A running coupling constant of a hypothetical quantum gravitational field (QGF) supporting a subtype of bimetric gravity theory (BGT) which implies two graviton modes: a super-massive one and a massless one

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Abstract (with abbreviations)

This paper proposes a running coupling constant of a hypothetical quantum gravitational field (**QGF**) (in relation to both the strong nuclear field [**SNF**] and the electromagnetic field [**EMF**] and based on an interesting logarithmic coincidence relating the running coupling constants of all these three fundamental physical fields: QGF, SNF and EMF) supporting a subtype of bimetric gravity theory (**BGT**) which implies two graviton modes: a spin-2 super-massive graviton (with rest energy around 1TeV) and a spin-2 massless graviton; this subtype of BGT is closely related to massive gravity theory (**MGT**).

This paper continues (from alternative angles of view) the work of other past articles/preprints of the same author [**1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **10**, **11**, **12**, **13**, **14**, **15**, **16**, **17**, **18**, **19**, **20**, **21**, **22**, **23**, **24**, **25**] and is actually a separate article dedicated only to "conjecture no.4" of author's quantum general relativity (**QGR**) variant [**3**].

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I. A running coupling constant of a hypothetical quantum gravitational field (QGF)

Observation no. 1 (Obs1). Let us start from the following observation:

$$\alpha_S/\alpha \cong \log_2(\alpha/\alpha_G) \cong 1/140 \cong \alpha \quad \textbf{(1a)},$$

which is equivalent to (see below)

$$\alpha/\alpha_G \cong 2^{\alpha_S/\alpha} \quad \textbf{(1b)}$$

and

$$\alpha_G \cong \alpha/2^{\alpha_S/\alpha} \quad \textbf{(1c)},$$

The previous three equations all use the following notations:

a. $\alpha_S(\cong 1)$ [URL] is the running coupling constant of the strong nuclear field (**SNF**)

$$\alpha_{SNF}(E) = \frac{12\pi}{(22-2n_f)\ln(E/E_{QCD})} = \frac{6\pi}{5\ln(E/E_{QCD})} \quad \text{(a}$$

formula only valid for $E >> E_{QCD}$) at the energy scale of a proton at rest $E = E_p = m_p c^2 \cong 0.94GeV$, more precisely $\alpha_{SNF}(1.5E_p) \cong 1$ (which is a function of the number of quark flavors $n_f = 6$ and the energy scale quantum chromodynamics [**QCD**] $E_{QCD} \cong 0.22GeV$);

b. $\alpha = k_e q_e^2/(\hbar c) \cong 1/137$ is the running coupling constant of the electromagnetic field [**EMF**] $\alpha_{EMF}(E) = \frac{\alpha}{1-(\alpha/3\pi)\ln(E^2/E_e^2)}$ at the energy scale of an electron at rest $E = E_e = m_e c^2 \cong 0.51MeV$ (also known as FSC at rest, valid for scales larger than electron's Compton wavelength $E = \lambda_{C(e)} = hc/E_e \cong 2.4\times10^{-12}m$) [**26**];

c. $\alpha_G = Gm_e^2/(\hbar c) \cong 1.75\times10^{-45}$ is the gravitational coupling constant (**GCC**), standardly defined as a function of the electron rest mass $m_e \cong 0.51MeV/c^2$ and measuring the strength of the gravitational field (**GF**).

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Conjecture no. 1 (Conj1). One may easily notice that α is a "junction"-term in **Eq.1a** (with α being present in both left and right parts of Eq.1a): this fact indicates that the running coupling constant α may actually have a "hybrid"/dual electromagnetic and gravitational significance, acting like a binary logarithmic strength "tuner" between SNF and QGF (through EMF). We consider Obs1 (with its main equation) to NOT be just a simple coincidence and we conjecture a generalized equation defining a generalized quantum big G $G_q(E)$ (varying with the energy scale) and a variable quantum GCC (assigned to a quantum gravitational field [**QGF**] with variable strength) $\alpha_{QGF}(E)$ being a function of this $G_q(E)$, such as:

