(Toy-model) A simple “digital” vacuum composed of space voxels with quantized energetic states

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ABSTRACT

Based on a plausible electro-gravitational scaling factor of nature, this paper proposes a relatively simple “digital” vacuum toy model (**DVTM**) based on a quantized 3D space composed of space voxels with quantized energetic states. DVTM contains a relatively small set observations and statements (the assumptions of the model) that may generate a relatively large number of explanations (on the common origin of both gravitational and inertial masses and Einstein’s special/general relativity) and predictions “inside” and beyond the Standard Model (**SM**) of particle physics: a model of movement, a Big Bounce universe and a unification pattern for all known fundamental fields. DVTM can be considered a kind of “patch” for some Loop Quantum Gravity theories (**LQGTs**) and for M-Theory (**MT**).

*Keywords: electro-gravitational scaling factor of nature; “digital” vacuum toy model (**DVTM**); quantized 3D space; space voxels with quantized energetic states; Standard Model (**SM**) of particle physics; model of movement; Big Bounce universe; unification pattern for all known fundamental fields; Loop Quantum Gravity theories (**LQGTs**); M-Theory (**MT**);*

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PART I.
THE MAIN OBSERVATIONS USED BY DVTM

1. ON A POSSIBLE RECIPROCAL FINE TUNING BETWEEN BIG G MAGNITUDE AND THE KNOWN ELEMENTARY NON-ZERO REST MASSES FROM THE STANDARD MODEL

The main parameters of a hypothetical micro black hole (mbh) (as expressed in Planck units). Let us consider a hypothetical quantum mbh with rest mass m_{mbh} and its condition of existence: that its Schwarzschild radius $r_{s(mbh)} = 2m_{mbh}G/c^2$ to be equal to its Compton wavelength $\lambda_{mbh} = h/(m_{mbh}c)$. Mbh is thus deducted to have a rest mass $\boxed{m_{mbh} = m_{Pl}\sqrt{\pi}}$, a rest energy $\boxed{E_{mbh} = E_{Pl}\sqrt{\pi}}$ and a radius $\boxed{r_{mbh} = \left(r_{s(mbh)} = \lambda_{mbh}\right) = l_{Pl}\sqrt{4\pi}}$ (with m_{Pl}, E_{Pl} and l_{Pl} being the Planck mass, Planck energy and Planck length respectively). **Note**. At least in principle, E_{mbh} is considered a plausible candidate for the lower mass bound for any black hole (including mbh), with the reserve of the possible existence of additional large extra dimensions (**LEDs**) predicted by supersymmetric string theories (**SSTs**) and M-Theory (**MT**), which may also imply the existence of a set of values $G_x > G$ and implicitly $E_{Pl}(G_x)\left[=\sqrt{\hbar c^5/G_x}\right] < E_{Pl}$ at sufficiently small length scales λ_x (relatively close to l_{Pl} and corresponding to energy scales $E_x = hc/\lambda_x$ close to E_{Pl}), at which the majority of the (hypothetical) gravitons emitted by a body are predicted to won't have yet "escaped" our 3D space in those hypothetical LEDs.

Observation on a base-2 logarithmic connection between mbh mass and elementary non-zero masses (at rest) through the fine structure constant (at rest). There are several physicists who predicted a possible logarithmic numerical "connection" between the inverse of the fine structure constant (**FSC)** at rest $\boxed{a = \left[\alpha^{-1} = \hbar c/\left(k_e q_e^{\,2}\right)\right] \cong 137}$ and the inverse of an arbitrary gravitational coupling constant (**GCC**) at rest $\boxed{a_G = \hbar c/\left(G m_p m_e\right) \cong 10^{41}}$ (with m_p and m_e being the rest masses of the proton and the electron respectively) (Teller, 1948; Salam, 1970; Sirag, 1980, 1983 etc) [**1**,**2**,**3**]. In a previous article [**4**], the author of this paper has also extensively analyzed this potential logarithmic connection as applied on all rest masses of all known elementary particles (**EPs**) from the Standard Model (**SM**) (an analysis that concluded in a plausible triple significance of the fine structure constant: electromagnetic, gravitational and informational) starting from Sirag's observation (discovered in 1980 [or before] and officially published in 1983) that $\boxed{\log_2(a_G) = 137.84 \overset{100.6\%}{\cong} a}$, which is equivalent to $\boxed{a_G \cong 2^a}$.

Definition. Based on the FSC inverse $a(\cong 137)$, let us consider a function $\boxed{f(m) = \log_2(m_{mbh}/m)/(a/2)}$ for any non-zero rest mass $\boxed{m \in \begin{Bmatrix} \mathrm{m}_u,\ \mathrm{m}_d,\ \mathrm{m}_c,\ \mathrm{m}_s,\ \mathrm{m}_t,\ \mathrm{m}_b, \\ \mathrm{m}_e,\ \mathrm{m}_\mu,\ \mathrm{m}_\tau,\ \mathrm{m}_W,\ \mathrm{m}_Z,\ \mathrm{m}_H \end{Bmatrix}}$ of any elementary particle (**EP**) in the standard model (**SM**). **Observation.** $f(m)$ has its values relatively close to 1, in the set $\begin{Bmatrix} 1.065,\ 1.05,\ 0.932,\ 0.986,\ \boxed{0.829},\ 0.907 \\ \boxed{1.097}, 0.985, 0.925, 0.845, 0.842, 0.836 \end{Bmatrix}$ $\in [0.829,\ 1.097] \in [1 \pm 0.2]$, relatively symmetrical and "equilibrated" around its arithmetic average $\boxed{av \cong 0.94}$, corresponding to

$\boxed{av \cdot a \cong 129}$. **Observation.** The electron neutrino $\left(\nu_e{}^0\right)$ rest mass is hypothesized to be in the interval $[0.2,\ 2]eV / c^2$ [**5**]. For $m_{\nu e} \cong 1.85 eV / c^2$ (which is the last experimental estimation of $m_{\nu e}$), $f\left(m_{\nu e}\right) \cong 1.361$ is an apparently "isolated" value, which may suggest the existence of EPs with non-zero rest masses with magnitude between m_e and $m_{\nu e}$, to fill the (empirical) "gap" between $f\left(m_e\right)\left(\cong 1.097\right)$ and $f\left(m_{\nu e}\right)\left(\cong 1.361\right)$: the most plausible candidates to fill this "gap" (at least partially) are the sterile neutrinos (which are also predicted by SM).

Checkpoint conclusion. DVTM considers unlikely for the values of $f(m)$ to be strongly centered around the arithmetic average $av \cong 0.94(\cong 1)$ only due to a simple coincidence: on the contrary, DVTM considers that the existence of this base-2 logarithmic "unity in diversity" (of all the known elementary non-zero rest masses) to be the consequence of a more profound law of nature. The values of $f(m)$ may essentially "hide" a possible **reciprocal fine tuning between big G magnitude** (which has an essential role in significantly "assuring" the m_{mbh} magnitude "necessary" for centering f values around $av \cong 1$) **and the magnitude of all EPs non-zero rest masses**: actually, **it is plausible that both big G and the set of EPs (non-zero rest) masses to be both determined by a general property/law of space vacuum itself.**

Hypothesis. A first step in trying to throw a light on this possible general space property/law (previously mentioned) would be to consider that experimentally measuring the value of FSC at rest (usually done directly, by quantum Hall effect) is in fact measuring the value of an <u>electro-gravitational scaling factor</u> $n_a\left(\cong 1.8\times 10^{41}\right)$ <u>at rest</u>, so that FSC (at rest) can be redefined (**redef.**) independently of $\hbar$, c, Coulomb constant k_e and elementary charge q_e, such as: $\boxed{a \overset{redef.}{=} \log_2\left(n_a\right)}$ and $\boxed{\alpha \overset{redef.}{=} 1/a}$, so that $f(m)$ can be approximated as $\boxed{f(m) \cong n_a{}^{0.5(\pm 0.1)}}$ and interconnects any known EP (non-zero) rest mass m with m_{mbh}, so that $\boxed{m \cong m_{mbh} / n_a{}^{0.5(\pm 0.1)}}$.

2. ON A PLAUSIBLE TRIPLE SIGNIFICANCE (ELECTROMAGNETIC, GRAVITATIONAL AND INFORMATIONAL/ENTROPIC) OF THE FINE STRUCTURE CONSTANT (AT REST)

Analysis (including hypothesis and predictions). In terms of thermodynamics, DVTM interprets $\boxed{N_{mbh}\left(\overset{def.}{=} m_{mbh} / m\right) \cong n_a{}^{0.5(\pm 0.1)}}$ as the total maximum number of <u>distinct quantum gravitational microstates</u> **(qgms)** of an mbh with a finite "mass ambitus", defined as the ratio between m_{mbh} and the (non-zero) rest mass of the lightest known/unknown EP allowed to possibly exist inside that mbh. **Hypothesis**. All qgms (of an mbh) are stated to have approximately equal probabilities. **Prediction**. Based on the previous hypothesis, a hypothetical mbh Shannon entropy H_{mbh} can be approximated as $\boxed{H_{mbh} = \log_2(N_{mbh}) \cong a/2 \cong 69\,gbits}$ (with gbits being defined as "[quantum] gravitational bit" measuring the total number of qgms in base-2 logarithmic units) with a minimum of $\boxed{H_{mbh(\min)} = \log_2(n_a{}^{(0.5-0.1)}) \cong 55\,gbits}$.

