A play with four virtual gravitational constants (Associated with the four basic interactions)

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Abstract: When heavenly bodies are made up of tiny atoms, it is imperative to find the correlations that might exist among 'atoms' and 'heavenly body' as whole. In this context, **by considering three virtual gravitational constants assumed to be associated with the three atomic interactions i.e. (electromagnetic, strong and weak interactions) and by considering four basic semi empirical (reference) relations pertaining to the four gravitational constants, a bold attempt is made to estimate the Newtonian gravitational constant (G_N). Its fitted and recommended values are 6.679855x10-(11) m3/kg/sec2 and 6.67408x10-(11) m3/kg/sec2 respectively and error is - 0.08653%. As current unification paradigm is failing in estimating (G_N) from atomic and nuclear physical constants, our work can be recommended for further study.**

Keywords: Newtonian gravitational constant, Three atomic gravitational constants

1. INTRODUCTION

It is well established that, on large scales, stars, galaxies and universe are controlled by 'gravity' and on small scales, atoms and atomic nuclei are controlled by 'quantum mechanics'. It is also well established that, stars are made up of so many atoms, galaxies are made up of so many stars and universe is made up of so many galaxies. Very unfortunate thing is that, so far, either qualitatively or quantitatively, at atomic and nuclear scales, there exist no generally accepted unified theoretical models, no formulae or no numerical procedures for estimating the magnitude of the Newtonian gravitational constant, G_N. So far, many laboratory experiments had been carried out for estimating the magnitude of G_N. Its current recommended CODATA [2,3,4] value is $6.67408 \times 10^{-11}\ \mathrm{m}^3\mathrm{kg}^{-1}\mathrm{sec}^{-2}$ and relative standard uncertainty is 4.7×10^{-5}. 2007 onwards, scientists and engineers are trying to estimate the magnitude of G_N by 'Atomic interferometry' and gradiometers [5, 6,7]. In this method, cold atoms are allowed to have free fall under gravity. Clearly speaking, an atomic gravity gradiometer is used to measure the differential acceleration experienced by two freely falling samples of laser-cooled rubidium atoms under the influence of nearby tungsten masses.

1.1 To estimate the Newtonian gravitational constant in a theoretical approach

To estimate the value of G_N in a theoretical approach, we would like to suggest the following points.

(1) As there is a large gap in between nuclear and Planck scales, with currently believed notion of unification paradigm, it seems impossible to implement gravity in atomic, nuclear and particle physics [1].
(2) In a unified approach, one can see a great initiative taken by J. E. Brandenburg [8].
(3) G_N is a man created empirical constant and is having no physical existence. Clearly

speaking, it is not real but virtual. For understanding the secrets of large scale gravitational effects, scientists consider it as a physical constant.

(4) In the same way, each atomic interaction can be allowed to have its own gravitational constant [9-15].

(5) With further study, their magnitudes can be refined for a better fit and understanding of the nature.

1.2 History of the three atomic gravitational constants

(1) Since 1974, K. Tennakone, Abdus Salam, C. Sivaram, K.P.Sinha, Dj. Sijacki, Y. Ne'eman, J.J. Perng, J. Strathdee, Usha Raut, V. de Sabbata, E. Recami, T.R. Mongan, Robert Oldershaw and S.G. Fedosin like many scientists proposed the existence of 'Nuclear' or 'strong' gravitational constant with a magnitude approximately $(10^{35}$ to $10^{39})$ times the Newtonian gravitational constant. In this context, one can see a detailed discussion by F. Akinto and Farida Tahir in their arXiv preprint [16].

(2) In 2010, 2011 and 2012, in a series of papers, we proposed the existence of 'electromagnetic' gravitational constant [17,18,19]. In 2016 Franck Delplace also proposed its existence [20].

(3) In 2013, Roberto Onofrio proposed the existence of 'weak' gravitational constant [21].

2. FOUR SEMI EMPIRICAL REFERENCE RELATIONS

1) Interaction constants are connected both with global phenomena of physics and with phenomena at small distances, such as quantum gravity. Therefore, the search for relations among the constants of the four types of interactions is important, relevant and necessary. At present, there exist no basic formulae or mechanisms using by which one can develop at least models with ad hoc relations. It would be important to consider in detail such theories as microscopic quantum gravity and a combination of the fields inherent in the unified description of the four interactions.

2) According to Rosi et al [1]:There is no definitive relationship indeed between G_N and the other fundamental constants and no theoretical prediction for its value to test the experimental results. Improving the knowledge of G_N has not only a pure metrological interest, but is also important for the key role that this fundamental constant plays in theories of gravitation, cosmology, particle physics, astrophysics, and geophysical models.

