Self-Consistent Quantum-Gravitational Quadrupole Fluctuations

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To establish a self-consistent system of mutually interacting gravitational quadrupoles, a characteristic number N of quantum masses μ are related to a characteristic velocity scaling. For this purpose a critical reference is defined by the flux and flux number of mass quanta constituting a confining unit field generating mass $m_G = N\mu$. In the field of m_G any small test mass orbits at unit distance r_u with unit velocity u (human artificial units). The velocity limit c with angular momentum quantum h is assigned to the Schwarzschild black hole photon sphere with radius given by the Compton wavelength. For this quantum mass we find the constitutional scaling relation $N \approx 3m_G/\mu \propto (c/u)^5$ which indicates a quadrupole exchange. The corresponding coupling strength can be exactly related to previous results confirming the quantum mass μ hidden in the action quantum related at the Planck scale to the gravitational coupling constant G by $\mu^4 G = 1$. The coupling deficits can be assigned to a duality of coupling and non-coupling fluxes with 4th power flux scaling. This fits very well to existing models assuming a non-gravitating vacuum energy to give a satisfactory answer to the cosmological constant problem.

I. INTRODUCTION

Real fluctuating bodies are usually neither point like nor spherical. Carrying quadrupole mass moments and higher they give rise to differential effects in the gravitational interaction [2]. But how can stable multipole properties be generated and identified? Trough the nonlinearities of the Einstein field equations in general relativity, the multipole moments of any finite distribution of energy and momentum interact with each other in vacuum giving rise to non-linear physical effects, e.g. nonlocal memory effect due to the re-radiation by the stress-energy distribution of linear waves. The gravitational back-reaction of quadrupole radiation have been calculated in the framework of post-Minkowskian approximation and post-Newtonian expansion [3, 4, 5]. The gravitational multipole flux scales with a characteristic power law with frequency or velocity and propagates according to General Relativity with a finite flux propagation velocity c [2, 6]. Dictated by conservation laws the proper cancellation of aberration effects (similar to the electromagnetic case) is guaranteed by the velocity scaling and the quadrupole nature of gravitational radiation [6]. Nuclear mass quanta are the basic monopole units and can be counted and distinguished by irreducible quantum properties. For a system-invariant treatment involving gravitation and relativistic motion, it is proper to use a system that is based on Einstein's vacuum field equations. In this case the Schwarzschild spacetime as the static and spherical symmetric solution qualifies for a test and spherically symmetric reference platform for quantum, thermodynamic and topological parameters [2] without quadrupole property. The fluctuating quadrupole property can be included by allowing a slightly deformed spherical Schwarzschild metric, i.e. a gamma or Zipoy-Vorhees quadrupole metric [7].

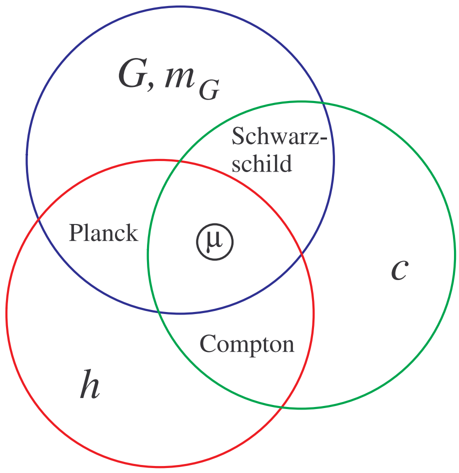

FIG. 1: The invariant baryon mass unit $\mu = q^2$ can be extracted form the action quantum $\hbar$ and Gravitational constant G if the light velocity c is known. This requires to extrapolate dimensionless Planck units $\hbar = c = \lambda_1 = 1$ to the System of Units (SI) by introducing the human artificial SI velocity unit $v = u$ and length unit $\lambda = \lambda_u$.

