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

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Abstract

This paper proposes a universal *seesaw mechanism* (**SMEC**) applicable to all *elementary particles* (**EPs**) (*quantum black holes*), offering an alternative to *supersymmetry* (**SUSY**) and predicting a new type of *aether theory* (**AT**): this newly proposed universal SMEC is essentially based on *an extended zero-energy hypothesis* (**eZEH**) which predicts a general formula for all the rest energies of all EPs from Standard model (**SM**), also indicating an unexpected profound bijective connection between bosons and fermions and new types of EPs, including a *4th generation of Majorana massless neutrinos* (moving at the speed of light) that can be a plausible candidate for a superfluid aether/fermionic condensate.

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I. The main section of this paper

I-1. A zero-energy hypothesis (ZEH). This paper proposes a simple *zero-energy hypothesis* (**ZEH**) applied on any *virtual (particle-antiparticle) pair* (**VP**) (with total rest energy $E_{VP}=2E=2mc^2$ and total charge $q+(-q)=0C$) popping out from the quantum vacuum at hypothetical length scales comparable to the Planck length $l_{Pl}\left(=\sqrt{\hbar G/c^3}\right)\left(\cong 1.62\times 10^{-35}m\right)$. More specifically, *ZEH states that the total rest energy of that VP* $E_{VP}\left(=2E\right)$ *is nullified by the sum of both the negative gravitational energy of attraction* E_g *(between that EP and its anti-EP composing that VP) and the negative electrostatic/electromagnetic energy of attraction* E_q *inside that same VP* (with ZEH being essentially *an energy conservation principle applied to a hypothetical ex-nihilo creation of VPs*):

$$\boxed{E_{VP}+E_g+E_q=0(\mathrm{J})} \qquad (1)$$

The ZEH variant proposed in this paper considers and develops the simplest conceivable hypothetical non-relativistic case (at rest) *in which the gravitational and electrostatic inverse-square laws are just hypothesized to be valid down to* l_{Pl} *scales* so that $E_g=-Gm^2/r$ and $E_q=-k_e|q|^2/r$ (with G being the Newtonian gravitational constant and k_e being the Coulomb's constant). By also defining the ratios $\phi_g=G/r$ and $\phi_e=k_e/r$ the previous equation is equivalent to these other three $\boxed{E_{VP}-|E_g|-|E_q|=0(\mathrm{J})}\Leftrightarrow\boxed{|E_g|+|E_q|-E_{VP}=0(\mathrm{J})}\Leftrightarrow\boxed{|E_g|-E_{VP}+|E_q|=0(\mathrm{J})}$, this last "translating" to the following simple *quadratic equation with unknown* $x(=m)$:

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

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

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

The realness condition $\boxed{c^4\geq\phi_g\phi_e q^2\geq 0}$ implies the existence of a minimum (and mass-independent!) distance between any two EPs (composing the same VP) $\boxed{r_{\min}(q)=q\sqrt{Gk_e}/c^2}$ ($\cong 10^{-1}l_{Pl}$ for $q\cong e$): 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*.

Both generic conjugated mass solutions $m_{\pm}$ defined by formula (3) indicate that, *because* $m_{\pm}$ *has discrete values only,* ϕ_g *(and* E_g *implicitly) and* ϕ_e *(and* E_q *implicitly) should all have discrete values only*: however, ϕ_g and ϕ_e ratios can take discrete values *only if both their nominators (*G *and* k_e *respectively) and their common denominator (the length scale* r*) take only discrete values* (at scales relatively close to $r_{\min}$) a fact which, together with $r_{\min}(q)$ function, strongly suggests that *space is actually quantized/granular around Planck length-scale (**PLS**) and allows only discrete distances between EPs (of the same VP) at those scales*. ZEH thus predicts a spacetime vacuum with two main essential features:

(**1**) granular/quantized structure around PLS, and
(**2**) "*ex-nihilo*" creation of VPs at that same PLS measured by $r_{\min}(q)$.