3) The most desirable cases of any unified description are:

   a) To implement gravity in microscopic physics and to estimate the magnitude of the Newtonian gravitational constant (G_N).
   b) To develop a model of microscopic quantum gravity.
   c) To simplify the complicated issues of known physics. (Understanding nuclear stability, nuclear binding energy, nuclear charge radii and neutron life time etc.)
   d) To predict new effects, arising from a combination of the fields inherent in the unified description. (Understanding strong coupling constant, Fermi's weak coupling constant and radiation constants etc.)

4) Objectives of this short communication are:

a) To see the possibility of estimating the magnitude of Newtonian gravitational constant in a theoretical approach within the scope of nuclear physics.

b) To see the possibility of understanding the historical mysteries of the proton-electron mass ratio, the radiation constant $(\hbar c)$, the strong coupling constant (α_s) and the Fermi's weak coupling constant (G_F).

(5) With reference to our recent publications and conference presentations [9-15], we propose the following set of four semi empirical REFERENCE relations. In a scientific approach and with further study, these 'ad hoc' relations can be analyzed for extracting possible physics. Let,

Electromagnetic gravitational constant = G_e
Nuclear gravitational constant = G_s
Weak gravitational constant = G_w
Mass of proton = m_p
Mass of neutron = m_n
Mass of electron = m_e
Elementary charge = e
Reduced Planck's constant = $\hbar$
Speed of light = c
Fermi's Weak coupling constant = G_F

$$\frac{m_p}{m_e} \cong 2\pi\sqrt{\frac{4\pi\varepsilon_0 G_e m_e^2}{e^2}} \cong \left(\frac{G_e m_e^2}{\hbar c}\right)\left(\frac{G_s m_p^2}{\hbar c}\right) \quad (1)$$

$$\left.\begin{aligned} \hbar c &\cong \left(\frac{m_p}{m_e}\right)^2 \left(G_e^2 G_N\right)^{1/3} m_p^2 \\ (\mathrm{Or}) \quad m_p &\cong \left(\frac{\hbar c m_e^2}{\left(G_e^2 G_N\right)^{1/3}}\right)^{\frac{1}{4}} \end{aligned}\right\} \quad (2)$$

$$G_F \cong \left[\left(G_e m_p^2\right)^2 \left(G_N m_p^2\right)\right]^{\frac{1}{3}} \left(\frac{2G_s m_p}{c^2}\right)^2 \cong \frac{4G_w \hbar^2}{c^2} \quad (3)$$

$$\frac{G_w}{G_N} \cong \left(\frac{m_p}{m_e}\right)^{10} \quad (4)$$

(6) Based on relation (1), magnitudes of (G_e, G_s) can be estimated. Based on relation (2), magnitude of G_N can be estimated. Based on relation (3), magnitudes of (G_F, G_w) can be estimated [21, 22]. Again, based on relation (4), G_N can be estimated. Estimated values seem to be:

$$\boxed{\begin{aligned} G_e &\cong 2.374335\times10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_s &\cong 3.329561\times10^{28}\text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_w &\cong 2.909745\times10^{22}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_N &\cong 6.679855\times10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_F &\cong 1.44021\times10^{-62}\ \text{J.m}^3 \end{aligned}}$$

3. OTHER RELATIONS AND DISCUSSION

(1) It may be noted that, since 1992, J. E Brandenburg is working on 'GEM unification theory' [8] and proposed an interesting and unified relation, $\frac{e^2}{4\pi\varepsilon_0 G_N m_p m_e} \cong \left(\frac{1}{\alpha}\right)\left\{\exp\sqrt{\frac{m_p}{m_e}}\right\}^2$. Compared to J. E Brandenburg and other available models of current unification theories, in this paper, with reference to three atomic gravitational constants, we present a variety of multipurpose arithmetic relations pertaining to nuclear, electroweak and astrophysical applications. In a verifiable approach, we are working on deriving them [12,15] from basic principles.

(2) With reference to Planck mass, we noticed that,

$$\boxed{\frac{\pi R_0^2}{\pi R_{pl}^2} \cong \frac{G_s^2 m_p^2}{G_N \hbar c} \cong \left(\frac{m_p}{m_e}\right)^{12}} \tag{5}$$

$$\boxed{\begin{aligned} &\text{where, } R_0 \cong \frac{2G_s m_p}{c^2}, \\ &R_{pl} \cong \frac{2G_N M_{pl}}{c^2} \cong 2\sqrt{\frac{G_N \hbar}{c^3}} \end{aligned}}$$