Verification(1). The Bekenstein bound (**BB**) (upper limit) for a 3D spherical mass with radius r_{mbh} and energy E_{mbh} as expressed in bits would be

$\boxed{BB[bits] = 2\pi r_{mbh} E_{mbh} / (\hbar c \ln 2) \cong 57 bits}$, with $H_{mbh(\min)} (\cong 55 gbits)$ being slightly lower than this BB upper limit, which validates in principle this mbh model and also validates the usage of Shannon entropy for mbh and the equivalence between bits and gbits. **Verification(2)**. Furthermore, based on the estimated mbh event horizon area $\boxed{A_{mbh} = 4\pi r_{mbh}^2}$ and Planck area $A_{Pl} = l_{Pl}^2$, the Bekenstein-Hawking (**BH**) entropy (also expressed in bits) of mbh can be estimated as $\boxed{S_{BH(mbh)} \cong A_{mbh} / (\ln(2) \cdot 4A_{Pl}) \cong 57 bits}$ $(= BB[bits])$, with $H_{mbh(\min)} (\cong 55 gbits)$ being also close to (and slightly lower than) BH entropy estimation applied on mbh.

Interpretation (and prediction). The fact that N_{mbh} values are relatively well centered around $\cong n_a^{0.5}$ indicates that $\boxed{a/2 = \log_2 (n_a^{0.5})}$ (at rest) may be also interpreted as the theoretical Shannon (quantum gravitational) entropy of any mbh (at rest) (in which the number of N_{mbh} distinct qgms are attributed approximately equal probabilities). $\boxed{2FSC \overset{redef.}{=} 1/\log_2 (n_a^{0.5}) \cong 1/\log_2 (N_{mbh})}$ (at rest) is additionally interpreted as the inverse of the mbh Shannon entropy (thus, the level of mbh "order") **so that** n_a**,** a **and** α **may all share a triple significance: informational (entropic), electromagnetic and (quantum) gravitational (estimating the number of qgms of an "elementary" mbh); FSC may thus define a fundamental property of space vacuum itself, more specifically FSC would define the doubled inverse of the quantity of quantum gravitational information stored in any mbh**: **in other words, EPs and mbh may share a common quantum entropy, as described by FSC** and also argued next.

Redefinitions (and predictions). Based on n_a, DVTM (re)defines (and predicts): (**1**) the Coulomb constant as $\boxed{k_e \overset{redef.}{=} \hbar \frac{c / q_e^2}{\log_2 (n_a)}}$ (which can be essentially regarded as an indirect measure of $\hbar$); (**2**) a (reduced) gravitational Planck-like constant (for the hypothetical graviton) $\boxed{\hbar_g = \hbar / n_a \cong 5.9 \times 10^{-76} Js}$, with the graviton energy scalar $E_g(\lambda)$ defined analogously to the photon, such as $\boxed{E_g(\lambda) = \hbar_g \lambda / c}$; (**3**) a quantum gravitational coupling constant (**GCC**) at rest for an electron/positron pair $\boxed{\alpha_{Gq} \overset{def.}{=} (2a^{3/2} n_a)^{-1} \cong 1.74 \times 10^{-45}}$ defining the strength of a (hypothetical) quantum gravitational field (**QGF**) (mediated by the hypothetical graviton), in which α_{Gq} approximates the empirical GCC $\alpha_G = Gm_e^2 / (\hbar c) \left(\cong 1.75 \times 10^{-45}\right)$ with 99.6% accuracy and also predicts a quantum G scalar $\boxed{G_q = \alpha_{Gq} \hbar c / m_e^2 = \hbar_g \frac{c / m_e^2}{2a^{3/2}}} \cong 6.648 \times 10^{-11} m^3 kg^{-1} s^{-2}$ $\overset{99.6\%}{\cong} G$ with the same high accuracy, which G_q can be actually considered an indirect measure of the predicted gravitonic quantum momentum $\hbar_g$, analogously to k_e being the indirect measure of $\hbar$.

Redefinitions and predictions. The running coupling constant of the electromagnetic field (**EMF**) $\boxed{\alpha_f(E) \cong \frac{\alpha}{1 - (\alpha / 3\pi) \ln\left[(E / E_e)^2\right]}}$ (as determined in quantum electrodynamics by using the beta function computed in perturbation theory, as a function of a variable energy scale $E \gg E_e \left(= m_e c^2 \cong 0.51 MeV\right)$ starting from the experimental FSC value at rest $\alpha \cong 1/137$ **[6, 7])** may be interpreted/explained and redefined as actually being the consequence of n_a variation of with a variable energy scale E, as described by the function $\boxed{nf_a(E) \overset{def.}{=} n_a / (E/E_e)^{\frac{\ln(4)}{3\pi}}}$, so that $\alpha_f(E)$ can be equivalently redefined as $\boxed{\alpha_f(E) \overset{redef.}{\cong} 1/\log_2[nf_a(E)]}$, with a Landau pole for the value $\boxed{E_{sup} = E_e \cdot n_a^{3\pi/\ln(4)} \cong 1.45\times 10^{277}\, GeV}$, which corresponds to $nf_a(E_{sup}) = 1$.

Definitions and predictions. Based on $nf_a(E)$ and $\boxed{\alpha_{Gq} = (2a^{3/2}n_a)^{-1}}$, an analogous $nf_{Gq}(E)$ is defined as $\boxed{nf_{Gq}(E) \overset{def.}{=} 2[nf_a(E)]^{3/2}\, nf_a(E)}$, with a running GCC of QGF $\boxed{\alpha_{Gq}(E) \overset{def.}{=} 1/nf_{Gq}(E)}$, which has the same Landau pole for $E = E_{sup}$. Based on $\alpha_{Gq}(E)$, G_q can be generalized as a function of the energy scale $\boxed{G_q(E) = \alpha_{Gq}(E) \cdot \hbar c / m_e^2}$, with predicted $\alpha_{Gq}(E_{Pl}) \cong 10^3 \alpha_G$ and $\boxed{G_{q(Pl)} = \alpha_{Gq}(E_{Pl}) \cdot \hbar c / m_e^2 \cong 10^3 G}$.

Redefinitions of Planck units. Based on the running n_a and $G_q(E)$, all Planck units can be redefined using $G_q(E)$ so that: (**1**) $E_{mbh}\left(= E_{Pl}\sqrt{\pi}\right)$ becomes $\boxed{E_{mbh}(E) = \sqrt{\pi\hbar c^5 / G_q(E)}}$, with redefined(r) $\boxed{E_{mbh(r)} = E_{mbh}(E_{Pl}) \cong E_{Pl}/27}$ and (**2**) $r_{mbh}\left(= l_{Pl}\sqrt{4\pi}\right)$ becomes $\boxed{r_{mbh}(E) = \sqrt{4\pi\hbar G_q(E)/c^3}}$, with redefined $\boxed{r_{mbh(r)} = r_{mbh}(E_{Pl}) \cong 167\, l_{Pl}}$.

PART II. THE MAIN STATEMENTS (ASSUMPTIONS) OF DVTM (WITH EXPLANATIONS AND PREDICTIONS)

1. A QUANTIZED 3D SPACE COMPOSED OF SPACE VOXELS WITH QUANTIZED ENERGETIC STATES

Conjecture (and matrix model). Similarly to Loop Quantum Gravity theories (**LQGTs**), DVTM conjectures a quantized 3D space and models the 3D vacuum of our observable universe (**ou**) as a **finite** 3D grid (3D "spatial matrix") with 3 spatial dimensions (defined by generic Oxyz axis system) composed from a finite (positive) number of spherical space voxels **(SVs)** (each SV being defined as 3D "micro" brane in the terms M-Theory and being composed from "superficial" and "deeper" spherical concentric layers)**,** each SV with a geometrical SV center (**SVc**), a variable finite (but non-infinitesimal) positive non-zero radius $\boxed{r_{SV} > 0m}$, area $\boxed{A_{SV} = 4\pi r_{SV}^2 > 0m^2}$ and volume $\boxed{V_{SV} = 4\pi r_{SV}^3/3 > 0m^3}$.

Definition. Each (spherical) SV is assigned a positive energy quanta $\boxed{E_{SV} > 0J}$. The 3D space localized inside the surface of each x-the SV (with finite and non-infinitesimal external area $A_{SV(x)} > 0m^2$) will be named "inner space" (**IS**) and is assigned a finite (and non-infinitesimal) volume $\boxed{V_{SV(x)} > 0m^3}$ and a finite (and non-infinitesimal) positive energy $\boxed{E_{SV(x)} > 0J}$: the global (g) IS of all SVs (of ou) will be abbreviated as "**gIS**" and is assigned a (total) finite (and non-infinitesimal) positive global volume

$V_{gIS} = \sum_{x=1}^{N} V_{SV(x)}$ (with N being the finite total number of SVs of ou), a finite total area $A_{gIS} = \sum_{x=1}^{N} A_{SV(x)}$ and a finite total energy $E_{gIS} = \sum_{x=1}^{N} E_{SV(x)}$. **Definition**. The 3D space between the spherical SVs is named "outside space" (**OS**) (space "outside" SVs) and is assigned a global finite non-zero volume $V_{OS}\left(\gg V_{SV}\right) > 0m^3$ and a total (global) negative energy $E_{OS} < 0J$. **Three types of ou**. Let us define a (global) differential (dif) energy $E_{dif} = E_{gIS} - \left|E_{OS}\right|$ (which is also finite, as both E_{gIS} and E_{OS} are stated to be finite) such as: (**1**) ou with $E_{dif} = 0J$ is a zero-energy ou; (**2**) ou with $E_{dif} > 0J$ is a positive-energy ou with finite positive total energy E_{dif}; (**3**) ou with $E_{dif} < 0J$ is a negative-energy ou with finite negative total energy E_{dif}.