II. GENERATING THE SCALE REFERENCES

With Gauss law any gravitational multipole flux through any closed unit surface is proportional to the flux of N quantum sources enclosed by the surface. With the unit flux composed by N flux quanta the characteristic velocity scaling becomes a number scaling where the local and global aspects are coupled with only one real degree of freedom: the value of N. Self-consistent gravitational flux treated as a gravitational N-body problem, is essentially a self-gravitating system. If N exists, it is hidden behind metric units carrying irreducible properties like an angular momentum quantum $\hbar$. For the monopole and quadrupole flux we want to find the characteristic number scaling and to relate it to a spherical symmetric spacetime, where quadrupole radiation is exited by background fluctuations. Einstein's field equation provide for one exact solution that carries quadrupole properties: the gamma or Darmois-Zipoy-Vorhees metric corresponding to the Weyl family of axisymmetric static vacuums, where the Schwarzschild metric is the limit without quadrupole component. Similar to the previous work identifying a hidden quantum mass in $\hbar$ we will introduce unit scales in distance, velocity, and field strength (or flux) such, that the critical limit and scaling properties can be explored. Human reference scales designed for practical usage can be related by fixed numbers to natural quantum units and limits. The most prominent example is the SI-defined ratio light velocity to unit velocity $u = 1\text{m/s}$ [8]

$$\Xi = \frac{c}{u} = 299792458\,. \tag{1}$$

Practical necessity motivates to choose a unit velocity $0 < u \ll c$ with $\Xi \gg 1$.

A successful strategy will be to switch from a unit mass to a unit confinement field generating mass description. This enables to assign the unit spacetime geometry to a unit field, and later also to assign a critical spacetime geometry to a critical field where both cases can be connected by geometry and invariants. For a small test particle orbiting slowly at unit distance $r_u = 1\text{m}$ and unit orbit frequency $\omega_u = 2\pi\text{s}^{-1}$ the unit gravitational field Υ_G will have a unit field generating mass

$$m_G = 4\pi^2/|G| \approx 5.91506 \cdot 10^{11}\text{kg} \tag{2}$$

with $G = (6.674215 \pm 0.000092) \times 10^{-11}$ m^3 kg^{-1} s^{-2} [13], where

$$\Upsilon_G = Gm_G = r^3\omega(r)^2 = r_u^3\omega_u^2 = (2\pi)^2\text{m}^3\text{s}^{-2}\,. \tag{3}$$

This definition has the advantage that Υ_G is Kepler invariant and enables Υ_G to act as a bridge between all circular Schwarzschild orbits [2]: the ratio of the cube of the distance of a test particle from the gravitation center and the square of the orbital period is the same for all test particles. Consequently, every orbit beyond the critical limit has a characteristic frequency. Taking a 1kg test mass, the energy unit can easily be realized in any system. m_G as a characteristic of the SI-system can only be obtained by measuring the gravitational force to determine G, so m_G is dual to the coupling constant and a priori without relation to any existing matter or particle.

III. CRITICAL LIMIT

Human artificial units reveal a characteristic scaling behavior if they are combined with natural limits. The most prominent natural limit is the light velocity c. Another natural limit can be assigned to the action quantum h, this is twice the minimum intrinsic angular momentum a quantum fermion particle must carry. Building a bridge between those limits via human artificial units and proper physical relations provides for a scaling behavior with interesting properties. Choosing a Schwarzschild black hole mass m_G such that a test particle orbits at unit distance r_u with unit velocity u, metric units in G are cancelled with $Gm_G = 4\pi^2u^2r_u$. Compressing the unit field generating mass m_G to a size smaller than the Schwarzschild radius r_S of m_G results in the formation of a virtual black hole with Schwarzschild horizon r_S given by [2]

$$r_S = \frac{2Gm_G}{c^2}\,. \tag{4}$$

The Schwarzschild radius is the horizon of no return characterizing the black hole [2]. The most inner stable orbit in the virtual field of m_G is given by the photon sphere radius

$$\lambda_\mu = \frac{3}{2}r_S = \frac{3\Upsilon_G}{c^2} = \frac{12\pi^2\text{m}^3\text{s}^{-2}}{c^2} = \frac{12\pi^2\text{m}}{\Xi^2}\,, \tag{5}$$