$$G_q(E) = (\hbar c/m_e^2)\alpha_{EMF}(E)/2^{\alpha_{SNF}(E)/\alpha_{EMF}(E)} \quad \textbf{(2a)}$$

$$\alpha_{QGF}(E) = G_q(E)m_e^2/(\hbar c) = \alpha_{EMF}(E)/2^{\alpha_{SNF}(E)/\alpha_{EMF}(E)} \quad \textbf{(2b)}$$

a. Note that $1.5E_p$ (the argument of $\alpha_{SNF}(1.5E_p) \cong (\alpha_S \cong 1)$) and E_e (the argument of $\alpha_{EMF}(E_e) \cong \alpha$) aren't the same so that $G_q(E)$ and

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$\alpha_{QGF}(E)$ aren't quite exact, but only reasonably approximations. A more exact form of the two previous definitions (Eq.2a and Eq.2b) would be $G_q(E) = \left(\hbar c / m_e^2\right)\alpha_{EMF}(E) / 2^{\alpha_{SNF}(1.5\beta E)/\alpha_{EMF}(E)}$

and $\alpha_{QGF}(E) = G_q(E) m_e^2 / (\hbar c) = \alpha_{EMF}(E) / 2^{\alpha_{SNF}(1.5\beta E)/\alpha_{EMF}(E)}$, with $\beta = E_p / E_e$ being the ratio between the rest energies/masses of the proton and the electron.

b. Conj1 actually proposes a smooth transition from $G_{q(\min)}\left(\overset{def.}{=} G\right)$ to $G_{q(\max)} \overset{estim.}{=} G_q(E_{Pl}) \cong 10^{41} G$ by using this E-depending variable $G_q(E)$ with variable energy scale E taking values up to Planck energy $E_{Pl} \cong 1.96\times 10^9 J$. Interestingly enough, the $G_{q(\max)} / G_{q(\min)} \left(\cong 1.2\times 10^{41}\right)$ ratio has the same order of magnitude as the ratio $m_{Pl}^2 / (m_p m_e)\left[\cong m_{Pl}^2 / (m_n m_e) \cong 3.1\times 10^{41}\right]$ (with $m_{Pl}\left(= \sqrt{\hbar c / G}\right) \cong 10^{-8} kg$ being the Planck mass and m_p, m_n and m_e being the rest masses of the proton, the neutron and the electron respectively). The logarithmized graph of $p(E) = \log_{10}\left[G_q(E)/G\right]$ is presented **next**:

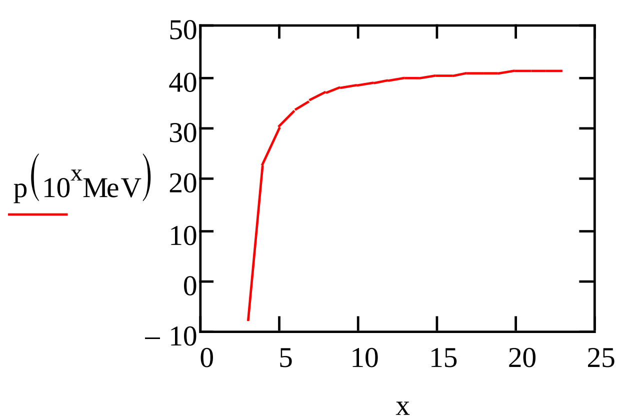

Image 1. The graph of $p(E) = \log_{10}\left[G_q(E)/G\right]$ for $E = 10^x MeV$ and $x \in [y, z]$, with $y = \log_{10}(E_{QCD} / 1MeV) + 1 (\cong 3)$ and $z = \log_{10}(E_{Pl} / 1MeV) + 1 (\cong 23)$

c. Very interestingly, the (next) graph of $\alpha_{QGF}(E)$ (which is the predicted running coupling constant of the quantum gravitational field [**QGF**]) has a growth pattern similar to the graph of the (previously explained) running coupling constant of WNF $\alpha_{WNF}(E) = \dfrac{E_W G_F / (\hbar c)^3}{e^{E_W / E}}$ (with a pattern of unification between QGF and WNF around Planck energy scale $E_{Pl}\left(\cong 1.96\times 10^9 J\right)$, which is another argument for QGF and WNF being unifiable at those sufficiently large energy scales): **see the next image**.

