairs of its lighter conjugate) also obeying both *energy and charge conservation principles*: Wtb decays to a tauon (plus other possible EPs), Wmb decays to a muon (plus other possible EPs), LQs decay to quarks, the hypothetical graviton (with sufficient energy) may generate a pair of electron neutrinos, the photon (with sufficient energy) may generate a pair of muon neutrinos, the gluon (with sufficient energy) may generate a pair of tauon neutrinos (plus other EPs with color charge), the $W^{(+/-)}$ boson is already known to can decay to a positron/electron plus an electron neutrino (the *beta decay*), the Higgs boson may decay in one or more "Higgs-fermions" (**Hfs**) (defined as massless Majorana neutrinos) plus other EPs, the Z-boson may decay in one or more "Z-fermions" (**Zfs**) (also defined as massless Majorana neutrinos) plus other EPs.

*Furthermore, SUSYA offers many additional eZEH-based interesting predictions and explanations, including the prediction that all three known generations of neutrinos are actually Majorana neutrinos and that there is a "0th"/4th generation of neutrinos called "Higgs (scalar) fermion" (**Hf**) and "Z (vector) fermion" (**Zf**)* proposed as the main constituents of a superfluid Hf/Zf-based aether. Some other important implications and predictions of SUSYA were already presented in a past article [**Error! Bookmark not defined.**].

3. DISCUSSION

eZEH is essentially a *conservation principle applied on a zero-energy ground-state of vacuum* and quantitatively describing a form of "*ex-nihilo*"-like creation of *virtual particle-antiparticle pairs* (**VPAPs**). This SUSYA mainly proposes an eZEH-based *universal seesaw mechanism* (applicable to all EPs) called "Z-SMEC" which is a quite powerful concept, predicting 4 generations of Majorana neutrinos (**MNs**), from which the massless MNs Hf and Zf (composing the so-called "0th" generation) are hypothesized to actually compose a *superfluid aether*). SUSYA predicts the existence of the *graviton* (as a spin-2 boson and mass-conjugate of the electron neutrino), the *leptoquarks*, the *primordial "W-tauonic" boson* and also predicts a *length-scale-dependent variable* $G_{\mathrm{var}}\left(>>G\right)$ bringing General relativity and quantum field theory closer to one another by offering a natural elegant solution to the *hierarchy problem* in physics.

eZEH also offers a new interpretation of Planck length as the approximate length threshold above which the rest masses of all known EPs have real number values (with mass units) instead of complex/imaginary number values (as predicted by the unique quadratic equation proposed by eZEH): the existence of this minimum distance $r_{\min}=q\sqrt{Gk_e}/c^2\left(\cong 10^{-1}l_{Pl}\right)$ (allowed between any two virtual EPs of the same VPAP popping out from the vacuum) strongly indicates that spacetime may have a granular/quantum structure near the Planck scale (as also predicted by *Loop quantum gravity theory*) possibly composed from "uncompressible" 3D/4D spatial/ spacetime voxels which don't allow true gravitational singularities, but only quasi-singularities with large but finite density (including the possibility of a *pre-Big Bang quasi-singularity* [**pBBQS**] *with large but finite density*).

eZEH also helps predicting the behaviour of the electromagnetic field and gravitational field at Planck length/energy scales which may reach a balance at that length-scale so that $\boxed{\left|E_g\right|\cong\left|E_q\right|\Leftrightarrow\phi_g m^2\cong\phi_e q^2}$ and *a very large-valued universal gravitational constant around Planck length scale* $G_{Pl}\geq G_{gr}\left(>2.1\times10^{27}G\right)$ (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 $r\left(\geq r_{\min}\right)$ thus to take the forms $G(r)$ and $k_{\mathrm{e}}(r)$ respectively, the variable ϕ_g and ϕ_e ratios can be also rewritten as $\phi_{\mathrm{g(var)}}(r)$ and $\phi_{\mathrm{e(var)}}(r)$ 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 $\phi_g(r)x^2-\left(2c^2\right)x+\phi_e(r)q^2=0$, with solutions

$$\boxed{m_{\pm}\left(=x_{\pm}\right)=\frac{c^2\pm\sqrt{c^4-\phi_g(r)\phi_e(r)q^2}}{\phi_g(r)}}.$$

The growth pattern of $G(r)$ (with a decreasing length scale r) probably keeps $G(r)$ values close to $G\left(\cong 6.67\times10^{-11}m^3kg^{-1}s^{-2}\right)$ on both macroscopic and microscopic scales but "suddenly" increases exponentially $G(r)$ values when r becomes comparable with $r_{\min}\left(\cong10^{-1}l_{Pl}\right)$ as also shown in a previous article [**Error! Bookmark not defined.**]. A simple function which may model this special growth pattern of $G(r)$ would be (with $a_G\cong5.7\times10^{44}$ being the inverse of the gravitational coupling constant $\alpha_G=\frac{Gm_e^{\,2}}{\hbar c}\cong1.8\times10^{-45}$):

$$\boxed{G_{\mathrm{var}}(r)=G\cdot a_G^{\,r_{\min}/\mathrm{r}}} \qquad (7)$$

The graph of this simple $G_{\mathrm{var}}(r)$ function (illustrated in base-10 logarithmic units) is presented together with the previously estimated big G values (or the lower bounds of these big G values): $G_{gr/en}\left(>2.1\times10^{27}G\right)$, $G_{ph/mn}\left(>1.2\times10^{22}G\right)$, $G_{gl/tn}\left(>1.2\times10^{20}G\right)$, $G_{Zb/Zf}\cong2.1\times10^{16}G$, $G_{Hb/Hf}\cong1.7\times10^{16}G$ and $G_{\mathrm{W/e}}\cong2.6\times10^{16}G$ (**see next figure**). A function similar to $G_{\mathrm{var}}(r)$ was also proposed in a past article of the author [44] and transforms the classical Planck mass $m_{Pl}=\sqrt{\hbar c/G}$ in a Planck mass series $\boxed{m_{Pl(\mathrm{var})}(r)=\sqrt{\hbar c/G_{\mathrm{var}}(r)}}$ which may offer a very interesting new glimpse in the domain of *quantum/micro black holes* (as explained next).