More interestingly, for neutral EPs 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

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all three known 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 $m\left(=0kg\right)$ and are assigned only relativistic mass/energy by the Standard model).

The quantized spectrum containing the discrete rest energies of EPs $E_{\pm}=m_{\pm}c^2$ can be also derived from formula (3) by multiplying its both factors with c^2 and isolating the Planck force $\boxed{F_{Pl}=c^4/G\left(\cong 1.21\times 10^{44}N\right)}$ in the right term of that formula (3), resulting this simple elegant definition:

$$\boxed{E_{\pm}=rF_{Pl}\left(1\pm\sqrt{1-\frac{\left|E_q\right|}{rF_{Pl}}}\right)} \qquad (\mathbf{3'})$$

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I-2. A proposed extended zero-energy hypothesis (eZEH). This paper also proposes and analyzes a more "ambitious" *extended ZEH* (**eZEH**) *which assumes and applies the main formula (3) of ZEH (**3**) not only on virtual particle-antiparticle pairs (**VPs**) but also on specific boson-fermion pairs which share the same zero/non-zero electromagnetic charge* $\left(q\right)$ 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 q) are the eZEH-proposed alternative to the concept of *partner-superpartner pair* (or vice versa) used in *supersymmetry theory* (**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 fermionic MC is also its antiparticle, thus it is actually a Majorana fermion*.

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):* eZEH can be thus considered an "out-of-the-box" *SUSY alternative* (**SUSYA**).

In other words, formula (**3**) allows neutral EPs (**nEPs**) to be divided in two major families (nEPs with non-zero rest mass and nEPs possessing only relativistic mass) which may be regarded as an indirect proof for $m_{\pm}$ being a function of q (thus 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 $m_{\pm}$ actually define a boson-fermion pair (with conjugated masses) called here "*conjugated boson-fermion pair*" or "*mass conjugates*" (**MCs**). 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 (proposed as the main constituents of *dark matter* or even the constituents of *a hypothetical fermionic superfluid aether*), 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 the next sections of this paper**).

Returning to the same $m_{\pm}$ formula (3) of eZEH, the $c^2/\phi_g\left(=rc^2/G\right)$ ratio can be redefined as a "center" of mass-symmetry/conjugation between any two MCs proposed by this eZEH-based SUSYA, which "center" is mainly determined by the $\phi_g\left(=G/\mathrm{r}\right)$ ratio, thus by strength of the gravitational field (measured by a possibly variable/length-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 formula (3) of eZEH does not allow the existence of electromagnetically charged EPs with zero rest-mass, thus *doesn't allow the existence of elementary Weyl fermions*.

If interpreted as a non-coincidence, the previous equation (**3**) suggests/indicates that *the non-zero mass (**nzrm**) of EPs (possessing nzrm) depends inverse-proportionally with the strength of the gravitational field (**GF**) (measured by big G scalar) at those* r*-scales (comparable to Planck scale) so that: a stronger GF (measured by larger big G values at* r *scales, thus larger* $\phi_g\left(=G/r\right)$ *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 two previously published articles of the author [**1**,**2**]).

From the square root term $\pm\sqrt{c^4-\phi_g\phi_e q^2}$ of the same formula (3) also note that *a stronger GF (measured by larger big G values at* r *scales, thus a larger* $\phi_g\left(=G/r\right)$ *ratio) also produces a smaller variation of the rest masses* $m_{\pm}$ *(of the two MCs) around their center of mass symmetry* $c^2/\phi_g\left(=rc^2/G\right)$.

It is also very important to notice that the $m_{\pm}$ solutions proposed by eZEH strikingly resembles to the solutions proposed by the *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**) $|A'|(= x \cdot I_2 - A)$ of a proposed 2x2 symmetrical mass matrix of neutrinos $A = \begin{pmatrix} 0 & M \\ M & B \end{pmatrix}$ (with B being the Majorana mass component of the neutrinos and M being the Dirac mass component of the neutrinos) [**3**]. CP is the polynomial which is invariant under matrix similarity and has the eigenvalues of A as roots; $I_2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ is the 2x2 identity matrix with 1-values on the main diagonal and 0-values on the secondary diagonal). This very important aspect of eZEH is detailed later on in the subsection of this paper dedicated to the three known generations of neutrinos.