Antigravity (definition and statements). In DVTM, each SV (with assigned positive energy) is stated to repel any other (positive energy) SV: in DVTM, this repulsive force between any pair of SVs is defined as antigravity (**AG**), with all matter (and radiation) being defined as the manifestations of AG. AG is also stated to always tend to increase the entropy of any physical system: AG is predicted to also manifest itself as the second law of thermodynamics (**2LT**), which is inversely defined as a consequence of AG. AG (with its tendency of raising entropy) is stated to generate the normal time arrow (oriented from past to future and named "time"). AG is also assigned an energy scale dependent quantum antigravitational constant $G_{q(AG)}\left(E\right)[m^3kg^{-1}s^{-2}]$.

Quantum gravitational field (definition and statements). In DVTM, the negative energy OS is stated to exert a suctional force which tends to attract all SVs to one another, thus opposing to the (previously defined) AG: this suctional field is identified by DVTM with a (basic/fundamental) quantum gravitational field (**QGF**) and assigned the same negative energy E_{OS} of OS. **Note(1).** QGF was coined as "quantum" for the moment, because it is defined as a universal suctional field between all the "atoms" of ou space ("atoms" identified with SVs): more arguments will be brought later for the "quantum" attribute of QGF. The suctional QGF is also stated to always tend to decrease the entropy of any physical system and thus to oppose 2LT. QGF is also stated to generate a reversed time arrow (from future to past and named "anti-time"). QGF is assigned the energy scale dependent quantum gravitational constant $G_q\left(E\right)[m^3kg^{-1}s^{-2}]$.

Note(2). DVTM regards both QGF and AG as fundamental and inseparable phenomena: "pure" space (which is assigned negative energy) and "matter" (including radiation) (which is assigned positive energy) are also considered inseparable in both theory and practice. **Statement.** As AG and QGF were stated to act simultaneously and inseparably in OS, the (experimentally) measured (classical) Newtonian gravitational field (**NGF**) is also stated to be actually the resultant of these two inseparable fields (AG and QGF) so that DVTM redefines an energy scale dependent Newtonian big G as $G\left(E\right) = G_q\left(E\right) - G_{q(AG)}\left(E\right)$. The fact that big G has a relatively low absolute value (but larger than $0m^3kg^{-1}s^{-2}$) implies that, at least in the present space and moment of ou, global QGF slightly surpasses global AG in strength: in other words, the global AG is sufficiently strong to almost completely nullify the global suctional effect of QGF (on all SVs from ou). **Statement (and explanation)**. Furthermore, the suctional effects of QGF and the repulsive effects of AG will both dilute with the square of the distance, as OS is defined as 3D medium which generally disperses any local effect with the square of the distance: this is how DVTM explains the inverse square law (**ISL**) of Newtonian gravity. **Important statement**. In DVTM, each SV in part is also stated to occupy a very small and finite (but possibly infinitesimal) fraction of OS volume V_{OS} (which OS fraction is also assigned negative energy), so that QGF is stated to act not only in OS, but also inside each SV exerting a suctional force on that SV (directed from outside to inside), which force is stated to explain both the stability and spherical shape of each SV in part. **Explanation**. All physical bodies stated to be composed from SVs which are the subject of QGF acting in both IS and OS, which QGF generates the phenomenon of "universal gravity". **Consequence**. As they act on all SVs, both QGF and AG are stated to cannot be shielded, as all possible shields are also physical bodies stated to be composed from SVs. **Note**. One may observe that DVTM treats positive and negative energy/mass as a kind of "gravitational charges" (analogous to electromagnetic charges): this is one of the main principles of DVTM. **Statement**. SVs are stated to allow translations (on any possible 1D linear/curved trajectory), including rotations (around any geometrical point inside or outside that SV) and so they can be also assigned a positive kinetic energy $\boxed{E_{k(SV)} > 0J}$. **Note**. SVs are stated to show permanent volumic micro-oscillations (defined as volumic micro-variations): if a SV has only such (permanent) volumic micro-oscillations (without any other types of translational and/or rotational and/or vibrational movements), it is stated to be a SV "at rest". The term "micro" shall be defined later on in this paper, after presenting the energetic quantization of SVs in DVTM.

An explanation for the common origin of both gravitational mass and inertial mass. When any chosen SV is accelerated in any direction of the 3D OS (by using any type of force, including gravity), the attraction force between that SV and its surrounding OS will tend to oppose to that (initial) induced movement, an opposition which generates a "friction"-like force/energy (with magnitude directly-proportional to the radius of that SV, hence its area and volume) which is identified by DVTM with the inertial mass/energy of that SV: that is how DVTM actually explains inertial mass, gravitational mass and the equivalence principle between both gravitational and inertial masses, which is also the main principle of Einstein's General Relativity Theory (**GRT**). **Prediction beyond the Standard Model (SM)**. As previously explained, the fact that each SV in part has a non-zero surface area A_{SV} (which is the interface between that SV and its surrounding OS) implies the mandatory existence of a non-zero "friction"-like force between any SV and OS: based on this fact, DVTM predicts that all SVs will have rest masses/energy and all elementary particles (**EPs**) (which are identified with different excitations states of SVs, as explained later on), including the photon and the gluon (which are assigned theoretical zero rest masses in SM), are also predicted by DVTM to have very small but non-zero rest masses/energies, as also explained in detail later on.

Statement (and definition). The generic SV is assigned a maximum allowed energetic state at rest $\boxed{E_{SV(\max)} = E_{mbh(r)} \cong E_{Pl} / 27}$ which corresponds to a maximum SV radius $\boxed{r_{SV(\max)} = r_{mbh(r)} \cong 167 l_{Pl}}$: a SV assigned with both $E_{SV(\max)}$ and $r_{SV(\max)}$ is stated to be in its highest energetic state. **Statement (and definition)**. The generic SV is also assigned a minimum allowed energetic state at rest $E_{SV(\min)}$: DVTM firstly proposes $E_{SV(\min)}$ as equal to the energy of a hypothetical photon with a wavelength equal to the ou diameter $D_{ou} \cong 10^{27} m$, so that $\boxed{E_{SV(\min)} = hc / D_{ou} \cong 1.4 \times 10^{-33} eV}$. **Statement (and definition)**. The ratio $\boxed{N_{SV} = E_{SV(\max)} / E_{SV(\min)} \cong 10^{59}}$ and its binary logarithm $\boxed{n_{SV} = \log_2 \left(N_{SV} \right) \cong 198}$ are stated to both measure the maximum energetic "ambitus" $\boxed{A \overset{def.}{=} 198 \left(\cong n_{SV} \right)}$ of any SV from ou, so that

$E_{SV(\min)}$ can be also redefined as

$$E_{SV(\min)} \overset{redef.}{=} E_{SV(\max)} / 2^A \cong 1.1\times 10^{-33}\, eV.$$

Statement (and definition). In DVTM, all SVs at rest are stated to allow only fixed quantized energetic states $E_{SV}(i) = 2^i E_{SV(\min)}$ with positive integer $i \in [0, A]$ and $E_{SV}(0) = E_{SV(\min)}$: a SV in any i-th energetic state will be indexed as SV(i), so that each SV(i) at rest (with A≥i≥0) will have the doubled energy of SV(i-1) and each SV(i) at rest (with A>i≥0) has the half energy of SV(i+1) at rest. **Note (1).** $E_{SV}(i)\left(=2^i E_{SV(\min)}\right)$ was chosen not only for being among the simplest possible exponential functions, but also for the reason that it has a unique property among the sums of power series of integers so that $\sum_{x=0}^{i-1} E_{SV}(x) \to E_{SV}(i)$, which is equivalent to $L(i) \to 1$, with

$$L(i) = \sum_{x=0}^{i-1}\left[E_{SV}(x)/E_{SV}(i)\right]$$

and $|L(i)-1| \cong 1/10^{i/3}$. **Demonstration.** It is well known from the mathematical literature on geometric series [1] that the sum of the first i elements of a geometric series with ratio r and first term a is

$$\left(\sum_{x=0}^{i-1} ar^x\right)\left(=a+ar^1+ar^2+ar^3+...+ar^{i-1}\right)=a\left(\frac{1-r^i}{1-r}\right).$$

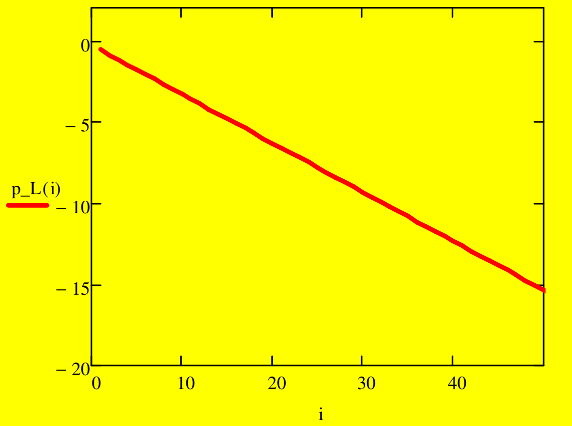
$E_{SV}(x)$ is a special case in which $a = E_{SV(\min)}$ and ratio $r=2$, so that

$$\sum_{x=0}^{i-1} E_{SV}(x) = \sum_{x=0}^{i-1}\left(E_{SV(\min)}2^x\right) = E_{SV(\min)}\left(\frac{1-2^i}{1-2}\right)$$
$$= E_{SV(\min)}\left(2^i-1\right) = E_{SV}(i) - E_{SV}(0)$$

and

$$L(i) = \frac{E_{SV}(i)-E_{SV}(0)}{E_{SV}(i)} = \frac{E_{SV}(i)-E_{SV(\min)}}{E_{SV}(i)} \overset{<}{\cong} 1,$$

which obviously approaches value 1 when $E_{SV}(i)$ increases exponentially and $|L(i)-1| \cong 1/10^{i/3}$ as shown in the next graph.



Graph II-1. The decrease of $p_L(i) = \log_{10}\left(|L(i)-1|\right)$ with the increase of index i.

