Gravity in the shadow of stable atoms and their three interactions

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Abstract: Even though materialistic atoms are having independent existence in this current accelerating universe, they are not allowing scientists and engineers to explore the secrets of gravity at atomic scale. This may be due to incomplete unification paradigm, inadequacy of known physics and technological difficulties etc. In this challenging scenario, in an analogical and semi empirical approach, each atomic interaction can be allowed to have its own gravitational constant. Proceeding further, with respect to strong coupling constant of high energy nuclear physics, Planck's constant of electromagnetic interaction and Fermi's coupling constant of weak interaction, we tried to fit the Newtonian gravitational constant. It's estimated value seems to fall in the range of (6.67-6.68)x10^(-11) m3/kg/sec2. By considering experimental nuclear charge radii and binding energy of stable isotopes, it is possible to improve the accuracy of estimation. With further study, a practical model of materialistic quantum gravity can be developed.

Keywords: materialistic atoms, three atomic gravitational constants, Newtonian gravitational constant, materialistic quantum gravity.

1. Introduction

In this paper, with respect to the available physics literature pertaining to large gravitational coupling constants [1-6], we propose the existence of four different gravitational constants assumed to be associated with the observed four fundamental interactions and study their possible role in understanding nuclear stability and binding energy [7-12] for light, medium, heavy and super heavy atomic nuclides. 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 nuclear elementary charge, strong coupling constant and Fermi's weak coupling constant etc.)

In this context, in our recent and earlier publications [13-30], we could present many interesting relations among all the key physical constants of nuclear and atomic physics. Objectives of this paper are:

- To give support to the proposed four gravitational constants with possible applications.
- To see the inter play among the four gravitational constants.
- To see the possibility of estimating the magnitude of Newtonian gravitational constant in a theoretical approach within the scope of nuclear physics.

2. Four simple assumptions

With reference to our recent paper publications and conference proceedings [13-30], we propose the following four assumptions.

1) There exist four different gravitational constants associated with gravitational, weak, electromagnetic and strong interactions.

   Let, Nuclear gravitational constant= G_s
   Weak gravitational constant = G_w
   Electromagnetic gravitational constant = G_e
   Newtonian gravitational constant = G_N

2) Nuclear charge radius can be addressed with,

$$R_0 \cong \frac{2G_s m_p}{c^2} \tag{1}$$

3) Strong coupling constant [31,32] can be expressed with,

$$\alpha_s \cong \left(\frac{\hbar c}{G_s m_p^2}\right)^2 \tag{2}$$

4) There exists a strong elementary charge in such a way that,

$$e_s \cong \left(\frac{G_s m_p^2}{\hbar c}\right) e \cong \frac{e}{\sqrt{\alpha_s}}$$
$$\rightarrow \frac{G_s m_p}{c^2} \cong \sqrt{\frac{1}{\alpha_s}}\left(\frac{\hbar c}{m_p^2}\right) \cong \left(\frac{e_s}{e}\right)\left(\frac{\hbar}{m_p c}\right) \tag{3}$$

Note: Considering the relativistic mass of proton, it is possible to show that, $\alpha_s \propto \left(\frac{1}{m_p}\right)^4 \left[1-\frac{v}{c}\right]^2$ where v can be considered as the speed of proton. Qualitatively, at higher energies, strength of strong interaction seems to decrease with speed of proton.

3. To fix the magnitude of G_s

With our experience in this approach, we could find two useful methods for estimating the magnitude of G_s. We are working on refining them for better understanding.

Method-1:

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

$$G_s \cong \frac{4\pi\varepsilon_0 h^2 c^2 m_e}{e^2 m_p^3} \tag{5}$$

Method-2:

$$\left(\frac{m_p}{m_e}\right)^{10} \cong \exp\left(\frac{1}{\alpha_s^2}\right) \tag{6}$$

$$\left(\frac{1}{\alpha_s}\right) \cong \sqrt{\ln\left(\frac{m_p}{m_e}\right)^{10}} \tag{7}$$

$$G_s \cong \sqrt{\frac{1}{\alpha_s}}\left(\frac{\hbar c}{m_p^2}\right) \cong \left[\ln\left(\frac{m_p}{m_e}\right)^{10}\right]^{1/4}\left(\frac{\hbar c}{m_p^2}\right) \tag{8}$$

4. Characteristic relations connected with three atomic interactions

The following three relations can be given some consideration in understanding the fundamentals of atomic interactions.

$$\frac{e_s^2}{e^2} \cong \frac{m_p}{m_e}\left(\frac{G_s m_p^2}{G_e m_e^2}\right) \cong \left(\frac{G_s m_p^3}{G_e m_e^3}\right) \tag{9}$$

Fine structure ratio,

$$\alpha \cong \frac{e^2}{4\pi\varepsilon_0 \hbar c} \cong \left(\frac{e_s^2}{4\pi\varepsilon_0 G_s m_p^2}\right)\left(\frac{\hbar c}{G_s m_p^2}\right) \tag{10}$$