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For the beginning, let us start to estimate the values of ϕ_g for the known electromagnetically-neutral EPs (**nEPs**). 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 $\phi_{g(nEP)} = \left(c^2 \pm c^2\right)/m_{nEP}$.

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I-3. Two predicted types of neutral massless fermions (defined as mass conjugates of the Higgs boson and Z boson) proposed as candidate constituents of a predicted fermionic superfluid aether. In a first step and defining the unit of measure of $\phi_g \left(= 2c^2/m\right)$ as $u = m^2 s^{-2} kg^{-1}$, eZEH directly estimates ϕ_g for the Z boson (**Zb**) and Higgs boson (**Hb**) (with both Zb and Hb having non-zero rest energies) such as $\phi_{g(Zb)}\left(= 2c^2/m_{Zb}\right) \cong 10^{42} u$ and $\phi_{g(Hb)}\left(= 2c^2/m_{Hb}\right) \cong 8 \times 10^{41} u$. 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 $\phi_{g(\mathrm{Hb})}\left(\cong 8 \times 10^{41} u\right)$ with Hb) with zero rest masses $m_{Zf} = \left(c^2 - c^2\right)/\phi_{g(Zb)}\left(= 0\,kg\right)$ and $m_{Hf} = \left(c^2 - c^2\right)/\phi_{g(\mathrm{Hb})}\left(= 0\,kg\right)$ (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 actually be their own particles* thus to be *massless Majorana fermions*. Because Zb is a *spin-1 vector boson*, SUSYA also defines its mass-conjugate *Zf as being a Majorana vector-fermion*. Because Hb is a scalar boson, SUSYA also defines its mass-conjugate *Hf as being a Majorana scalar-fermion*. Being both fermions, Zf and Hf are also stated by SUSYA to obey *Pauli's exclusion principle*. Regarding the Zfs (vector-fermions), the left-handed Zfs are stated to form *isospin doublets*, while the right-handed Zf are stated to form *isospin singlets* (like all the other vector-fermions from the Standard Model).

These 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 who defined it as an EP 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 $H_0 \cong 70\left(km/s\right)/Mpc$ being the Hubble constant) and rest energy $E_0 = \frac{3}{2}\hbar H_0 \left(\cong 10^{-33} eV\right)$ [**4**].

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 [**5**]. In some variants of SUSY massless Majorana fermions (like Hf and Zf) are considered hypothetical "natural" superpartners of neutral spin-1 or spin-0 bosonic EPs, as also proposed by this SUSYA: since the three known generations of neutrinos have been found to have non-zero rest masses, Hf and Zf both partially "save" SUSY by replacing it with this SUSYA: furthermore (as explained in the next sections of this paper), *the three known generations of neutrinos are proposed by SUSYA to be actually the mass conjugates of the photon, the gluon and a hypothetical graviton*.

Zf and Hf are defined by this SUSYA as "*weakly-interacting lightest particles*" ("**WILPs**") which are stated by SUSYA to interact only (and very weakly!) via gravitational force/field both locally and at distance (by their very low but non-zero relativistic energy which couples gravitationally) and possibly via weak interaction (locally). An electron and such a massless Majorana neutrino (like Hf and Zf) can actually interact (but only locally) via charged-W exchange (as W boson has a very short mean lifetime and mediates only local interactions at very low length scales comparable to the size of a proton/neutron of about $10^{-15} m$). Note that in a Standard Model with a massless neutrino, there is no

right-handed neutrino. The existence of a conserved lepton number in the theory with massless neutrinos is the reason one usually favors the Weyl over the Majorana form of the theory.