For any integer value of the ratio $r \neq 1$, $L(i)$ can be generalized as

$$L(i,r) = \frac{E_{SV}(i)-E_{SV(\min)}}{E_{SV}(i)(r-1)},$$

which $L(i,r)$ is closest to value 1 when $r=2$.

Note (2). Given this unique property, a generic SV(i) at rest with energy $E_{SV}(i)$ (at rest) approximates with very high accuracy the energetic summation of each of all inferior SV(x) (at rest) with generic energies $E_{SV}(x)$ (and with x<i), so that any SV(i) can be regarded as the superposition of all its inferior SVs(x) (with x<i). In this way, DVTM assumes and "incorporates" the quantum superposition principle.

The volume-energy-information equivalence principle (VEI-EP). VEI-EP is one of the main principles of DVTM and states that (quantum) energy and (quantum) information are both equivalent to (quantum) volume and thus are essentially reciprocally equivalent and interchangeable and, implicitly, (quantum)

[1] See URL: https://en.wikipedia.org/wiki/Geometric_series#Formula

volume, information and energy are all reciprocally equivalent. **Prediction**. DVTM also predicts that both the energy conservation principle and (quantum) information conservation principle are actually the consequence of the more general VEI-EP.

Statement and calculations. Applying VEI-EP as a volumic conservation principle (**VCP**) to a simple iterated symmetrical binary split of a SV(A) (with energy $E_{SV}(A) \overset{def.}{=} E_{mbh(r)}$ and radius $r_{SV}(A) \overset{def.}{=} r_{mbh(r)} = r_{S(mbh)} = = 2E_{mbh(r)}G/c^4 = 2E_{SV}(A)G/c^4$) into a pair of SVs(A-1) (each SV(A-1) with $V_{SV}(A-1) = V_{SV}(A)/2^1$ resulting a radius $r_{SV}(A-1) = r_{SV}(A)/2^{1/3}$ and a SV(A-1) with energy $E_{SV}(A-1) = E_{SV}(A)/2^1$ and volume $V_{SV}(A-1) = V_{SV}(A)/2^1$), DVTM obtains $E_{SV}(i) = E_{SV}(A)/2^{(A-i)}\left[= E_{SV(\min)} \cdot 2^i\right]$ and a generalized radius function for any SV(i), such as

$$r_{SV}(i) = r_{SV}(A)/2^{(A-i)/3} = = \left[2E_{SV}(A)G_{q(Pl)}/c^4\right]/2^{(A-i)/3} = 2E_{SV}(i)2^{2(A-i)/3}G_{q(Pl)}/c^4.$$

Observation. It is also important to notice that, for each SV(i) split into a SVs(i-1) pair, the total volume conserves so that $2V_{SV}(i-1) = V_{SV}(i)$, but total (2D) external area of the resultant SVs(i-1) pair dilates at each split with the same factor $2^{1/3}$ so that $2^1 A_{SV}(i-1) = 2^{1/3} A_{SV}(i)$: this (step-by-step) increasing area $2^j A_{SV}(i-j) = 2^{j/3} A_{SV}(i)$ implies a progressively larger $A_{gIS} = \sum_{x=0}^{N} A_{SV(x)}$ (the area of the quantized 2D global interface between IS and OS) with the decrease of the average index $i_{av} = \sum_{x=0}^{N} i_x / N$ of all SVs from our universe (with i_x defining the $i_x - th$ energetic excitation level i_x**-EL** of each x-th SV(i_x) of ou).

SV series modeled as quantum mbh series. DVTM models each SV(i) (identified with a specific type of EP) as a distinct quantum mbh with radius $r_{SV}(i) = 2E_{SV}(i)2^{2(A-i)/3}G_{q(Pl)}/c^4$ equal to a newly defined **quantum Schwarzschild radius** $r_{qs(SV)}(i) = 2E_{SV}(i)G_q(i)/c^4$: keeping $r_{SV}(i) = r_{qs(SV)}(i)$ equality at progressively lower sub-Planck size scales also implies a variable quantum big G $G_q(i) = 2^{2(A-i)/3}G_{q(Pl)}$ (as previously marked in red) assigned to space (both IS and OS) at progressively lower length scales, with $G_q(A) \overset{def.}{=} G_{q(Pl)}$ and $G_q(1) \cong 7.6 \times 10^{42} G$, with $r_{SV(\min)} = r_{SV}(1) \cong 10^{-20} l_{Pl}$. **Observation.** The majority of authors have calculated a value for a hypothetical strong gravitational constant (**SGC**) (Γ) from $\Gamma_{\inf} \cong 10^{35} G$ up to $\Gamma_{\sup} \cong 10^{47} G$ (Fisenko et al. [**8**]; Recami et al. [**9**]; Stone [**10**]; Mongan [**11**] etc). DVTM predicted $G_q(1) \cong 10^{43} G$, which is in the interval $\left[\Gamma_{\inf}, \Gamma_{\sup}\right]$ and relatively close to $\Gamma_{\sup} \cong 10^{47} G$. **Note.** In a spacetime in which time is modeled as a 4th large extra dimension (**LED**), $G_q(1) \cong 10^{43} G$ measures the strength of QGF at very small sub-Planck length scales $r_{SV(\min)} \cong 10^{-20} l_{Pl}$, at which the majority of the (hypothetical) gravitons emitted by a body are predicted to won't have yet "escaped" our 3D space in that hypothetical LED.

Prediction and explanation. Note that the alternative functions $G_q(i)$ and $\boxed{\alpha_{Gq}(i)=G_q(i)m_e^2/(\hbar c)}$ are defined only for integer indexes $i\in[1,A]$, so that DVTM also defines a general interpolation (**in**) function based on any real index $i\in[1,A]$, for any length scale $r_{SV}(i)$ and any energy scale $E(i)=hc/r_{SV}(i)$: this interpolation function uses a variable energy scale E as argument and it is based on the (inverse) extraction of an interpolated real index $i_f(E)$ from any length-scale such as

$$\boxed{i_f(E)=A-\log_{(2^{1/3})}\left(r_{mbh(r)}/(hc/E)\right)},$$

$$\boxed{G_{q(in)}(E)=2^{2\left(A-i_f(E)\right)/3}G_{q(Pl)}}$$ and

$$\boxed{\alpha_{Gq(in)}(E)\begin{cases}=\alpha_{Gq}(E), for\, E\le E_{mbh}\\ =G_{q(in)}(E)\cdot m_e^2/(\hbar c), for\, E>E_{mbh}\end{cases}}.$$

Prediction (and explanation). Any group of adjacent SVs with larger/smaller than average radii mimics a local space dilation/contraction than may also induce a position change in other surrounding groups of SVs on a much larger scale: this is how DVTM explains spacetime dilation/contraction and (experimentally confirmed) gravitational waves, as also predicted by Einstein's GRT. **Note.** In DVTM, $l_{Pl(r)}$ does not represent the lowest SV radius allowed in nature, but the inflexion point which marks a phase change from a slow growing $\alpha_{Gq(in)}(E)$ (and G_q) to a fast growing $\alpha_{Gq(in)}(E)$.

New estimation (prediction) for the unification energy scale of all fields acting in ou. The previously calculated minimum length quanta allowed by ou as $\boxed{r_{SV(\min)}=r_{SV}(1)\cong 1.3\times10^{-20}l_{Pl}}$ predicts a maximum energy scale allowed in ou (identified with the unification [**unif.**] scale of all the four known fundamental forces/fields of ou) $\boxed{E_{unif}=hc/r_{SV(\min)}\cong10^{20}E_{Pl}\cong10^{39}GeV}$: $nf_a(E)$, $\alpha_f(E)$, $nf_{Gq}(E)$, $\alpha_{Gq}(E)$, $i_f(E)$, $G_{q(in)}(E)$ and $\alpha_{Gq(in)}(E)$ are all stated to apply up to this huge energy scale (E_{unif}).

Important observation. It is important to note that $\boxed{E_{sup}\left(=E_e\cdot n_a^{3\pi/\ln(4)}\cong1.45\times10^{277}GeV\right)}$ is much larger than E_{unif}, so that DVTM "wipes out" the Landau poles of both $\alpha_f(E)$ and $\alpha_{Gq}(E)$ predicting a maximum FSC (corresponding to E_{unif}) $\boxed{\alpha_f(E_{unif})\cong1/\log_2\left[nf_a(E_{unif})\right]\cong1/116}$ and a super-unitary $\boxed{\alpha_{Gg(in)}(E_{unif})\cong637}$, which indicates QGF as a primordial field with huge strengths at size scales measured by $r_{SV(\min)}$.

Important note. In DVTM, $E_{unif}\cong10^{39}GeV$ (and not $E_{Pl}\cong10^{19}GeV$) is considered by DVTM the true unification energy scale of all the four fundamental fields (together with the newly defined $\alpha_{Gq(in)}(E)$ and $\alpha_f(E)$): this approach may solve the hierarchy problem, as it may explain the huge divergence of the two electromagnetic and gravitational (fields, with theoretical infinite range) coupling constants by the largeness of both $E_{unif}(\gg E_{Pl})$, n_a and the simple (base-2 logarithmic) law that interconnects $\alpha_{Gq}(E)$ and $\alpha_f(E)$.

Graph. The approximated running coupling constants of QGF and EMF can be represented on the same graph using the base-10 logarithmic functions $p_{GF}(E)=\log_{10}\left[\alpha_{Gq(in)}(E)\right]$ and $p_{EMF}(E)=\log_{10}\left[\alpha f(E)\right]$: **see the next graph**, which shows a unification pattern of QGF and EMF at $E_{unif}\cong10^{39}GeV$.