and corresponds to a critical radial wavelength already found in the previous work as a Compton wavelength hidden in the action quantum [9]. It seems that the geometric reduction/compression of fluctuations with coupling parameter $q^{-2} = 12\pi^2$ can be assigned to a general relativistic effect at the critical photosphere radius. Without propulsion directing outwards or any other kind of external support an observer who traverses a photon sphere will be drawn into the black hole [2]. In a typical unit momentum system like the SI-system the mass unit is a base unit whose definition is based on a physical artifact rather than on fundamental properties of nature. But due to the critical limit of the black hole this artifact can be replaced by well-defined quantum units that can be used to explore the critical limit.

IV. THE QUANTUM UNIT

Quantum properties as natural units qualify for a system-invariant reference that can be used to redefine human chosen units. Decomposing the unit field generating matter m_G into countable quantum units with mass μ provides for a dimensionless characteristic m_G/μ for any systems of units. The quantum unit will be a quantum state carrying a quantum angular momentum $L = h$ captured in the unit field. Generally, angular momentum in Schwarzschild spacetime can be written as [2]

$$L = \frac{m(r)}{\Lambda(r)}r^2\omega_\infty, \quad \Lambda(r) = 1 - \frac{2\Upsilon_G}{c^2r}\,, \tag{6}$$

where the external angular reference velocity $\omega_\infty = \omega(r \to \infty) = d\phi/dt = \omega(r)\sqrt{\Lambda(r)}$ is defined for an observer at $r \to \infty$ via Schwarzschild coordinate time t and longitude ϕ. $\Lambda(r)$ provides for the red shift of ω_∞ with respect to the local value $\omega > \omega_\infty$, since the photon loses energy as it escapes from the gravitational well. Reducing the orbit radius requires to increase the mass and/or velocity since angular momentum for the quantum test particle is fixed to the fundamental limit given by the Planck quantum h. With

$$L = h,\, v(r) = r\omega(r)\,, \tag{7}$$

eq.(6), and the Kepler invariant eq.(3), the combined invariant at $2\pi r = \lambda_\mu$ is given by

$$\frac{\Upsilon_G}{h} = \frac{v(\lambda_\mu)\Lambda(\lambda_\mu)}{m(\lambda_\mu)}\,. \tag{8}$$

This relation can now be tested at the quantum limit and origin of Planck units.

V. GEOMETRIC QUANTUM-GRAVITY INTERFACE

From eq.(5) in eq.(6) the general relativistic correction at the photon sphere radius λ_μ is given by $\Lambda(\lambda_\mu) = 1/3$. The orbital reduction limit at λ_μ is with eq.(5) related to the flux velocity limit $v(\lambda_\mu) = \omega(\lambda_\mu)\lambda_\mu = \sqrt{3}\omega_\infty\lambda_\mu = c$. With the redshift factor inserted into eq.(8)

$$3\Upsilon_G = 3\omega_\infty^2\lambda_\mu^3 = \frac{hc}{\mu}\,, \tag{9}$$

λ_μ is the Compton wavelength of the quantum mass $\mu = h/\lambda_\mu c$ as desired. Consequently, the photon sphere of the unit field generating mass establishes a geometric quantum-gravity interface. Realized with eq.(5) the theoretical values obtained from extrapolating Planck units to SI units are in accordance with [9] $12\pi^2 = q^{-2}$ given by

$$\mu = \frac{\hbar}{c}\frac{\Xi^2}{6\pi \mathrm{m}} \approx 1.67724 \cdot 10^{-27}\mathrm{kg},$$
$$\lambda_\mu = \frac{12\pi^2\mathrm{m}}{\Xi^2} \approx 1,31777 \cdot 10^{-15}\mathrm{m}\,. \tag{10}$$

With this quantum relation we should also be able to determine the theoretical gravitational coupling strength from Planck units. The ansatz will be the critical field strength to generate the desired photosphere horizon in terms of the number of quantum units to generate the flux.