Like all Majorana fermions (which possess only *positive/negative helicity* which coincides with *chirality* for massless spinors), Hf and Zf are also stated by SUSYA to cannot possess intrinsic electric or magnetic moments, but *only toroidal moments* (a consequence of their helicity) and that is why *they minimally interact with the electromagnetic field* (which makes them potential candidates for *dark energy identified with a Hf/Zf-based superfluid aether* and even candidates for *cold dark matter* if/when agglutinating in larger clumps of Hfs and Zfs with co-centered circular trajectories) [**6**, **7**].

SUSYA defines Hfs and Zfs to be maximally stable and to can not decay (thus with practically infinite lifetimes): more exactly, Hfs and Zfs are stated to be actually the final ultra-stable products of various possible decays of heavier EPs (mainly the decays of their heavier mass-conjugates). Furthermore, SUSYA retrodicts that the Big Bang would had mainly and firstly produced Hfs and Zfs (two types of very weakly interacting EPs) in huge quantities which compose a *superfluid aether (**SA**)* identified with our 3D non-empty space (as explained later in this section). In this way, SUSYA actually retrodicts a pre-Big-Bang singularity which may had generated both spacetime (identified with this Hf/Zf-based SA) and all EP-based physical objects (playing various "actor"-like "roles" on this aetherial spacetime "scene" identified with SA): this approach of SUSYA has some similarities with a special type of TOE (*theory of everything*) called "*Causal fermion system*" (firstly introduced by Felix Finster and collaborators) which derives both spacetime and the objects therein as secondary objects from the structures of an underlying *causal fermion system* [**8**].

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) [**9**]. LPDM was previously called "hot" because Zf and Hf are defined as being massless neutral (Majorana) 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 *fermionic superfluid aether/vacuum* (**FSA**), as also proposed by the notorious *Superfluid vacuum theory* (**SVT**) (in which the physical vacuum is modeled as a bosonic/fermionic superfluid) [**10**,**11**,**12**,**13**].

Because Hf is defined as a scalar neutral massless fermion (**NMF**) and the Zf is defined as a vectorial NMF, this FSA 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 [**14**]; the scalar Hf-based fermionic subfield (of FSA) 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 and a few GeV [**15**].

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 aether/ vacuum*. The initial concept of a "*luminiferous aether*" (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*: however, MM and MM-like experiments *cannot* exclude *a non-absolute preferred reference frame (**NAPRF**)* which can exist in fact; this hypothetical "sea/ocean" composed of these proposed "Z-fermions" and Higgs-fermions (moving at the speed of light, as proposed by SUSYA) may be indeed a plausible candidate for such NAPRF, as explained next.

*Furthermore, this Hf/Zf-based fermionic superfluid aether (**HZ-FSA**) may behave 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 thus possibly explaining the 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) [**16**]. A weakly-coupled but profound subtle connection may exist between this HZ-FSA and both the *Higgs field* and the *electroweak Z-subfield*, 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 VP 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* may be redefined as *collective distortions of the Hfs/Zfs trajectories composing this HZ-SFA*.

Furthermore, this SUSYA-proposed HZ-SFA may also rebring into attention the *Fatio/Le Sage theory of gravitation* (**FTG**) (which never gained widespread acceptance until present) in which streams of Hfs/Zfs 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 Hfs/Zfs, resulting in a net imbalance in the pressure exerted by the impact of Hfs/Zfs on the bodies, tending to drive the bodies together.

This SUSYA-proposed HZ-FSA may explain many apparent paradoxes of quantum mechanics/world (listed below):

(**1**) HZ-FSA may explain *Heisenberg's Uncertainty principle* and *the wave-particle duality* by the fact that any EP (or any EP-based composite physical object) produces ripples in this HZ-FSA

which may be identified with the so-called "*matter waves*" (firstly proposed by de Broglie).

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

(**3**) this HZ-FSA is stated by SUSYA to interact very weakly with all the other 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**) (by a resonance-like phenomenon at distance);

Additionally, this HZ-FSA 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 [**17**]) and further developed by: (**1**) Jacobson, Mattingly and their "*aetheory*" (launched in 2000) [**18**]; (**2**) Heinicke et al. in 2005 [**19**]; (**3**) Złośnik et al. in 2018 [**20**]; (**4**) Battye et al. in 2019 [**21**].