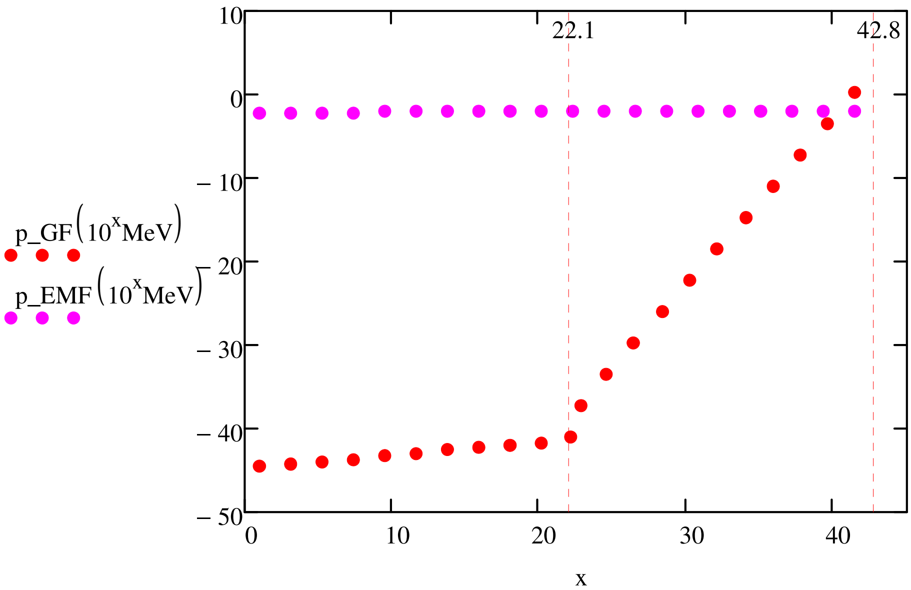


Figure II-1. A unification pattern of the running coupling constants of QGF and EMF at E_{unif}, with two additional markings (as vertical lines) for $x_1 = \log_{10}\left(E_{Pl} / MeV\right) \cong 22.1$ and $x_2 = \log_{10}\left(E_{unif} / MeV\right) \cong 42.8$.

The correspondence between a specific SV(i) and a specific type of elementary particle (EP). In DVTM, each known EP from the Standard Model (**SM**) is redefined as a (relatively) specific (but not necessarily distinct) level of SV excitation indexed as SV(i), so that a specific SV(i) corresponds to one (or more) specific (type of) EPs.

Analysis. The set of EPs with non-zero rest energies $\left(E_{EP}\right)$ arranged in ascending order of E_{EP} magnitudes (from left to right and up to down in the next arranged set) $\begin{Bmatrix} \nu_e & \nu_\mu & \nu_\tau & e^- & u \\ d & s & \mu^- & c & t^- \\ b & W^+ & Z^0 & t & H^0 \end{Bmatrix}$, with E_{EP} in the set of (approximated) rest energies (measured in electronvolts [**eV**] and including the electron neutrino rest mass latest estimation of $1.85\ eV$ from the estimated interval $[0.2,\ 2]eV$ [**12**]) $\begin{Bmatrix} 1.85 & 1 & 1 & 5.1\times10^5 & 2.3\times10^6 \\ 4.8\times10^6 & 1\times10^8 & 1.1\times10^8 & 1.3\times10^9 & 1.8\times10^9 \\ 4.2\times10^9 & 8\times10^{10} & 9.1\times10^{10} & 1.7\times10^{11} & 1.3\times10^{11} \end{Bmatrix}$ are stated to correspond to SVs(i) with predicted indexes i_{pred} in the set $\begin{Bmatrix} 108 & 109 & 110 & 128 & 131 \\ 132 & 136 & 137 & 140 & 141 \\ 142 & 146 & 146 & 147 & 147 \end{Bmatrix}$ and predicted rest energies $\left(E_{EP(pred.)} = E_{SV}\left(i_{pred}\right)\right)$ (also measured in eV) in the set $\begin{Bmatrix} 0.4 & 0.7 & 1.5 & 3.9\times10^5 & 3.1\times10^6 \\ 6.2\times10^6 & 1\times10^8 & 2\times10^8 & 1.6\times10^9 & 3.2\times10^9 \\ 6.4\times10^9 & 10.2\times10^{10} & 10.2\times10^{10} & 2.1\times10^{11} & 2.1\times10^{11} \end{Bmatrix}$ with values relatively close to the those from E_{EP} set. The approximate radii $r_{SV}\left(i_{pred}\right)$ of those EPs are predicted to be found in the set $\begin{Bmatrix} 10^{-9} & 10^{-9} & 10^{-9} & 10^{-7} & 10^{-7} \\ 10^{-7} & 10^{-7} & 10^{-6} & 10^{-6} & 10^{-6} \\ 10^{-6} & 10^{-6} & 10^{-6} & 10^{-5} & 10^{-5} \end{Bmatrix} \times l_{Pl}$ and the approximate quantum $G_q\left(i_{pred}\right)$ are also predicted to be found in the set $\begin{Bmatrix} 10^{19} & 10^{19} & 10^{18} & 10^{15} & 10^{14} \\ 10^{14} & 10^{13} & 10^{13} & 10^{12} & 10^{12} \\ 10^{12} & 10^{11} & 10^{11} & 10^{11} & 10^{11} \end{Bmatrix} \times G.$

Prediction. For ou, DVTM now predicts the existence of at least $T = 199\left(= A+1\right)$ distinct types (**T**) of EPs (plus their corresponding 199 antiparticles [**aEPs**]), with each EP-aEP pair defined by a specific SV(i), with $i \in \left[0, A\right]$**:** all EPs and aEPs (including the photon, the gluon and even the hypothetical graviton) are also predicted to have (possibly very small but) non-zero rest masses**.** However, $T = 199\left(= A+1\right)$ is not an exact prediction because: T may be lower than A, if (at least) some bosons share the same i-th SV energetic level (**i-EL**) with (at least) some quarks (like in the case of the top quark $t^{+2/3}$ and Higgs boson H^0 which both share the same 147-EL of a SV)

Prediction. The fact that all EPs of a specific type (and the corresponding aEP) appear as identical (by having the same physical properties in all experiments until present) are easily explained by DVTM which associates all EPs of specific type with the same SV(i) (which all share the same excitation level i-EL of the vacuum). For example, all electrons appear identical because they are all actually SVs(128) and so on. **Additional prediction**. DVTM states that SV stability decreases inverse-proportionally with index i, so that SVs with high index/radii/energies (and their corresponding EPs) are stated to be unstable and tend to rapidly split into SVs with lower indexes.

Explanation. This almost infinitesimal $r_{SV}\left(i\right) \in \left[r_{SV(\min)}, r_{mbh(r)}\right]$ series predicted by DVTM offers the image of an "almost continuum" ou space (with a relative high degree of "smoothness", when compared to the nuclear scale for example), a fact which may explain the viability of Einstein's GRT**,** which treats ou as a 4D spacetime continuum.

Important note. A larger number of bosonic EPs types also implies a larger number of fundamental fields (**FFs**), additional to the five known quantum FFs: the (quantum) gravitational field (**QGF**/**NGF**), the electromagnetic field (**EMF**), the weak nuclear field (**WNF**), the strong nuclear field (**SNF**) and the Higgs field (**HF**).

Prediction. As the experimental upper limit of a possible non-zero rest mass of the photon (which is assigned theoretical zero mass in SM) is set to $1\times10^{-18} eV$ [**13**] (which upper limit approximately corresponds to a SV(50)), SVs(i<50) are not only good candidates for the photon, but also for the hypothetical graviton (which is predicted to be a spin-2 boson) and even candidates the hypothetical preons/rishons. **Additional prediction**. The experimental upper limit of a possible non-zero rest mass of the gluon (which is also assigned theoretical zero mass in SM) is set to $1.3\times10^{-3} eV$ [**14**], which upper limit approximately corresponds to a SV(100): SVs(50<i<100) are thus good candidates for the gluons.

Prediction. SVs(i) with $i \in \left[111, 127\right]$ are also good candidates for the (still undiscovered) sterile neutrinos (with rest mass lower than m_e but larger than m_{ν_τ}) , other bosons (suggesting the existence of other possible but still undiscovered FFs) and even dark matter/energy particles.

Explanation. DVTM states that <u>electromagnetic charge</u> comes as a secondary "bonus" property of SVs(i) (as charge is always assigned a non-zero rest mass in SM) with "sufficient" energy $E_{SV}\left(i\right)$ (also associated with a sufficiently large $r_{SV}\left(i\right)$, which translates in a sufficient spatial complexity) to generate complex phenomena associated with electromagnetic charge and EMF. **Prediction**. DVTM also predicts the existence of other Higgs bosons with electromagnetic charge, given the large index i assigned to this type of bosons.

Explanation (and prediction). DVTM additionally states that <u>color charge</u> comes as a tertiary "super-bonus" property of SVs(i) (with color charge also predicted to always associate with a non-zero rest mass EP, including the gluons and the quarks) with sufficiently large $E_{SV}\left(i\right)$ and $r_{SV}\left(i\right)$, which parameters translate in a spatial complexity/entropy higher than of photons, which may allow more complex phenomena like that associated with color charge: SNF studied by quantum chromodynamics **(QCD).**

Explanation. DVTM also states that SVs(i) with sufficiently high index i can have both electromagnetic charge and color charge, like in the case of all quarks. **Prediction**. DVTM also predicts the existence of Higgs bosons with both electromagnetic charge and color charge, given the large index i assigned to this type of bosons.