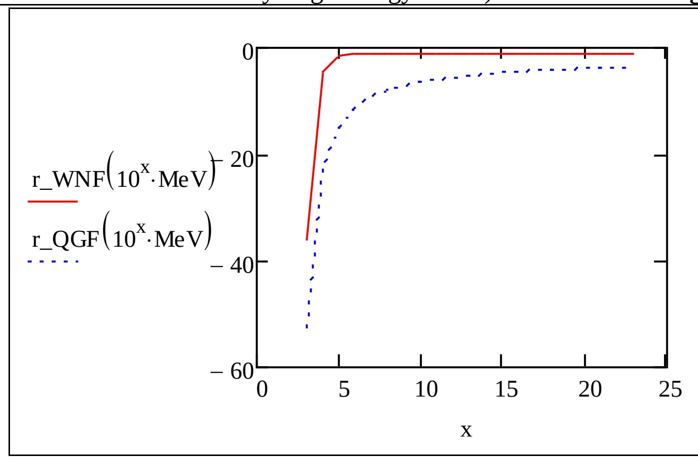

Image 2. The comparative graph of both $r_{WNF}(E) = \log_{10}\left[\alpha_{WNF}(E)\right]$ and $r_{QGF}(E) = \log_{10}\left[\alpha_{QGF}(E)\right]$ for $E = 10^x MeV$ and $x \in [y, z]$ (see the 1st image of this paper)

d. **Important note (1)**. From the previous image, one may easily notice that $\alpha_{QGF}(E)$ grows rapidly with the energy scale (being however negligible at atomic size scale $l_a \cong 10^{-10} m$ corresponding to an energy scale $E_a = hc / l_a \cong 10^{-2} MeV$) up to an inflexion (**i.**) point (**ip**) (from which $\alpha_{QGF}(E)$ grows much slower with the increasing energy scale), which ip corresponds to an energy scale $E_{QGF(i)} \cong 10^6 MeV$ and to a subnuclear (Compton) length scale $l_{QGF(i)} = hc / E_{QGF(i)} \cong 10^{-18} m$ $\left(\cong r_p / 10^3\right)$ (with $r_p \cong 0.87\times 10^{-15} m$ being the radius of the proton and $d_p = 2r_p \cong 1.64\times 10^{-15} m$): even more interestingly, $E_{QGF(i)}\left(\cong 10^6 MeV\right)$ is approximately one order of magnitude larger than the rest energies (**E**) of the Higgs boson (**Hb**) (E_{Hb}) and top quark (**tq**) (E_{tq}) (which are the heaviest known elementary particles) so that $\boxed{E_{QGF(i)} / E_{Hb} \cong 8}$ and $\boxed{E_{QGF(i)} / E_{tq} \cong 5.7}$; it is also interesting that the length-ratio $\boxed{d_p / l_{QGF(i)} (\cong 1403)}$ is relatively close to the mass-ratio $\boxed{m_p / m_e (\cong 1836)}$.