Important prediction. This 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 Hfs and 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.

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I-4. The proposed mass-conjugation between the three known types of neutrinos and the photon, gluon and a 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 $E_{en} < 1eV$ [**22**], the muon neutrino (**mn**) with $E_{mn} < 0.17MeV$ [**23**] and the tau neutrino (**tn**) with $E_{tn} < 18.2MeV$ [**24, 25**]: $\phi_{g(en)} > \cong 10^{53}u$, $\phi_{g(mn)} > \cong 6\times10^{47}u$ and $\phi_{g(tn)} > \cong 6\times10^{45}u$, with $\phi_{g(en)}$ being assigned a very large G_{var} upper bound $G_{en}\left(=\phi_{g(\text{en})}r_{\min}\right) \cong 2\times10^{28}G$, 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 length-scale. 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 problem. However, eZEH additionally proposes 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* (*Majorana neutrinos*): from this new point of view, *the previously-proposed hypothetical aether components Hf and Zf may be actually considered a "0th" (**4th**) (still undetected) generation of (Majorana) neutrinos.*

SUSYA is thus 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 $\left(x_+\cdot x_-=-M^2\right)$ to $x_-\left(\cong\frac{-M^2}{x_+}\right)\cong\frac{-M^2}{B}\cong 0$ [**3**] [**26**, **27**, **28**].

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:

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

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). Also considering the fact that k_e (which is directly-proportional to the *electromagnetic coupling constant* $\alpha(r)$ varying with the r-scale) and G are both stated by SUSYA to vary with the length r-scale with this *specific seesaw-like pattern* (as variable $k_{e(\mathrm{var})}(r)$ and $G_{\mathrm{var}}(r)$), the 2x2 symmetrical mass matrix with $m_{\pm}$ solutions as eigenvalues would be:

$$\boxed{Z(q,r)=\begin{pmatrix}0 & \frac{q}{2}\sqrt{\frac{-2k_{e(\mathrm{var})}(r)}{G}}\\ \frac{q}{2}\sqrt{\frac{-2k_{e(\mathrm{var})}(r)}{G_{\mathrm{var}}(r)}} & \frac{2rc^2}{G_{\mathrm{var}}(r)}\end{pmatrix}} \quad (\mathbf{5})$$

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 $Z(q,r)$ mass matrix.

In a checkpoint conclusion, SUSYA proposes a $Z(q,r)$-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.

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I-5. The proposed mass-conjugation between the electron and the W boson; two proposed bosonic mass-conjugates for the muon and the tauon. In a third step, eZEH additionally states that the W boson and the electron may also form a conjugate boson-fermion pair with a common $\phi_{g(\mathrm{W/e})}$ ratio, a common term $T=\sqrt{c^4-\phi_{g(W/e)}\phi_{e(W/e)}{q_e}^2}$ and rest masses $m_e=\left(c^2-T\right)/\phi_{g(\mathrm{W/e})}$ and $m_W=\left(c^2+T\right)/\phi_{g(\mathrm{W/e})}$. The common term T 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 $\boxed{\phi_{g(\mathrm{W/e})}=2c^2/\left(m_e+m_W\right)\left[\cong 2c^2/m_W\right]\cong 1.25\times10^{42}u}$, which is relatively close to $\phi_{g(Zb)}\left(\cong10^{42}u\right)$ and $\phi_{g(\mathrm{H}b)}\left(\cong 8\times10^{41}u\right)$, thus we have an estimated $\boxed{G_{W/e}\left(=\phi_{g(\mathrm{W/e})}r_{\min}\right)\cong G_{Zb}\cong G_{Hb}\cong 2\times10^{16}G}$. 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 $\boxed{\phi_{\mathrm{e(W/e)}}\cong 6.4\times10^{24}F^{-1}}$.

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.

