

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

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 $6.679855 \times 10^{-11} \text{ m}^3/\text{kg}/\text{sec}^2$ and $6.67408 \times 10^{-11} \text{ m}^3/\text{kg}/\text{sec}^2$ 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 $6.67408 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ sec}^{-2}$ 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

- 38 speaking, it is not real but virtual. For understanding the secrets of large scale
39 gravitational effects, scientists consider it as a physical constant.
40 (4) In the same way, each atomic interaction can be allowed to have its own gravitational
41 constant [9-15].
42 (5) With further study, their magnitudes can be refined for a better fit and understanding
43 of the nature.
44

45 1.2 History of the three atomic gravitational constants

- 46
47 (1) Since 1974, K. Tennakone, Abdus Salam, C. Sivaram, K.P.Sinha, Dj. Sijacki, Y.
48 Ne'eman, J.J. Perng, J. Strathdee, Usha Raut, V. de Sabbata, E. Recami, T.R.
49 Mongan, Robert Oldershaw and S.G. Fedosin like many scientists proposed the
50 existence of 'Nuclear' or 'strong' gravitational constant with a magnitude
51 approximately (10^{35} to 10^{39}) times the Newtonian gravitational constant. In this
52 context, one can see a detailed discussion by F. Akinto and Farida Tahir in their
53 arXiv preprint [16].
54 (2) In 2010, 2011 and 2012, in a series of papers, we proposed the existence of
55 'electromagnetic' gravitational constant [17,18,19]. In 2016 Franck Delplace also
56 proposed its existence [20].
57 (3) In 2013, Roberto Onofrio proposed the existence of 'weak' gravitational constant
58 [21].
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60

61 2. FOUR SEMI EMPIRICAL REFERENCE RELATIONS

- 62
63 1) Interaction constants are connected both with global phenomena of physics and with
64 phenomena at small distances, such as quantum gravity. Therefore, the search for
65 relations among the constants of the four types of interactions is important, relevant and
66 necessary. At present, there exist no basic formulae or mechanisms using by which one
67 can develop at least models with ad hoc relations. It would be important to consider in
68 detail such theories as microscopic quantum gravity and a combination of the fields
69 inherent in the unified description of the four interactions.
70 2) According to Rosi et al [1]: There is no definitive relationship indeed between G_N and the
71 other fundamental constants and no theoretical prediction for its value to test the
72 experimental results. Improving the knowledge of G_N has not only a pure metrological
73 interest, but is also important for the key role that this fundamental constant plays in
74 theories of gravitation, cosmology, particle physics, astrophysics, and geophysical
75 models.
76
77 3) The most desirable cases of any unified description are:
78
79 a) To implement gravity in microscopic physics and to estimate the magnitude of
80 the Newtonian gravitational constant (G_N).
81 b) To develop a model of microscopic quantum gravity.
82 c) To simplify the complicated issues of known physics. (Understanding nuclear
83 stability, nuclear binding energy, nuclear charge radii and neutron life time etc.)
84 d) To predict new effects, arising from a combination of the fields inherent in the
85 unified description. (Understanding strong coupling constant, Fermi's weak
86 coupling constant and radiation constants etc.)
87
88 4) Objectives of this short communication are:
89

- 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_N
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

$$\frac{m_p}{m_e} \cong 2\pi \sqrt{\frac{4\pi\epsilon_0 G_e m_e^2}{e^2}} \cong \left(\frac{G_e m_e^2}{\hbar c} \right) \left(\frac{G_s m_p^2}{\hbar c} \right) \quad (1)$$

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

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

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

(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:

$$\begin{aligned}
G_e &\cong 2.374335 \times 10^{37} \text{ m}^3 \text{ kg}^{-1} \text{ sec}^{-2} \\
G_s &\cong 3.329561 \times 10^{28} \text{ m}^3 \text{ kg}^{-1} \text{ sec}^{-2} \\
G_w &\cong 2.909745 \times 10^{22} \text{ m}^3 \text{ kg}^{-1} \text{ sec}^{-2} \\
G_N &\cong 6.679855 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ sec}^{-2} \\
G_F &\cong 1.44021 \times 10^{-62} \text{ J.m}^3
\end{aligned}$$

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,

$$\frac{e^2}{4\pi\epsilon_0 G_N m_p m_e} \cong \left(\frac{1}{\alpha}\right) \left\{ \exp \sqrt{\frac{m_p}{m_e}} \right\}^2.$$

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,

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

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

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

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

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

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

Strong coupling constant [15],

$$\alpha_s \cong \left(\frac{e}{e_s} \right)^2 \cong \left(\frac{\hbar c}{G_s m_p^2} \right)^2 \cong \left(\frac{G_e m_e^3}{G_s m_p^3} \right) \cong 0.115194 \quad (9)$$