VI. SELF-CONSISTENT SCALING

Asking about the scaling properties of the gravitational flux, one could compare the flux density at λ_μ to the flux density at r_u based on Gauss law where the flux density

$$\rho(r) \propto \frac{m^2}{r^4} \tag{11}$$

is proportional to the self-coupling strength m^2 with coupling density $\rho = E/V \propto 1/(rV) \propto 1/r^4$. With $N \propto m$ the number scaling at reference distance $r_u = \lambda_u/(2\pi) = 1\mathrm{m}$ is given by

$$N^2 = \frac{\rho(\lambda_\mu)}{\rho(r_u)}\,. \tag{12}$$

Now the effective number of quantum mass units can be calculated with the dynamical Kepler-Schwarzschild relations eq.(8)

$$N = \frac{r_u^2 v(\lambda_\mu)\Lambda(\lambda_\mu)}{\lambda_\mu^2 v(r_u)\Lambda(r_u)}\,. \tag{13}$$

Energy redshift provides for $\Lambda(\lambda_\mu) = 1/3$, $\Lambda(r_u) \approx \Lambda(\infty) = 1$,

$$\frac{r_u^2}{\lambda_\mu^2} = q^4\Xi^4,\ \frac{v(\lambda_\mu)}{v(\lambda_u/2\pi)} = 2\pi\Xi\,, \tag{14}$$

where $v(\lambda_\mu) = c$ is the velocity on the quantum photosphere and $v(\lambda_u) = u$ the unit velocity. Inserting the characteristic constants eq.(14) into eq.(13) provides for

$$N = \frac{2\pi}{3}q^4\Xi^5 \approx 3.61576.. \cdot 10^{38}\,. \tag{15}$$

m_G represents the equivalent static mass to generate the critical field and can be equivalently defined by the necessary number of quantum units or quantum flux number to generate a black hole

$$N_G = \frac{m_G}{\mu} \approx 3.5267(3) \cdot 10^{38}\,, \tag{16}$$

the characteristic SI–number and critical field condition providing for a self–consistent field flux with mass quanta μ characterized by the Planck quantum. The number N functions as a dimensionless representative of the system of units on the same level like Ξ. Comparing N with N_G it can be found that the measured number N_G necessary to generate the quantum black hole photosphere condition is reduced with respect to the theoretical value N by more than $\approx 2\%$. N_G is inversely proportional to G, a self–consistent coupling of the form according to eq.(2)

$$\mu c^2 = 3G\frac{m_G\mu}{\lambda_\mu} = 3G\frac{m_G\mu^2 c}{h}\,, \tag{17}$$

and condition

$$\Upsilon_G N_G\mu = G m_G^2, \quad N = N_G\chi^2\,. \tag{18}$$

For a given Υ_G there is only one possibility to assign the deviations from the theoretical Planck unit value: a factor χ increase to μ, h, and G, and a factor χ decrease to m_G part of G. In [10, 11] measurement showed a $\approx 1.35\%$ reduced e/h with respect to the theoretical value given by Planck units, where e was defined and h measured (the dimension of charge e in becomes kilogram). In both, the electromagnetic and gravitational cases the theoretical free local μ value is increased with respect to a mean global measurement value and the coupling strength per unit free mass reduced. Therefore we will assume, that a mean reduction of a "cosmically mixed" coupling mass can be assigned to a kind of non-coupling energy that is part of the basic mass quantum obtained from Planck units [10]. Taking the mass reduction from exact electromagnetic measurements with uncertainty $< 10^{-7}$ a more or less accurate prediction for a mean cosmic gravitational constant can be made with eq.(17)

$$G = \frac{hc}{3N_G\mu^2} = \chi^2\frac{hc}{3N\mu^2} = u\chi^2\frac{\hbar}{q^4\Xi^4\mu^2}\,, \tag{19}$$

To estimate χ, measurement techniques and values of G are discussed in [12] and given in [13], the CODATA value $G \approx 6.673 \cdot 10^{-11}\mathrm{m}^3/\mathrm{kg}/\mathrm{s}^2$ and the russian result (see table [14]) agrees well with roughly about 0.15% error. This provides for a $\chi^2 = N/N_G \approx 1.025$.