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I-5. The proposed mass-conjugation between the three known generations of quarks and three predicted generations of fractional-charge bosons (known as "*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 $+\frac{2}{3}e$ (the mass-conjugate of the up quark sharing the same EMC $+\frac{2}{3}e$) may decay (by conserving its EMC, however) into an up quark (with the same EMC $+\frac{2}{3}e$) and an electron neutrino/antineutrino **OR** may decay into a down quark (with emc $-\frac{1}{3}e$) 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 $-\frac{1}{3}e$ (the mass-conjugate of the down quark sharing the same EMC $-\frac{1}{3}e$) may decay into a down quark (with the same EMC $-\frac{1}{3}e$) and an electron neutrino(/antineutrino) **OR** may decay into an up quark (with EMC $+\frac{2}{3}e$) and an electron (with EMC $-e$);

The 2nd and the 3rd generation of LQs are defined similarly to the 1st one and predicted to contain the pairs: "*charm-LQ*" (**cLQ**) & "*strange-LQ*" (**sLQ**) (2nd gen.); "*top-LQ*" (**tLQ**) -- "*bottom-LQ*" (**bLQ**) (3rd gen.).

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.

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II. A synthesis of SUSYA

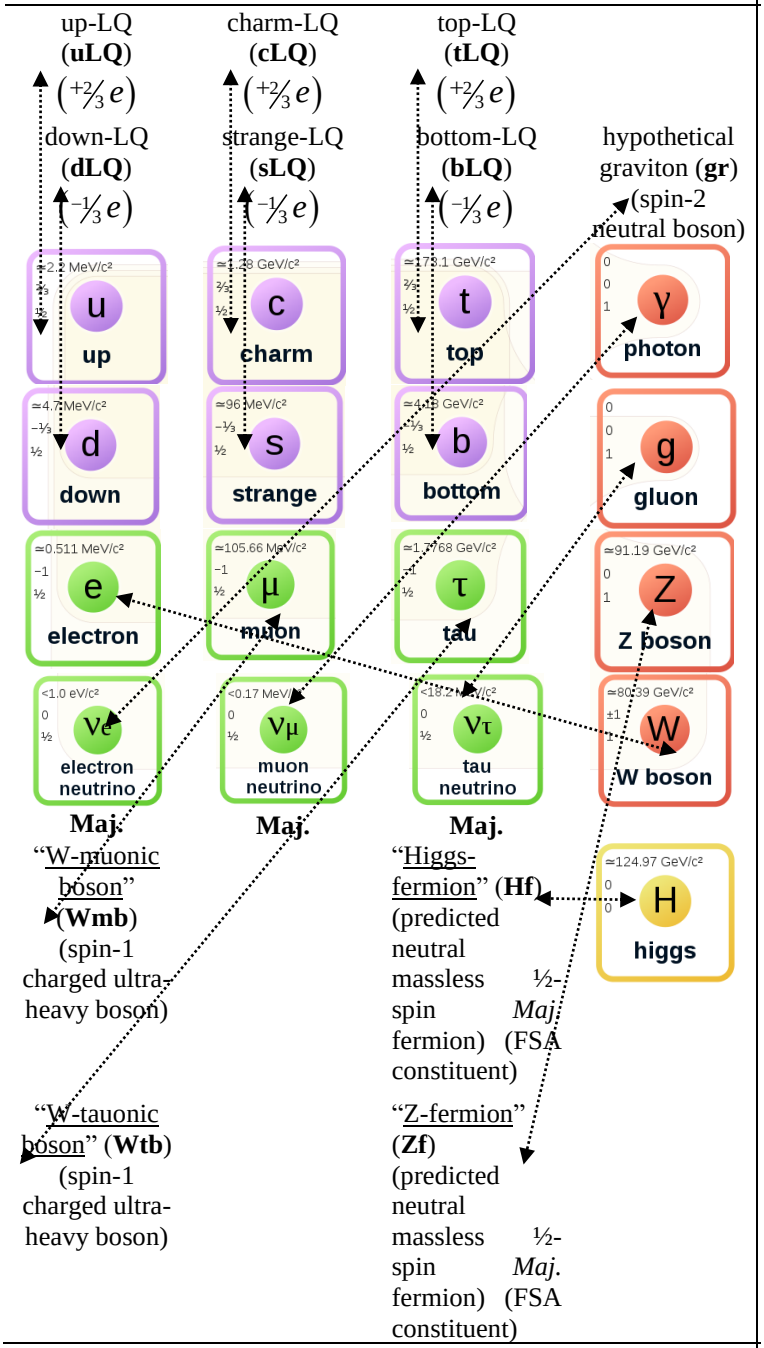
SUSYA essentially proposes *a universal seesaw mechanism* (abbreviated as Z-SMEC and previously expressed by the $Z(q,r)$ mass matrix) applicable to all known/unknown EPs. Z-SMEC actually replaces the "superpartner" notion (of SUSY) with the concept of (charge-based) "mass-conjugate" or simply "conjugate" 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)*.