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154 (4) Proton-Neutron-Nucleon stability can be understood with [23],
155

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

157

158 (5) Understanding nuclear binding energy with a single energy coefficient of magnitude 10.0
159 MeV is a challenging task and so far, except Ghahramany et al [24,25], no one could
160 attempt to do that. For ($z \geq 7$) nuclear binding energy can be fitted with,
161

$$\begin{aligned} B_A &\cong \left\{ A - \left(\frac{kAZ}{2.531} + 3.531 \right) - \left(\frac{A_s - A}{A_s} \right)^2 \right\} \times 10.09 \text{ MeV} \\ \text{where, } &\left\{ \begin{aligned} \frac{e_s^2}{8\pi\epsilon_0 (G_s m_p / c^2)} &\cong 10.09 \text{ MeV} \\ (m_n - m_p) / m_e &\cong \ln(1/\sqrt{k}) \cong 2.531 \end{aligned} \right\} \end{aligned} \quad (11)$$

163

164 (6) Coulombic energy coefficient being 0.7 MeV, with reference to $\ln \left(\frac{e^2}{4\pi\epsilon_0 G_s m_e m_e} \right) \cong 1.515$,

165 volume or surface energy coefficient can be expressed as $1.515 \times 10.09 = 15.3$ MeV and
166 asymmetric energy coefficient can be expressed as, $1.515 \times 15.3 = 23.0$ MeV. Thus, 10.09
167 MeV, 15.3 MeV and 23.0 MeV seem to follow a geometric series with a geometric ratio of
168 1.515. For ($z \geq 10$), binding energy [23] can also be estimated with,
169

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

171

172 (7) With further research in nuclear astrophysics, it is certainly possible to understand the
173 combined effects of Newtonian gravitational constant and proposed nuclear gravitational
174 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,

$$\begin{aligned} M_x &\approx \left(\frac{G_s}{G_N} \right) \sqrt{\frac{e^2}{4\pi\epsilon_0 G_N}} \approx 0.473 M_\odot \\ M_x &\approx \left(\frac{G_s}{G_N} \right) \sqrt{\frac{e^2}{4\pi\epsilon_0 G_N}} \approx 1.373 M_\odot \\ M_x &\approx \left(\frac{G_s}{G_N} \right) \sqrt{\frac{\hbar c}{G_N}} \approx 5.456 M_\odot \end{aligned} \quad (13)$$

$$\begin{aligned} M_x &\approx \sqrt{\frac{G_s}{G_N}} \frac{e^2}{4\pi\epsilon_0 G_N m_p} \approx 0.023 M_\odot \\ M_x &\approx \sqrt{\frac{G_s}{G_N}} \frac{e^2}{4\pi\epsilon_0 G_N m_p} \approx 0.2 M_\odot \\ M_x &\approx \sqrt{\frac{G_s}{G_N}} \left(\frac{\hbar c}{G_N m_n} \right) \approx 3.174 M_\odot \end{aligned} \quad (14)$$

(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,

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

(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,

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

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

$$\begin{aligned} &\text{Bohr radius, } a_0 \equiv \left(\frac{4\pi\epsilon_0 G_e m_e^2}{e^2} \right) \left(\frac{G_s m_p}{c^2} \right) \\ &\equiv 5.2918 \times 10^{-11} \text{ m} \end{aligned} \quad (17)$$

Atomic radius,

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

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

$$\sqrt{\frac{e_s^2}{4\pi\epsilon_0 G_s m_p m_e}} \cong 2\pi \quad (19)$$

$$\begin{aligned} hc &\cong \sqrt{\frac{e_s^2 G_s m_p^3}{4\pi\epsilon_0 m_e}} \cong \sqrt{\left(\frac{e_s^2}{4\pi\epsilon_0} \right) (G_e m_e^2)} \\ \hbar c &\cong \sqrt{(G_s m_p m_e) (G_e m_e^2)} \end{aligned} \quad (20)$$

- d) With reference to the nuclear gravitational constant and nuclear elementary charge,
I. Proton magnetic moment can be expressed with,

$$\mu_p \cong \frac{e_s \hbar}{2m_p} \cong \frac{e G_s m_p}{2c} \cong 1.488142 \times 10^{-26} \text{ J/T} \quad (21)$$

- II. Neutron magnetic moment can be expressed with,

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

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

$$\begin{aligned} \mu_B &\cong \frac{e \hbar}{2m_e} \cong \left(\frac{G_s^2}{G_e G_w} \right) \left(\frac{e G_e m_e}{2c} \right) \cong \frac{e G_s^2 m_e}{2G_w c} \\ &\cong \frac{e \sqrt{(G_s m_p) (G_e m_e)}}{2c} \end{aligned} \quad (23)$$

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

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

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

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

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,

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

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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