(3) Apart from these four gravitational constants, it is possible to assume the existence of a nuclear elementary charge in such a way that,

$$\boxed{\frac{e_s}{e} \cong \left(\frac{G_s m_p^2}{\hbar c}\right) \cong 2.946355} \tag{6}$$

$$\boxed{\frac{e_s^2}{e^2} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)^2 \cong \left(\frac{G_s m_p^3}{G_e m_e^3}\right)} \tag{7}$$

$$\boxed{\frac{e_s G_s}{e G_w} \cong \left(\frac{m_p}{m_e}\right)^2} \tag{8}$$

$$\begin{aligned}&\text{Strong coupling consant [15],}\\ &\alpha_s \cong \left(\frac{e}{e_s}\right)^2 \cong \left(\frac{\hbar c}{G_s m_p^2}\right)^2 \cong \left(\frac{G_e m_e^3}{G_s m_p^3}\right)\\ &\quad \cong 0.115194\end{aligned} \tag{9}$$

(4) Proton-Neutron-Nucleon stability can be understood with [23],

$$\begin{aligned}&A_s \cong 2Z + s(2Z)^2 \cong 2Z + (4s)Z^2\\ &\quad \cong 2Z + kZ^2 \cong Z(2+kZ)\\ &\text{where}\\ &s \cong \left\{\left(\frac{e_s}{m_p}\right) \div \left(\frac{e}{m_e}\right)\right\} \cong 0.001605\\ &\quad \cong \frac{G_s m_p m_e}{\hbar c} \cong \frac{\hbar c}{G_e m_e^2} \cong \frac{G_s^2}{G_e G_w}\\ &\text{and } (4s) \cong k \cong 0.0064185\end{aligned} \tag{10}$$

(5) Understanding nuclear binding energy with a single energy coefficient of magnitude 10.0 MeV is a challenging task and so far, except Ghahramany et al [24,25], no one could attempt to do that. For $(Z \ge 7)$ nuclear binding energy can be fitted with,

$$\begin{aligned}&B_A \cong \left\{A - \left(\frac{kAZ}{2.531} + 3.531\right) - \left(\frac{A_s - A}{A_s}\right)^2\right\} \times 10.09 \text{ MeV}\\ &\text{where,} \left\{\begin{aligned}&\frac{e_s^2}{8\pi\varepsilon_0 \left(G_s m_p / c^2\right)} \cong 10.09 \text{ MeV}\\ &\left(m_n - m_p\right)/m_e \cong \ln\left(1/\sqrt{k}\right) \cong 2.531\end{aligned}\right\}\end{aligned} \tag{11}$$

(6) Coulombic energy coefficient being 0.7 MeV, with reference to $\ln\left(\frac{e^2}{4\pi\varepsilon_0 G_s m_p m_e}\right) \cong 1.515,$ volume or surface energy coefficient can be expressed as 1.515*10.09 = 15.3 MeV and asymmetric energy coefficient can be expressed as, 1.515*15.3 = 23.0 MeV. Thus, 10.09 MeV, 15.3 MeV and 23.0 MeV seem to follow a geometric series with a geometric ratio of 1.515. For $(Z \ge 10)$, binding energy [23] can also be estimated with,

$$\begin{aligned}&B_A \cong \left(A - A^{2/3} - 1\right) * 15.3 \text{MeV}\\ &\quad - \frac{Z^2}{A^{1/3}} * 0.7 \text{MeV} - \frac{(A-2Z)^2}{A} * 23.0 \text{MeV}\end{aligned} \tag{12}$$

(7) With further research in nuclear astrophysics, it is certainly possible to understand the combined effects of Newtonian gravitational constant and proposed nuclear gravitational constant. Considering the ratio of nuclear gravitational constant and Newtonian

gravitational constant, estimated masses of white dwarfs, neutron stars and black holes [26,27], can be fitted approximately. For example,

$$\begin{aligned}
M_x &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{e^2}{4\pi\varepsilon_0 G_N}} \approx 0.473 M_\odot \\
M_x &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{e_s^2}{4\pi\varepsilon_0 G_N}} \approx 1.373 M_\odot \\
M_x &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{\hbar c}{G_N}} \approx 5.456 M_\odot
\end{aligned} \tag{13}$$

$$\begin{aligned}
M_x &\approx \sqrt{\frac{G_s}{G_N}}\,\frac{e^2}{4\pi\varepsilon_0 G_N m_p} \approx 0.023 M_\odot \\
M_x &\approx \sqrt{\frac{G_s}{G_N}}\,\frac{e_s^2}{4\pi\varepsilon_0 G_N m_p} \approx 0.2 M_\odot \\
M_x &\approx \sqrt{\frac{G_s}{G_N}}\left(\frac{\hbar c}{G_N m_n}\right) \approx 3.174 M_\odot
\end{aligned} \tag{14}$$