With dimensionless units in the single baryon limit $\hbar = c = u = \Xi = 1$, $\mu = q^2$ eq.(10), and without nuclear or screening corrections, eq.(19) can be further simplified to

$$G_{Planck} = q^{-8} = 1.9675.. \cdot 10^8\,, \tag{20}$$

and provides for the Planck scale self–consistency condition

$$\mu^4 G_{Planck} = 1\,. \tag{21}$$

Regarding the deviation from the previous section taking the proton q_{p+} value provides for an increase in G of about 1.0223 and suggests to assume a relation excluding non-gravitating massless currents with $q_m^4\chi = q^4$, where q_m represents a "local" cosmic nucleon average. This confirms the fundamental baryon mass scaling [10, 11] if we decompose μ into left-and right-handed opposite parity currents.

VII. MORE SCALING RELATIONS

The photon sphere flux $\rho(\lambda_\mu)$ can be taken as a system-invariant constant, with eq.(15) the human reference flux $\rho(r_u)$ at unit distance scales like Ξ^{-5}. To understand the role of the gravitational multipole flux one has to remember the cancellation of gravitational abberation [6]. Since charge and mass are conserved, there can be neither monopole electromagnetic radiation nor monopole gravitational radiation. Radiative exchange of energy requires dipole or higher moments in electromagnetic radiation and quadrupole or higher moments in gravitational radiation. In general relativity, the multipole moments of any finite distribution of energy and momentum interact with each other in vacuum, through the non-linearities of the field equations. In particular, the multipole moments which describe the gravitational waves emitted by an isolated system do not evolve independently, but rather couple together (including with themselves), giving rise to non-linear physical effects. Lack of aberration in gravitational interactions need not imply an infinite propagation speed, but can be explained as the effect of velocity-dependent terms in the multipole interaction [6]. Dimensional analysis yields for the balancing quadrupole-quadrupole unit flux

$$\rho_{QQ} \propto \Xi^{-5}\,, \tag{22}$$

the same scaling like the human reference flux $\rho(r_u)$ at unit distance, see eq.(15). The scaling of $N \propto \Xi^5$ guarantees, that for a variable (even statistical) ratio r_u-to-λ_μ the flux density at (or behind) λ_μ is critical. The simplest multipole interaction which contributes to the radiation field is that between the quadrupole moment Q and the mass monopole m (at spatial infinity, ADM mass) written as ρ_{QM}. Associated with the multipole interaction with velocity scaling $\rho_{QM} \propto \Xi^{-3}$ is the non-linear effect of tails [3, 4]. This effect is due to the backscatter of linear waves (described by Q) onto the space-time curvature generated by the mass-energy m. The tails can be computed within the theory of gravitational perturbations of the Schwarzschild background. A consequence of the existence of tails is a memory effect or non-locality in time. Regarding the scaling relations, what do we know from the self-consistent Schwarzschild solution?

- There is a global self-consistent quantum coupling $N \propto \Xi^5$ or $\rho(r_u) \propto \Xi^{-5}$, see eq.(15), that could be initiated and balanced by a quadrupole-quadrupole coupling flux eq.(22).
- There is a quantum coupling $\mu/\hbar \propto \Xi$.
- m_G corresponds to the unit flux $m_G \approx N\mu/3 \propto \Xi^6\hbar$, $4\pi^2 \propto Gm_G \propto \Xi^6\hbar G$, and the Planck length $r_p \propto \sqrt{\hbar G/c^3} \propto \Xi^{-9/2}$.

Obviously the quadrupole-quadrupole interaction scales exactly as required by a global self-consistent quantum coupling eq.(15). So there seem to be as many quanta as the many-particle quadrupole-quadrupole interaction with given flux velocity limit can support with back-reaction "memory" or rigidity. The unit monopole property corresponds to the energy and size of the quantum photon sphere subject to a given angular momentum quantum. In other words, many-particle quadrupole interaction that provide for the mass property serve for the localization of the mass quantum. But localization reduces the quadrupole effect that is necessary for quadrupole interaction. So there could be a balance in size reduction and deformation, since more reduction or localization reduces λ_μ, the overall coupling strength, and increases the the necessary N to reach the critical backscattering limit.