Fermi's weak coupling constant,

$$G_F \cong \left[\left(G_e m_p^2\right)^2 \left(G_N m_p^2\right)\right]^{\frac{1}{3}} \left(\frac{2G_s m_p}{c^2}\right)^2$$
$$\cong \hbar c\left(\frac{4G_w \hbar}{c^3}\right) \cong \frac{4G_w \hbar^2}{c^2} \cong \frac{4G_s^2 m_e^2 \hbar}{c^3} \tag{11}$$

5. Interplay among the four gravitational constants

We noticed that,

$$\left.\begin{aligned}\frac{m_p}{m_e} &\cong 2\pi\sqrt{\frac{4\pi\varepsilon_0 G_e m_e^2}{e^2}} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{G_e m_e^2}{\hbar c}\right) \\ &\cong \left(\frac{G_s}{G_N^{2/3} G_e^{1/3}}\right)^{\frac{1}{7}} \cong \left(\frac{G_F c^2}{4\hbar^2 G_N}\right)^{\frac{1}{10}} \cong \left(\frac{e_s G_s}{e G_N}\right)^{\frac{1}{12}}\end{aligned}\right\} \tag{12}$$

$$\frac{G_w}{G_s} \cong \frac{G_s m_e^2}{\hbar c} \tag{13}$$

$$\frac{G_w}{G_N} \cong \left(\frac{m_p}{m_e}\right)^{10} \tag{14}$$

$$\frac{G_e}{G_s} \cong \frac{\hbar c}{G_w m_p m_e} \tag{15}$$

6. To estimate the magnitudes of $\left(e_s, \alpha_s, G_e, G_w, G_N, G_F\right)$

Based on method-1 of estimating G_s,

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$$\left\{\begin{array}{l} G_s \cong 3.329561\times 10^{28}\,\mathrm{m^3kg^{-1}sec^{-2}} \\ \alpha_s \cong 0.115194 \\ e_s \cong 4.720587\times 10^{-19}\ \mathrm{C} \\ G_e \cong 2.374335\times 10^{37}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_w \cong 2.909745\times 10^{22}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_N \cong 6.679855\times 10^{-11}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_F \cong 1.44021\times 10^{-62}\ \mathrm{J.m^3} \end{array}\right\} \tag{16}$$

Based on method-2 of estimating G_s,

$$\left\{\begin{array}{l} \alpha_s \cong 0.1153515 \\ e_s \cong 4.717358\times 10^{-19}\ \mathrm{C} \\ G_s \cong 3.327283\times 10^{28}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_e \cong 2.375961\times 10^{37}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_w \cong 2.905766\times 10^{22}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_N \cong 6.670719\times 10^{-11}\ \mathrm{m^3kg^{-1}sec^{-2}} \\ G_F \cong 1.438240\times 10^{-62}\ \mathrm{J.m^3} \end{array}\right\} \tag{17}$$

Based on the estimated data from relations (16) and (17), average value of $G_N \cong 6.675287\times 10^{-11}\ \mathrm{m^3kg^{-1}sec^{-2}}$

7. Understanding proton-neutron stability with three atomic gravitational constants

Let,

$$\left.\begin{array}{l} s \cong \left\{\left(\dfrac{e_s}{m_p}\right) \div \left(\dfrac{e}{m_e}\right)\right\} \cong 0.001605 \\ \cong \dfrac{G_s m_p m_e}{\hbar c} \cong \dfrac{\hbar c}{G_e m_e^2} \cong \dfrac{G_s^2}{G_e G_w} \end{array}\right\} \tag{18}$$

Nuclear beta stability line can be addressed with a relation of the form [relation 8 of reference. 9],

$$\begin{array}{l} A_s \cong 2Z + s(2Z)^2 \cong 2Z + (4s)Z^2 \\ \quad \cong 2Z + kZ^2 \cong Z(2+kZ) \\ \quad \text{where } (4s) \cong 0.0064185 \end{array} \tag{19}$$

By considering a factor like $\left[2 \pm \sqrt{k}\right]$, likely possible range of A_s can be addressed with,

$$\left.\begin{array}{l} (A_s)_{lower}^{upper} \cong Z\left[(2 \pm 0.08) + kZ\right] \\ \to \left\{\begin{array}{l} (A_s)_{lower} \cong Z(1.92 + kZ) \\ (A_s)_{mean} \cong Z(2.0 + kZ) \\ (A_s)_{upper} \cong Z(2.08 + kZ) \end{array}\right\} \end{array}\right\} \tag{20}$$

Interesting point to be noted is that, for Z=112, 113 and 114, estimated lower stable mass numbers are 296, 299 and 302 respectively. Corresponding neutron numbers are 184, 186 and 188. These neutron numbers are very close to the currently believed shell closure at N=184. It needs further study [33].

8. Understanding nuclear binding energy with single unified energy coefficient

Interesting points to be noted are:

1. With reference to electromagnetic interaction, and based on proton number, $\left(1/\alpha_s\right) \cong 8.68$ can be considered as the maximum strength of nuclear binding energy.
2. $Z \approx 30$ seems to represent a characteristic reference number in understanding nuclear binding of light and heavy atomic nuclides.