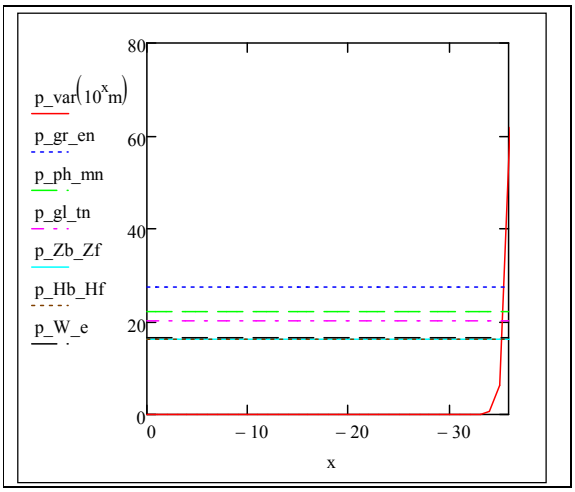


Fig. 1. The common graph of the ratios $p_{\mathrm{var}}\left(10^x m\right)=\log_{10}\left[\frac{G_{\mathrm{var}}\left(10^x m\right)}{G}\right]$, $p_{gr/en}=\log_{10}\left[\frac{G_{gr/en}}{G}\right]$, $p_{ph/mn}=\log_{10}\left[\frac{G_{ph/mn}}{G}\right]$, $p_{gl/tn}=\log_{10}\left[\frac{G_{gl/tn}}{G}\right]$, $p_{Zb/Zf}=\log_{10}\left[\frac{G_{Zb/Zf}}{G}\right]$ **and** $p_{W/e}=\log_{10}\left[\frac{G_{W/e}}{G}\right]$**, with integer exponential** $x\in[0,-36]$ **and (-36) value being chosen because** $\log_{10}\left[\frac{r_{\min}}{1m}\right]\cong-36$

The huge $G_{Pl}\left(>2.1\times10^{27}G\right)$ has many important implications indicating that *micro(/ quantum) black holes* (**MBHs**) usually assigned a size comparable to Planck length $l_{Pl}\left(=\sqrt{\hbar G/\mathrm{c}^3}\right)$ $\left(\cong1.62\times10^{-35}m\right)$ and a mass equal to the Planck mass $m_{Pl}=\sqrt{\hbar c/G}$ $\cong2.18\times10^{-8}kg$ (which is currently considered the approximate smallest mass of any MBH) may actually have much smaller masses of $\boxed{m_{MBH}=\sqrt{\hbar c/G_{Pl}}\left(<10^{-22}kg\right)\left(<10^{5}GeV/c^2\right)}$ which relatively superposes to the mass-domain of the known EPs (with the heaviest known EP namely the top-quark with rest mass $m_{tq}\cong174\,GeV/c^2$): by emphasizing this much smaller $m_{MBH}\left(<10^{5}GeV/c^2\right)$, 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 $G_{Pl}>2.1\times10^{27}G$) acting close to $r_{\min}\left(\cong10^{-1}l_{Pl}\right)$ scales. This possibility of EPs being actually MBHs was also previously considered in a past article of the author [45]. If they are all truly MBHs, then EPs should have non-zero radii relatively close to $r_{\min}$ which may be an additional argument for choosing the function $G_{\mathrm{var}}\left(r\right)\left(=G\cdot a_G{}^{r_{\min}/\mathrm{r}}\right)$ which maintains a relatively constant value in the macrocosmic and partially in the microcosmic domains of length scales and then grows very abruptly up to $\cong10^{45}G\left(\cong G_{Pl}\right)\left(>2.1\times10^{27}G\right)$ when getting close to $r_{\min}$.

The largeness of $G_{Pl}\left(>2.1\times10^{27}G\right)$ 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* $\left(r_{\min}\right)$.

SUSYA also predicts the existence of a primordial ultra-heavy EP (and the heaviest of all EPs) called "W-tauonic boson" (**Wtb**) which may had been the main component of pBBQS and "parent" of all the other lighter EPs, including the main generator of the primordial massless Majorana neutrinos (Hfs and Zfs) which still exist today and compose the *hypothetical superfluid Hf/Zf-based aether* proposed by SUSYA.

4. FINAL CONCLUSIONS

This eZEH-based SUSYA essentially *resurrects the aether theory in the form of a Hf/Zf-based superfluid aether* and may also help solving the *hierarchy problem*, the infinite-density *singularity problem* (of General relativity) and crystallizes new directions in theoretical physics beyond the Standard model, including the prediction of *a granular/quantum structure of spacetime near the Planck scale* and the existence of a *pre-Big Bang quasi-singularity* (with large but finite density), with *all EPs being redefined as quantum micro black holes governed by a very strong gravitational field acting around Planck length scale*.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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