Prediction. DVTM predicts that each distinct type of fermionic EP (together with its fermionic aEP) corresponds to a specific and distinct SV(i) (with a bijective correspondence between EP-aEP pair and SV(i)), but each distinct type of bosonic EP may be represented by more than one SV(i), with multiple bosonic SVs(i) (usually from the same bosonic family) being allowed to represent the same i-EL (which may be shared also by one distinct fermionic EP), like in the case of W and Z bosons which are both defined now as SVs(146) with slightly different rest masses/energies, a difference that shall be explained later on in this paper: as one distinct bosonic SV(i) may support slightly energetic variations of their rest masses around $E_{SV}(i)$, but only plus/minus variations that are multiples of $E_{SV(\min)}$ and this is stated to be the main difference between bosonic SVs and fermionic SVs (which don't support these slight rest energy variations). **Definitions**. SV "Macro-oscillations" as thus defined as transitions between the values of the function $E_{SV}(i) = 2^i E_{SV(\min)}$ through integer indexes i: in contrast, the (previously introduced) SV "micro-oscillations" are defined as transitions between the values of the function $i \cdot E_{SV(\min)}$ through integer indexes i. **Important observation.** The arithmetic average of the newly predicted indexes $i \in [0, A]$ (for known EPs only) is $\boxed{av_1 \cong 139.4}$ corresponding to $\boxed{2^{av_1} \cong 10^{42}}$ (without considering the three types of neutrinos with predicted indexes: 108, 109 and 110), $\boxed{av_2 \cong 133.33}$ corresponding to $\boxed{2^{av_2} \cong 10^{40}}$ (when also considering the three types of neutrinos): both av_1, av_2 and their geometric average $\boxed{\sqrt{av_1 \cdot av_2} \cong 136.34}$ are close to the $\boxed{a = \log_2(n_a) \cong 137}$, which may further validate the n_a-based mbh model proposed in the Part I of this paper and may explain the centering of the function $f(m)$ values around 1. Furthermore, $\boxed{A \cong 1.45a}$ which additionally predicts that n_a may have an even ample variation in the interval $n_a^{1\pm0.45} \cong \left[n_a^{0.55}, n_a^{1.45}\right]$ which also includes the value $\boxed{f(m_{\nu e}) \cong 1.361}$ which was apparently "isolated" at first look when compared to initial (least ample) variation $n_a^{1\pm0.2}$.

Checkpoint conclusion. EPs are thus stated to exist only as distinct specific excitation levels i-ELs (indexed with i) of the same "prototype" SV, with our space being a 3D matrix composed from a huge (but finite positive integer) number of "clones" of this "prototype" SV.

2. A MODEL OF MOVEMENT IN A QUANTIZED 3D SPACE

Redefinition of movement and its rules in a SV-based universe. DVTM also states that it's NOT the SV(h) that mainly moves when an EP (identified with a specific SV(h)) is observed to apparently change coordinates on a trajectory in ou space, but it's only a variable fraction $f_{erg}(x)$ of the energy quanta $E_{SV}(h)$ which is transferred in a "domino" pattern from a transmitter-SV(h) to a receiver-SV(i): this fractional quanta of energy will be named "**ergon**" and is stated to consist from a specific fraction $f_{erg}(x)$ from the superficial and (possibly) deeper layers of SV(h) (with any SV being defined as a 3D "micro" brane): ergon(x) energy quanta is generically defined as $\boxed{E_{erg}(x) = E_{SV}(h) / f_{erg}(x)}$. $f_{erg}(x)$ is specifically defined as a simple base-2 power function with integer exponentials: the ergons are additionally stated to share the same minimum energetic SV quanta $E_{SV(\min)}$ so that $\boxed{E_{erg(\min)} = E_{SV(\min)} \left(= E_{SV}(1)\right) \cong 10^{-33} eV}$ and any indexed ergon(x) is defined to have a generic energy quanta $\boxed{E_{erg}(x) = 2^x E_{erg(\min)}}$, with positive integer index $x \in [0, A]$. The ergon(x) transfer from SV(h) to SV(i) is stated to have some specific rules, as defined next. **Rule**. In DVTM, the transmitter-SV(h) is allowed to emit only ergons(x) with x<h so that $\boxed{E_{erg}(x) < E_{SV}(h)}$. **Description**. The ergon(x) emitted by SV(h) is stated to unfold from a superficial layer of SV(h) (with closed spherical shape) into an open shape "thin" 3D brane (the unfolded ergon(x)), which ergon(x) (and not the entire transmitter SV(h)) actually moves from the

SV(h) to the receiver SV(i): this partial unfolding of the emitter SV(h) into an ergon(x) may explain the dual/hybrid wave-particle character of any EP identified with any emitter SV(h). The ergon(x) is actually an (open shape) wave-like 3D brane which can be emitted by any SV(h) (with h>x). **Statement (general case)**. When an initial (receiver) SV(i) at rest with $\boxed{E_{SV}(i) = E_{erg}(i)}$ receives/absorbs an ergon(x) (with $\boxed{E_{erg}(x) = 2^x E_{erg(\min)}}$), the total (local) energy $\boxed{E_{tot} = E_{erg}(i) + E_{erg}(x) = 2^i E_{erg(\min)}\left(1+2^{x-i}\right)}$ is stated to be conserved (based on VEI-EP applied as a volume conservation principle) so that:

A. If $\boxed{1+2^{x-i} < 2}$, the resultant SV remains a SV(i) but gains a small kinetic energy $\boxed{E_{k(SV)} = 2^x E_{erg(\min)}}$ by absorbing that ergon(x) and covering a larger volume (by its movements / kinetic energy) than its "normal" volume at rest; $E_{k(SV)}$ of the resultant SV may manifest as a small translation or even a rotation of that SV (around a point from its interior, its surface or its exterior), depending from which direction the initial SV(i) received the transferred ergon(x).

B. If $\boxed{1+2^{x-i} = 2}$, the receiver SV(i) has two possibilities: (**1**) it may have gained a (larger) kinetic energy $\boxed{E_{k(SV)} = 2^x E_{erg(\min)}}$ by absorbing that ergon(x) or (**2**) it may turn to a resting SV(i+1) which, in specific conditions, may further split in a pair of resting SVs(i); the moving SV(i), the resting SV(i+1) and the resting pair of SVs(i) may all "happen" at the same time and are stated to actually co-exist as a quantum superposition with equal probabilities: for i=0 and x=0, this superposition explains the hybrid and apparently paradoxical "resting-and-moving" nature of our 3D vacuum which is stated by DVTM to be composed mainly from SVs(0) (and their surrounding OS) when found in its lowest energetic state.

C. If $\boxed{1+2^{x-i} > 2}$ the resultant SV(i) has more possibilities: (**1**) SV(i) may have gained an even larger kinetic energy $\boxed{E_{k(SV)} = 2^x E_{erg(\min)}}$ by absorbing that ergon(x); (**2**) in specific conditions, this moving SV(i) may also turn to a SV(i+1) with lower kinetic energy $\boxed{E_{k2(SV)} = 2^{x-1} E_{erg(\min)}}$; (**3**) if this $E_{k2(SV)}$ is large enough, it may even permit the conversion of the resultant SV(i+1) into a moving SV(i+2) with even lower kinetic energy $\boxed{E_{k3(SV)} = 2^{x-2} E_{erg(\min)}}$ and so on.

D. If further colliding with another SV(j), the moving (receiver) SV(i) may forward its "carried" ergon(x) to that SV(j), so that SV(j) becomes in turn a receiver-SV and the process may continue by the same iterated rules (as in the first absorption-reemission cycle of an ergon(x) by a SV(i)).

E. In the (previously anticipated) case of an ergon(x) propagating in a 3D (almost) "perfect" vacuum (which vacuum is defined by DVTM as a group of many adjacent SVs(0)), this is actually just a special case in which i=0 so that, when the initial SV(0) receives an ergon(x) (from another transmitter SV(h)), the same rules as above are applied.

F. **The emitter SV(h)**. When a SV(h) (containing an ergon(h) with $\boxed{E_{erg}(h) = 2^h E_{erg(\min)}}$) emits an ergon(x) (with only allowed x<h, x≥0 and $\boxed{E_{erg}(x) = 2^x E_{erg(\min)}} < E_{erg}(h)$), SV(h) reduces to a resultant SV with positive energy equal to

$$\boxed{E_y = E_{erg}(h) - E_{erg}(x) = \left(2^h - 2^x\right) E_{erg(\min)}}$$

so that: (**1**) If $\boxed{E_y \geq E_{erg}(h-1)}$, the initial emitter-SV(h) can turn into a moving/resting SV(h-1) with kinetic energy $\boxed{E_{k(SV)} = E_y - E_{erg}(h-1)}$; (**2**) The previous rule can be applied to any ergon(x) with energy $E_{erg}(x)$ that may be successively compared to SV(h-1), SV(h-2) etc energies $E_{erg}(h-1)$, $E_{erg}(h-2)$ etc.

G. **Examples**. The propagation of a hypothetical graviton or a photon can be modeled as a temporal sequence of successive excitation-dezexcitation cycles in a specific group of

SVs (by transferring a specific ergon(x) corresponding to the graviton or the photon), which group of SVs is identified with a geometrical locus that represents the observed trajectory of that graviton or photon in our 3D space.