eZEH also helps predicting a seesaw-like 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* $G_{\max}\geq G_{en}\left(>2.1\times10^{27}G\right)$ (with G_{en} being the big G assigned to the electron neutrino, as already explained in section I-5).

Furthermore, SUSYA offers many additional eZEH-based interesting predictions and explanations, including a new interpretation of Planck length, a granular/quantum structure of spacetime near the Planck scale (with a spacetime 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*), 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.

All the proposed pairs of EP-conjugates (as stated by the eZEH-based SUSYA) are also illustrated in the **next table**: eZEH transforms the already "classical" 2D table of EPs (from the Standard model of particle physics) in a 3D structure/table in which EPs are grouped *not only* in boson and fermion families/subfamilies, BUT they are also grouped and inter-related by an "underneath" relation of boson-fermion mass-conjugation, all based on the same simple semi-empirical quadratic equation proposed by eZEH as derivable from this proposed universal seesaw mechanism based on the $Z(q,r)$ mass matrix and applicable to all known and unknown EPs.

Table 1. The pairing of conjugated EPs predicted by the eZEH-based SUSYA and marked by interconnecting arrows [2].
↔ (marks each pair of conjugates stated by eZEH)
Additional abbreviation: Maj. (*Majorana neutrino*)



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III. Discussions and conclusions

The r-scale-dependent (variable) function $G_{\text{var}}(r)$ (with its previously defined maximum $G_{\max} > 2.1\times10^{27}G$) transforms the classical Planck mass $m_{Pl} = \sqrt{\hbar c / G}$ in a Planck mass series $\boxed{m_{Pl(\text{var})}(r) = \sqrt{\hbar c / G_{\text{var}}(r)}}$ which may offer a very interesting new glimpse in the domain of *quantum/micro black holes* (as explained next). The huge $G_{\max}\left(>2.1\times10^{27}G\right)$ has many important implications indicating that *micro(/ quantum) black holes* (**MBHs**) usually assigned a size comparable to Planck length l_{Pl} and a mass equal to the Planck mass $m_{Pl} = \sqrt{\hbar c / G} \cong 2.18\times10^{-8}kg$ (which is currently considered the approximate smallest mass of any MBH) may actually have much smaller masses of $\boxed{m_{MBH} = \sqrt{\hbar c / G_{\max}}\left(<10^{-22}kg\right)\left(<10^{5}GeV/c^{2}\right)}$ which relatively superposes to the mass-domain of the known EPs (with the heaviest known EP namely the top-quark with rest mass $m_{tq} \cong 174\,GeV/c^{2}$): 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 $G_{\max} > 2.1\times10^{27}G$) acting close to $r_{\min}\left(\cong10^{-1}l_{Pl}\right)$ scales: if all EPs are truly MBHs (as SUSYA predicts), then EPs should have non-zero radii relatively close to $r_{\min}$ (this possibility of EPs being actually MBHs was also previously considered in a past article of the author [**29**]). *VSGF may also explain the almost perfect spherical shape of the cloud of evanescent VPAPs covering / shielding any electron (as recently demonstrated).*

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

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