e. **Important prediction**. The similitude between $\alpha_{WNF}(E)$ and $\alpha_{QGF}(E)$ graphs (with $\alpha_{WNF}(E)$ variation graph also having an inflexion point corresponding to the rest energy of the W boson $E_W \cong 80GeV$ and to $x = \log_{10}(E_W / 1MeV) \cong 4.9$, as also visible in the previous graph) actually suggests that the massive graviton mode of at least one bimetric gravity theory (**BGT**) could be actually a **heavy spin-2 boson** with non-zero rest energy E_{gr} close to $E_{QGF(i)} (\cong 8E_{Hb} \cong 1TeV)$ (indentified with the quantum of QGF): **furthermore, all elementary particles (EPs) with non-zero rest masses could be actually composed from preons interchanging this kind of virtual super-massive hypothetical gravitons (which quantize QGF)**. We also consider these two possibilities: (**1**) EITHER what we measure as macroscopic/macrocosmic gravity is only a "residual" force/field (**residual QGF**) generated by exchange of heavy gravitons at subnuclear scales; (**2**) OR there are actually two types of spin-2 gravitons (a heavy one mediating gravity at subnuclear scales [**QGF**] AND a massless one mediating QGF at supra-nuclear atomic, microscopic and macroscopic/macrocosmic scales). **Note**. The predicted rest energy of this heavy spin-2 graviton (mediating QGR at subnuclear scales up to Planck scales) $E_{gr} (\cong E_{QGF(i)} \cong 1TeV)$ is almost one order of magnitude larger than the lower bound (**lb**) energy $E_{lb} \cong 170GeV$ established by quantum electrodynamics (**QED**) to be assignable to any possible (super-heavy) subcomponent of the electron (that may exist and act inside a composite electron with a hypothetical non-zero volume), with $E_{lb} (\cong 170GeV)$ being actually deducted from the very small difference $|\delta a| (< 8.3 \times 10^{-12})$ between the value of the electron magnetic moment that we measure in Bohr magnetons (called g/2) and the value of g/2 as predicted by QED as a function of FSC (α) at rest (called g/2(α)) [URL].

f. **Conclusion (with additional graph)**. All known fundamental forces/fields can be comparatively represented on the same graph, showing a unifying pattern close to Planck energy scale: **see the next image** (containing a graph which clearly shows that the strength of QGF approaches very closely the strength magnitudes of the other three fundamental physical fields [**FPFs**] at energy scales $E \in [10^{14}, 10^{15} MeV] (<< E_{Pl})$ (corresponding to a length scale interval $l \in [10^8 l_{Pl}, 10^9 l_{Pl}] (>> l_{Pl})$ which is approximately 4 orders of magnitude lower than the upper limit [**ul**] of the electron diameter $d_{e(ul)} = 10^{-22} m (>> l_{Pl})$, as estimated by using electrons trapped in Penning traps [URL]) (suggesting that the electron could actually have a non-zero volume and could be composed from preons interchanging these kind of super-massive gravitons), a fact that raises a great hope for all 4 known FPFs to be actually unifiable at energy scales much lower than E_{Pl} which are hypothetically achievable in other large hadron colliders (**LHCs**) potentially constructible in the distant future.

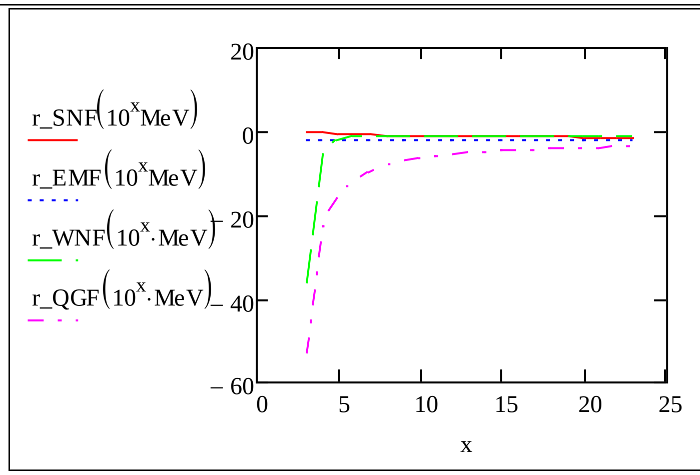

Image 3. The comparative graph (with a pattern of unification around Planck energy scale) of $r_{SNF}(E) = \log_{10}[\alpha_{SNF}(E)]$, $r_{EMF}(E) = \log_{10}[\alpha_{EMF}(E)]$, $r_{WNF}(E) = \log_{10}[\alpha_{WNF}(E)]$ and $r_{QGF}(E) = \log_{10}[\alpha_{QGF}(E)]$ for $E = 10^x MeV$ and $x \in [y,z]$ (see the 1st image of this paper)

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