Prediction of a set of finite maximum speeds of movement. A SV(h) dezexcitation (**de**) (from SV(h) to a resultant SV("h-x")) when emitting an ergon(x) is stated to happen in a very short but finite (and non-infinitesimal) positive time interval Δt_{de} which is also stated to have a finite (and non-infinitesimal) minimum $\boxed{\Delta t_{de(\min)} > 0s}$ (which can be regarded as a time-quanta of ou, as expressed in classical linear time units). A SV(i) excitation (**e**) (from SV(i) to a resultant SV("i+x")) when absorbing an ergon(x) is also stated to happen in a very short but finite (and non-infinitesimal) positive time interval Δt_e which is also stated to have a finite (and non-infinitesimal) minimum $\boxed{\Delta t_{e(\min)} > 0s}$ (which can also be regarded as a time-quanta). Let us define the sum $\boxed{\Delta t_{\min}\left(= \Delta t_{de(\min)} + \Delta t_{e(\min)}\right) > 0s}$, which can also be regarded as a "doubled" time-quanta. When the transferred ergon(x) crosses OS (as being passed from the emitter SV(h) to the receiver SV(i)) one may measure a variable time interval with real positive value $\boxed{\Delta t_{\text{var}} \geq 0s}$: note that Δt_{var} is also allowed a zero value, so that the possibility of an instantaneous ergon(x) transfer through OS is also considered. Let us define a total time interval with real positive value $\boxed{\Delta t_{tot}\left(= \Delta t_{\min} + \Delta t_{\text{var}}\right) > 0s}$ (which is strictly larger than zero). Let us consider the extreme case in which $\boxed{\Delta t_{\text{var}} = 0s}$ implying $\boxed{\Delta t_{tot}\left(= \Delta t_{\min}\right) > 0s}$. For a set of average distances $\boxed{D = \{d_1, d_2, d_3, ...d_k, ...d_n\}}$ (with k and n being positive integer indexes) between any two adjacent SVs exchanging ergons(x) in a set of moments (T) from ou history (including future) $\boxed{T = \{t_1, t_2, t_3, ..., t_k, ...t_n\}}$ (with distance d_k corresponding to a history moment t_k with the same integer index k), DVTM predicts a set of finite (and non-infinitesimal) positive maximum speeds

$$\boxed{v_{\max} = \left\{\frac{d_1}{\Delta t_{tot}}, \frac{d_2}{\Delta t_{tot}}, \frac{d_3}{\Delta t_{tot}}, ..., \frac{d_k}{\Delta t_{tot}}, ... \frac{d_n}{\Delta t_{tot}}\right\}}$$

(with all values strictly larger than zero) which maximum speeds will be the same when measured in all inertial frames of reference (because $\boxed{\Delta t_{\text{var}} = 0s}$). In this way DVTM predicts the existence of a maximum allowed ergon speed in ou and that speed of light in vacuum (c) is also in the $v_{\max}$ set so that $\boxed{c \in v_{\max}}$, with value c corresponding to our present moment $\boxed{t_{pr}}$ in ou history/evolution. DVTM also predicts that $\boxed{c \in v_{\max}}$ successively takes all the values $\boxed{t_k \in T}$ and thus may vary with index k of t_k, when expressed in classical linear time quanta units (measured in seconds). This is also a retrodiction and explanation of Einstein's Special Relativity Theory (**SRT**).

3. A BIG BOUNCE UNIVERSE PROPOSED BY DVTM

Definition. The perfect vacuum of ou (at ground state) is defined as the sum of all SVs(0) of ou and the OS between them.

Statements and definitions. Ou is stated to have started from a finite number of unstable SVs(A) all "clumped" together: this is the definition of pre-Big Bang singularity (**pBBS**) given by DVTM. Not that pBBS is not a true singularity with infinite density, but a quasi-singularity with (huge but) finite maximum density approximately equal to Planck density: in other words, DVTM does not allow true gravitational singularities. The pBBS "cooling" (with progressive raise of its global entropy) is stated to be generated by the binary splits of its unstable SVs(A): the SVs(A) which first split are stated to initialize the disintegration of the initial pBBS into smaller clumps (also composed from SVs(A)) which separated and departed from each other (driven by antigravity). Each clump of SVs(a) detached from pBBS (which clump is stated to be much more stable than each SV(A) in part) is defined as a primary black hole (**pbh**) (avoiding the "primordial black holes" term, which is currently assigned a slightly different meaning). Pbhs will be separated from each other by large groups of SVs(0) resulted from the complete (binary) split of some random SVs(A): these groups of SVs(0) were already defined as spatial vacuum which tends to progressively grow and depart pbhs from each other. **Explanation**. The binary split of SVs(A) inside pBBS is stated to be relatively random, which is stated to explain the isotropy and homogeneity of the resulting ou at large scales and all spatial directions. **Definition**. The cooling of pBBS and ou is thus defined by a progressive decrease of the average (av) SV index $\left(i_{av}\right)$ and a progressive increase in both the number of pbhs and the volume of spatial vacuum between pbhs. **Statement and explanation**. Each galaxy, cluster (of galaxies), supercluster and complex of superclusters are all stated to be centered in one or more pbhs: this may also explain both homogeneously distributed dark matter (consisting of pbhs: clumps of SVs(A)) and dark energy (the gravity and antigravity associated with pbhs, which explain both the stability of galaxies but also the accelerated expansion of ou).

Predictions. The entire ordinary matter (**om**) of ou (with rest mass $M_{ou} \cong 10^{54} kg$) is predicted to come from the partial disintegration of $N_{mbh(om)}\left(=M_{ou} / m_{mbh(r)}\right) \cong 10^{63} mbhs$ from the initial pBBS. The dark matter (**dm**) rest mass (which is estimated to be approximately 5.5 times larger than M_{ou}) is predicted to consist of $N_{mbh(dm)}\left(=5.5 M_{ou} / m_{mbh(r)}\right) \cong 10^{64} mbhs$: these $N_{mbh}\left(=N_{mbh(dm)}+N_{mbh(om)}\right) \cong 10^{64} mbhs$ are predicted to had occupied a total volume of $V_{pBBS}\left(=N_{mbh} V_{mbh(r)}\right) \cong 10^{-114} V_{ou}$ (with $V_{ou} \cong 10^{80} m^3$ being the ou volume and $V_{mbh(r)}$ being the volume of a single mbh [which is a SV(A)]) which corresponds to a predicted initial pBBS radius of $r_{pBBS}\left(\cong V_{pBBS}{}^{1/3}\right) \cong 10^{-12} m$ which is with two orders of magnitude smaller than the hydrogen atom radius: the maximum allowed rate of spatial compression of ou would be $R_{ou} / r_{pBBS} \cong 10^{38}$. $N_{mbh(om)} / N_{mbh} \cong 15.4\%$ is estimated to be the percent of initial SVs(A) that already splitted and generated vacuum and ordinary matter. **Prediction**. If all $N_{mbh(om)}$ would have turned to SVs(0), then the total number of SVs(0) of ou would have reached a maximum number $N_{SVs(0)}\left(=2^A \cdot N_{mbh(om)}\right) \cong 10^{123}$, which corresponds to a maximum volumic density of $\rho_{SVs(0)}\left(=N_{SVs(0)} / V_{ou}\right) \cong 10^{42} SVs(0) / m^3$ and a maximum linear density (on any spatial direction) of $\rho_{SVs(0)}{}^{1/3} \cong 2 \times 10^{14} SVs(0) / m$ (approximately one SV(0) per each femtometer [1 fm] of length, with 1fm being close to the proton radius and classical electron radius). **Explanation**. Dark energy is stated to be the global manifestation of AG between all SVs$\left(i_{av}\right)$ of ou.

Statement (conjecture). DVTM conjectures that AG strength only depends on the total gIS volume V_{gIS} (the sum of all SVs volumes from ou) which remains constant no matter the average index i_{av}, as SVs fusing or SVs splitting are stated to be governed by VEI-EP (applied as volume conservation principle): this conjecture is argumented by the fact that the repulsive force between two distinct deep layers of any two distinct SVs isn't shielded by the other superficial layers of those two distinct SVs. **Statement**. In contrast, QGF strength is stated to grow with the global increase of the total (finite) IS-OS 2D interface measured by $\boxed{A_{gIS} \overset{def.}{=} N \cdot A_{SV}\left(i_{av}\right)}$ (with N being the total number of SVs from ou, which is was stated to be finite): this statement is argumented by the fact that suctional force exerted by QGF on the deep layers of any chosen SV may be shielded by the superficial layers of that same SV, so that the lower the average index i_{av}, the fewer the superficial layers that may shield the suctional effect of QGF on SVs.

Big-Bounce universe prediction. DVTM predicts that all SVs of ou may reach a critical (cr) average index $i_{av(cr)}$ for which the total global 2D IS-OS interface may have reached a critical area $\boxed{A_{gIS(cr)} \overset{def.}{=} N \cdot A_{SV}\left(i_{av(cr)}\right)}$ which to produce a strong enough critical coupling between QGF and SVs of ou (a critical suctional strength exerted on SVs by QGF) measured by a critical $\boxed{G_{q(cr)}}$, so that the resultant Newtonian GF may have also reached a critical big G $\boxed{G_{(cr)}\left[=G_{q(cr)}-G_{q(AG)}\right]}$ necessary and sufficient to transform the present positive-acceleration inflation into a future negative-acceleration inflation which may finish with a universal halt, followed by a positive-acceleration deflation: this positive acceleration deflation may be also associated with a reversed 2LT (an "anti"-2LT) and may produce a progressive increase of i_{av} up to another critical value $i_{av(cr2)}$ which may produce another critical sufficiently low $\boxed{G_{q(cr2)}}$ and $\boxed{G_{(cr2)}\left[=G_{q(cr2)}-G_{q(AG)}\right]}$ so to cause a negative-acceleration deflation up to another second halt which may correspond to a pBBS. Another universal inflation-deflation cycle may then restart. Given this details, DVTM essentially predicts a <u>Big Bounce universe</u>, which is also predicted by Loop Quantum Cosmology (**LQC**) (which is derived from LQGTs).