(8) At the moment of a neutron star's birth, the nucleons that compose it have a temperature of around 10^{11} to 10^{12} K [28]. Considering M_x as an upper limit for neutron stars and lower limit for black holes, corresponding critical temperature can be fitted with,

$$\begin{aligned}
T_x &\approx \frac{\hbar c^3}{8\pi k_B G_N \sqrt{M_x M_{pl}}} \\
&\text{where, } M_{pl} \cong \sqrt{\frac{\hbar c}{G_N}} \cong 2.176\times 10^{-8}\,\text{kg}
\end{aligned} \tag{15}$$

(9) Considering the following relations (16) to (26), we are trying to understand the possible role and interplay of the three proposed atomic gravitational constants. If one is able to find the physics connected with (G_e, G_w, G_s), mystery of the reduced Planck's constant can be explored.

a) With reference to electromagnetic and Newtonian gravitational constants, it is possible to show that,

$$\begin{aligned}
&\text{Planck mass,} \\
&M_{pl} \cong \sqrt{\frac{\hbar c}{G_N}} \cong \left(\frac{G_e}{G_N}\right)^{\frac{1}{3}}\left(\frac{m_p^2}{m_e}\right)
\end{aligned} \tag{16}$$

b) With reference to nuclear and electromagnetic gravitational constants, it is possible to show that,

$$\begin{aligned}
&\text{Bohr radius, } a_0 \cong \left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e^2}\right)\left(\frac{G_s m_p}{c^2}\right) \\
&\cong 5.2918\times 10^{-11}\,\text{m}
\end{aligned} \tag{17}$$

Atomic radius,

$$R_{atom} \cong \left(\frac{2\sqrt{G_s G_e}\, m_p}{c^2} \right) \cong 33.1 \text{ picometer} \tag{18}$$

c) With reference to proposed nuclear elementary charge, nuclear and electromagnetic gravitational constants,

$$\sqrt{\frac{e_s^2}{4\pi\varepsilon_0 G_s m_p m_e}} \cong 2\pi \tag{19}$$

$$hc \cong \sqrt{\frac{e^2 G_s m_p^3}{4\pi\varepsilon_0 m_e}} \cong \sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0}\right)(G_e m_e^2)}$$

$$\hbar c \cong \sqrt{(G_s m_p m_e)(G_e m_e^2)} \tag{20}$$

d) With reference to the nuclear gravitational constant and nuclear elementary charge,

I. Proton magnetic moment can be expressed with,

$$\mu_p \cong \frac{e_s \hbar}{2m_p} \cong \frac{eG_s m_p}{2c} \cong 1.488142 \times 10^{-26} \text{ J/T} \tag{21}$$

II. Neutron magnetic moment can be expressed with,

$$\mu_n \cong \frac{(e_s - e)\hbar}{2m_n} \cong 9.8171 \times 10^{-27} \text{ J/T} \tag{22}$$

e) With reference to the three atomic gravitational constants, Bohr magneton can be expressed with,

$$\mu_B \cong \frac{e\hbar}{2m_e} \cong \left(\frac{G_s^2}{G_e G_w}\right)\left(\frac{eG_e m_e}{2c}\right) \cong \frac{eG_s^2 m_e}{2G_w c}$$

$$\cong \frac{e\sqrt{(G_s m_p)(G_e m_e)}}{2c} \tag{23}$$

f) Nuclear charge radii can be addressed with [29],

$$R_{(Z,A)} \cong \left\{ Z^{1/3} + \left(\sqrt{Z(A-Z)}\right)^{1/3} \right\} \left(\frac{G_s m_p}{c^2} \right) \tag{24}$$

g) With reference to electromagnetic and weak gravitational constants, ‘bottle method’ of neutron life time can be fitted with [30],

$$\boxed{t_n \cong \left(\frac{G_e}{G_w}\right)\left(\frac{G_e m_n^2}{\left(m_n - m_p\right)c^3}\right) \cong 874.94 \text{ sec}} \tag{25}$$

It may be noted that, relativistic mass of neutron seems to play a crucial role in understanding the ‘beam’ method of increasing neutron life time. It can be understood with,

$$\boxed{t_n \propto \frac{m_n^2}{\left[1-\left(v^2/c^2\right)\right]}} \tag{26}$$

4. CONCLUSION

Current unification paradigm is failing in developing a ‘practical unification procedure’ [1]. Even though our approach is speculative, role played by the four gravitational constants seems to be fairly natural. This kind of approach may help in producing a variety of such relations by using which in near future, an absolute set of relations can be developed. Proceeding further, estimated absolute theoretical value of G_N can be considered as a standard reference for future experiments. By implementing the four such gravitational constants in String theory models, it may be possible to explore the hidden unified physics. With further study, a practical model of materialistic quantum gravity can be developed and magnitude of the Newtonian gravitational constant can be estimated in a theoretical approach bound to Fermi scale.

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