VIII. NON-COUPLING CURRENTS.

Many parts of this work show energy or coupling deficits. The current densities can be in the case of the proton decomposed into two parts

$$q^4_{p+} = (q^4_L - q^4_R)\gamma^4,$$
$$\mu_{p+} = q_{p+}\mu,\; q^2_L + q^2_R = q^2 = \mu\,, \tag{23}$$

where the small part q_R could

- be a massless current responsible for a reduction of the proton mass or the neutron mass with respect to μ.
- be important for strong interaction in nuclear physics,
- explain the deficit in electric coupling or charge and ϵ_0,
- explain the deficit in gravitational coupling strength G.

Do massless currents contribute to strong interaction but not to gravitation? How can they be defined?

Non-gravitating vacuum energy in the matter lagrangian L_m can be found by introducing a new measure for the integration of action in addition to the standard $\sqrt{-g}d^4x$ integrand. This measure is built from 4 scalar fields ϕ_a in 4-dimensional space-time [15]. The geometric approach of consists of using an alternative volume element Φd^4x, in addition to the standard one $\sqrt{-g}d^4x$. Such a theory based on Non-Gravitating Vacuum Energy (NGVE) has an infinite dimensional symmetry group which contains volume-preserving diffeomorphisms in the internal space of scalar fields ϕ_a. These type of models are known to produce a satisfactory answer to the cosmological constant problem, with a general action of the form

$$S = \int L_1 \Phi d^4x + \int L_2 \sqrt{-g} d^4x. \tag{24}$$

Global scale invariance is implemented. In order to have Φd^4x as an invariant volume element, it is necessary that Φ transforms as a density just like $\sqrt{-g}$. This can be realized by choosing Φ to be the composite of 4 scalars φ_a $(a = 1, 2, 3, 4)$

$$\Phi = \varepsilon^{\mu\nu\alpha\beta}\varepsilon_{abcd}\partial_\mu\varphi_a\partial_\nu\varphi_b\partial_\alpha\varphi_c\partial_\beta\varphi_d. \tag{25}$$

Since Φ is a total derivative, a shift of L_1 by a constant, $L_1 \to L_1 + const$, has the effect of adding to S the integral of a total derivative, which does not change equations of motion and becomes relevant for the cosmological constant problem. In Eq. (24), L_1 and L_2 are Lagrange multipliers which are functions of the matter fields, the metric, the connection (or spin-connection) but not of the "measure fields" φ_a. [15] showed also that geometry (measure, connections, metric) are relevant to particle physics. Varying the measure fields φ_a provides for

$$A^\mu_a \partial_\mu L_1 = 0 \tag{26}$$

where L_1 is defined, according to Eq. (24), as the part of the integrand of the action coupled to the measure Φ and

$$A^\mu_a = \varepsilon^{\mu\nu\alpha\beta}\varepsilon_{abcd}\partial_\nu\varphi_b\partial_\alpha\varphi_c\partial_\beta\varphi_d. \tag{27}$$

Since $Det(A^\mu_a) = \frac{4^{-4}}{4!}\Phi^3$ it follows that if $\Phi \neq 0$,

$$L_1 = sM^4 = const \tag{28}$$

where $s = \pm 1$ and M is a constant of integration of the dimension of mass. It is straightforward to establish a connection between the scaling law of NGVE in eq.(28) and the scaling law of the coupling currents eq.(21) that can be decomposed according to eq.(23). Decomposing the total action integral into N units of action quanta means to assign the extensive measure L_1 of NGVE to the extensive quantity m_G. Consequently, it is easy to show that L_1 is proportional to the number of action quanta N and therefore inversely proportional to the Newton coupling constant G in accordance with eq.(21). It should be noted, that the appearance of a nonzero integration constant M^4 spontaneously breaks the scale invariance [15].