Observation, retrodiction and prediction. Additionally, when considering an (angular) momentum-like measure of ou $\boxed{L_{ou}=E_{ou}\cdot t_{ou}\cong 10^{89}\,Js}$ (with $E_{ou}\cong 10^{71}\,J$ being the estimated total rest energy of the ordinary matter from ou and $\boxed{t_{ou}\cong 13.8\times 10^{9}\,yrs}$ being the estimated age of ou), $\boxed{d_{ph}=\log_{na}\left(L_{ou}/\hbar\right)\cong 3}$ and $\boxed{d_g=\log_{na}\left(L_{ou}/\hbar_g\right)\cong 4}$, so that $\boxed{d_{ph}\cong 3}$ may retrodict (and explain) the 3 spatial dimensions of our ou (when ou is observed using photons), so that DVTM additionally assigns n_a with the "role" of a scaling factor for the space dimensionality: the n_a-based $\boxed{d_{ph}\cong 3}$ retrodicts a space with three "electromagnetic" dimensions and $\boxed{d_g\cong 4}$ retrodicts a spacetime with four "gravitational" dimensions. It may be further speculated that space may actually appear as 3D just *because* $\boxed{d_{ph}\cong 3}$, as we use light/photons (measured by $\hbar$) to perceive ou (also measured by L_{ou}). In other words, the perceived three dimensions of space may be defined as an a priori (empirical/observational) fact or it <u>may be considered the consequence of</u> $d_{ph}\cong 3$ (a kind of <u>dimensional relativity</u>, with many possible implications [including the growth of the number of spatial dimensions with ou aging] that won't be discussed here, as they were already extensively analyzed in another paper published by the author [**4**]).

4. A UNIFICATION PATTERN OF THE FOUR FUNDAMENTAL FORCES/FIELDS PROPOSED BY DVTM

Prediction. The running coupling constant of the strong nuclear field (**SNF**) $\boxed{\alpha f_S\left(E\right)\cong\frac{2\pi}{7\ln\left(E/E_{SNF}\right)}}$ (as determined in quantum chromodynamics (**QCD**) also using the beta function computed in perturbation theory) is also a function of a variable energy scale $E\gg E_{SNF}$ (with $E\leq E_{unif}$ and $E_{SNF}\cong 210\left(\pm 40\right)MeV$ being the QCD energy scale of quark confinement as determined experimentally) [**15**]. **Redefinition(1).** Analogously to $nf_a\left(E\right)$ and

$\alpha_f(E) \overset{def.}{\cong} 1/\log_2[nf_a(E)]$, the function $\alpha f_S(E)$ can also be considered as derived from an exponential function $nf_S(E)$ so that $\boxed{nf_S(E) \overset{def.}{=} (E/E_{SNF})^{\frac{7\ln(2)}{2\pi}}}$ and $\boxed{\alpha f_S(E) \cong 1/\log_2[nf_S(E)]}$. Similarly to $nf_a(E)$, $nf_S(E)$ also has finite values for any finite E (avoiding infinities), with the mention that it doesn't permit to calculate $\alpha f_S(E)$ for $E_{inf} = E_{SNF}$, which corresponds to $nf_S(E_{inf}) = 1$ and $\alpha f_S(E_{inf}) \approx 1/0$, which is the Landau pole of $\alpha f_S(E)$, as division by 0 generates infinity for $\alpha f_S(E_{inf})$. **Redefinition(2)**. Furthermore, if we consider $\boxed{k_{SNF} = E_{SNF}/E_e \cong 470}$ and $\boxed{N_{SNF} = k_{SNF}^{\frac{7\ln(2)}{2\pi}} \cong 116}$ (being the SNF scaling factor "homologous" to n_a), $nf_S(E)$ may be rewritten as an analogous function $\boxed{nf_s(E) = (E/E_e)^{\frac{7\ln(2)}{2\pi}}/N_{SNF}}$. Both exponential functions $nf_a(E)$ and $nf_s(E)$ have analogous structures (but inverse to each other). **Observation**. There is a "circularity" between $nf_S(E)$ and $nf_a(E)$ which suggests a unity and complementarity between SNF and EMF running coupling constants so that when E grows from E_e to $E_{unif} \cong 10^{39}\,GeV$: (**1**) nf_S function generates larger values up to $nf_S(E_{unif}) \cong 10^{31}$ corresponding to $\alpha f_S(E_{unif}) \cong 1/104$ which is higher but relatively close to $\alpha = \alpha_f(E_e) \cong 1/137$: at these very high energy scale, SNF may have a behavior and strength similar to EMF; (**2**) at the same time, nf_a generates smaller values up to $nf_a(E_{unif}) \cong 10^{35}$ corresponding to $\alpha f(E_{unif}) \cong 1/116$ which approaches the values of $\alpha f_S(E_{Pl}) \cong 1/51$, so that EMF may have a behavior and strength similar to SNF at this huge E_{unif} energy scale.

Prediction. The running coupling constant of the weak nuclear field (**WNF**) $\boxed{\alpha f_W(E) \cong \frac{E_W{}^2 G_F/(\hbar c)^3}{e^{E_W/E}}}$ is also a function of a variable energy scale $E \in [E_e, E_{unif}]$ and includes the rest energies of the W/Z bosons $\boxed{E_W = m_W c^2}(\cong E_Z)$ (which are the propagators of the WNF) and the Fermi coupling constant $G_F/(\hbar c)^3 \overset{exp.}{\cong} 1.1663787 \times 10^{-5}\,GeV^{-2}$ (with $G_F \cong 1.43585 \times 10^{-62}\,Jm^3$ and $E_W{}^2 G_F/(\hbar c)^3 \cong 1/13$), which can be indirectly determined by measuring the muon lifetime experimentally [**16**, **17**]. Analogously to $\alpha_f(E)$, $\alpha_{Gq(in)}(E)$ and $\alpha f_S(E)$, $\boxed{\alpha f_W(E)}$ can also be considered as derived from a function $\boxed{nf_W(E) = \frac{e^{E_W/E}}{E_W{}^2 G_F/(\hbar c)^3}}$, so that $\boxed{\alpha f_W(E) \cong 1/nf_W(E)}$. To also "align" $nf_W(E)$ to the other functions $nf_a(E)$ and $nf_S(E)$ by using the same "base-level" electron rest energy E_e, $nf_W(E)$ can be also written as a function of E_e such as $\boxed{nf_W(E) = \frac{e^{k_W(E_e/E)}}{E_W{}^2 G_F/(\hbar c)^3}}$, with $\boxed{k_W \overset{def.}{=} E_W/E_e \cong 1.6 \times 10^5}$.

Prediction (a pattern of the four fields unification). The approximated running coupling constants of QGF, EMF, SNF and WNF can all be represented on the same graph using the base-10 logarithmic functions $p_{GF}(E)=\log_{10}\left[\alpha_{Gq(in)}(E)\right]$, $p_{EMF}(E)=\log_{10}\left[\alpha f(E)\right]$, $p_{WNF}(E)=\log_{10}\left[\alpha f_W(E)\right]$ and $p_{SNF}(E)=\log_{10}\left[\alpha f_S(E)\right]$: **see the next graph**, which shows a unification pattern of all fundamental fields at $E_{unif} \cong 10^{39}\,GeV$ energy scale, with an interesting numerical closeness $E_{unif} \cong E_e \cdot n_a a/2$

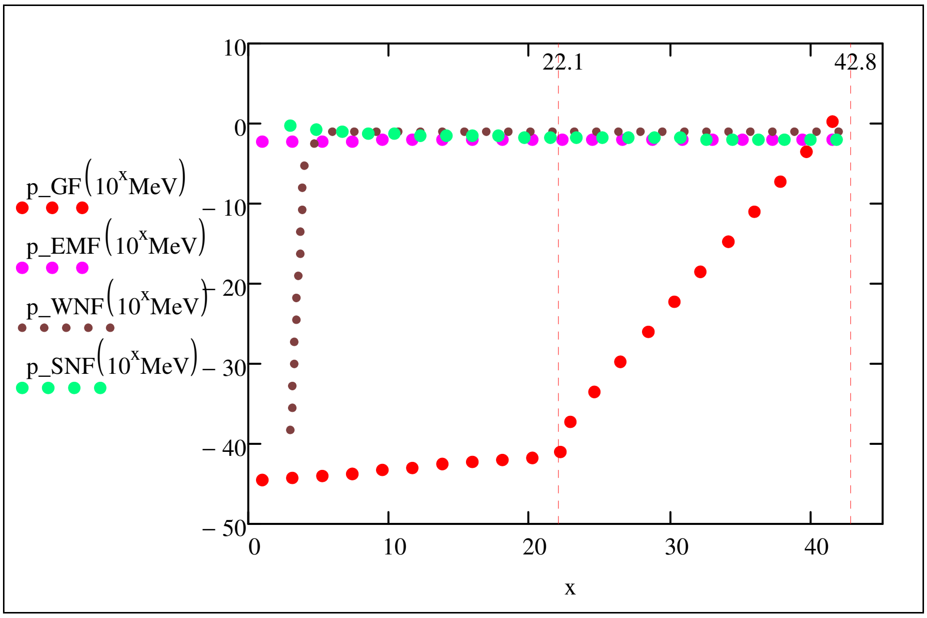


Figure II-2. A unification pattern of the running coupling constants of QGF, EMF, WNF, SNF at E_{unif}, with two additional markings (as vertical lines) for $x_1 = \log_{10}\left(E_{Pl}/MeV\right) \cong 22.1$ and $x_2 = \log_{10}\left(E_{unif}/MeV\right) \cong 42.8$.

CONCLUSIONS

DVTM can be considered a simple method of quantizing 3D branes and can be regarded as a patch of M-theory, leading to a specific "volumic"/voxel (**V**) branes theory ("**V-Theory**") and explaining the main principles of SRT, GRT and movement based on a "digital" space vacuum composed of SVs with quantized energetic states.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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