IX. RELEVANCE FOR NUCLEAR PHYSICS

Quadrupole deformations of vacuum solutions resulting from NGVE currents would fit well to the baryon current and energy reduction with respect to q and μ, respectively. Strong stationary deformations can be induced by strong coupling currents (two-body vector and scalar exchange currents) that can be nucleons. The question is, if the strong neutron-proton interaction is driven by deformations due to NGVE generating a quadrupole effect with strength ≈ 10 MeV, and if this interaction is responsible for the onset of collectivity (see e.g. [16]). A collective nucleon-nucleon interaction would be based on a collective quadrupole deformation driven and controlled by NGVE. This would be in strong agreement with the $1 - (\xi_{p+}\gamma)^4 \approx 0.011$ energy reduction. Much work has been done to elaborate the intrinsic quadrupole moment of nucleons (see e.g. [17]), where the proton nucleon is considered to be a prolate spheroid. Non-spherical nuclei are able to rotate about axes other than the axis of symmetry; this rotation gives rise to characteristic spectral features and transitions which permit the quadrupole moment to be measured. But one has to be carefully in approaching single nucleon properties since deformed orbits of valence nucleons could strongly amplify the multipole component. It seems that the prolate geometry can be much more frequently found than the oblate geometry. As a result of this work, nucleons or resonances with masses higher than $\mu \approx 940.8637$ MeV tend to be oblate and unstable, in [17] this property can be found for Δ-resonances at ≈ 1232 MeV. For many real nuclei the quadrupole moment is much larger than the single particle value and hence indicates that many nucleons must act together collectively to produce the large electric quadrupole moment (collective model). The system-invariant mass scale (the spherical Schwarzschild reference) is 1.00138 times the neutron and 1.00276 times the proton scale. In this context it is interesting to note, that two neutrons provide for approximately the same energy gain like one proton.

X. CONCLUSION

Schwarzschild spacetime as the static and spherical symmetric solution qualifies for a test and spherically symmetric reference platform for quantum, thermodynamic and topological parameters [2] without quadrupole property, and enables to built an idealized relativistic system of units. Human reference scales designed for practical usage, quantum properties as natural units qualify for a system-invariant reference that can be used to redefine human chosen units. The quantum unit carries a quantum angular momentum $L = h$ captured in the unit field of the unit field generating mass, where the photon sphere ("trapped spherical surface") represent the corresponding geometry. Trough the non-linearities of the Einstein field equations in general relativity, the multipole moments of any finite distribution of energy and momentum interact with each other in vacuum. The self-consistent gravitational monopole interaction scaling is a system with the necessary gravitational field strength given by the unit field. Quantum particle must exchange gravitational energy through quadrupole fluctuations to generate the self-consistent system of back reaction and balance flux exchange, Gauss law provides for a flux scaling where N flux quanta constitute the unit field. Carlip [6] has argued that the speed of Gravitation should be close to c such that the correspondent aberration effects in general relativity are (similar to the electromagnetic case) almost exactly cancelled by velocity-dependent interactions, the self-consistent flux ensures that waves propagate at light velocity near c. In general relativity, the characteristic scaling relations can be assigned to a gravitational N-body problem, where N quantum masses provide for the necessary gravitational field strength on the unit reference scale. Quantum particles act like converter of monopole interaction into balancing quadrupole flux, where the monopole-quadrupole interaction generates quadrupole radiation to constitute the particle energy coupled to the radiation reservoir, and carries a quadrupole moment adjusted to the equilibrium radiation exchange. This exchange is a massless current that leads to the known coupling deficits [10] that can be assigned to a duality of coupling and non-coupling fluxes with 4th power flux scaling. This fits very well to existing models assuming a NGVE to give a satisfactory answer to the cosmological constant problem. Moreover, NGVE as a balancing partner flux can vary in space, especially near nuclear regions, and could be responsible for a spatial variation in G up to 0.2%.

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