Based on the new integrated model proposed by N. Ghahramany et al [11,12],

$$B(Z,N) = \left\{A - \left(\frac{(N^2 - Z^2) + \delta(N-Z)}{3Z} + 3\right)\right\}\frac{m_n c^2}{\gamma} \tag{21}$$

where, $\gamma =$ Adjusting coefficient $\approx$ (90 to 100).
if $N \neq Z,\ \delta(N-Z) = 0$ and if $N = Z,\ \delta(N-Z) = 1$.

Readers are encouraged to see references there in [11,12] for derivation part. Point to be noted is that, close to the beta stability line, $\left[\dfrac{N^2 - Z^2}{3Z}\right]$ takes care of the combined effects of coulombic and asymmetric effects. In this context, we would like suggest that,

$$\left.\begin{array}{l} \dfrac{m_n c^2}{\gamma} \cong \dfrac{m_n c^2}{(90\text{ to }100)} \cong \text{Constant} \\ \cong \dfrac{e_s^2}{8\pi\varepsilon_0\left(G_s m_p / c^2\right)} \cong 10.09\,\mathrm{MeV} \end{array}\right\} \tag{22}$$

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Proceeding further, with reference to relation (19), it is also possible to show that, for $Z \cong (40 \text{ to } 83)$, close to the beta stability line,

$$\left[\frac{N_s^2 - Z^2}{Z}\right] \cong kA_s Z \quad (23)$$

$$\left[\frac{N_s^2 - Z^2}{3Z}\right] \cong \frac{kA_s Z}{3} \quad (24)$$

Based on the above relations and close to the stable mass numbers of $(\mathrm{Z} \approx 5 \text{ to } 118)$, with a common energy coefficient of 10.09 MeV, we would like to suggest two terms for fitting and understanding nuclear binding energy.

First term helps in **increasing** the binding energy and can be considered as,

$$\text{Term\_1} = A_s \times 10.09 \text{ MeV} \quad (25)$$

Second term helps in **decreasing** the binding energy and can be considered as,

$$\text{Term\_2} = \left(\frac{kA_s Z}{2.531} + 3.531\right) \times 10.09 \text{ MeV} \quad (26)$$

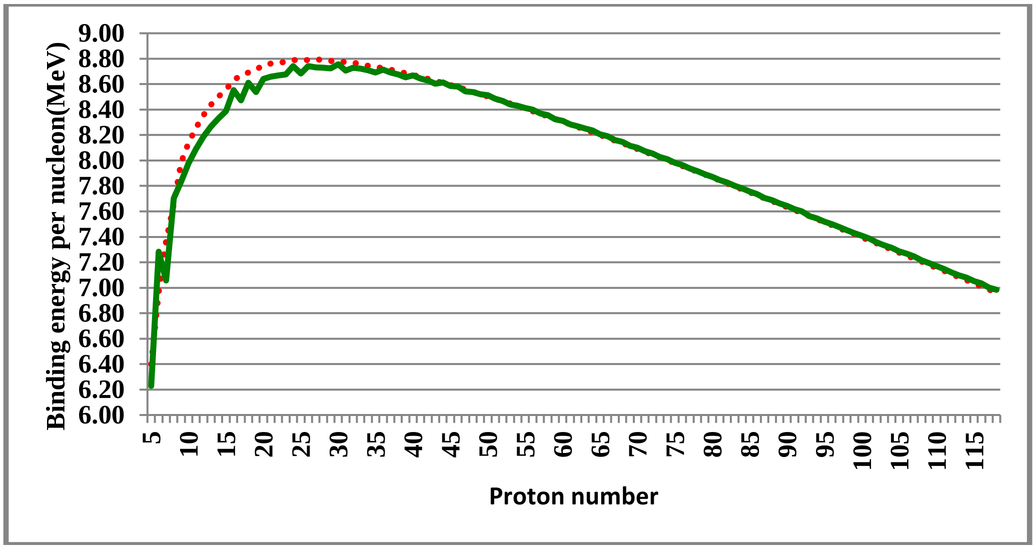
$$\text{where } \begin{cases} (m_n - m_p)/m_e \cong 2.531 \\ 3.531 \cong 1 + \left[(m_n - m_p)/m_e\right] \end{cases}$$

Thus, binding energy can be fitted with,

$$B_{A_s} \cong \left\{A_s - \left(\frac{kA_s Z}{2.531} + 3.531\right)\right\} \times 10.09 \text{ MeV} \quad (27)$$

See the following figure 1. Dotted red curve plotted with relations (19) and (27) can be compared with the green curve plotted with the standard semi empirical mass formula (SEMF). For medium and heavy atomic nuclides, fit is excellent. It seems that some correction is required for light atoms.

Figure 1: Binding energy per nucleon close to stable mass numbers of Z = 5 to 118

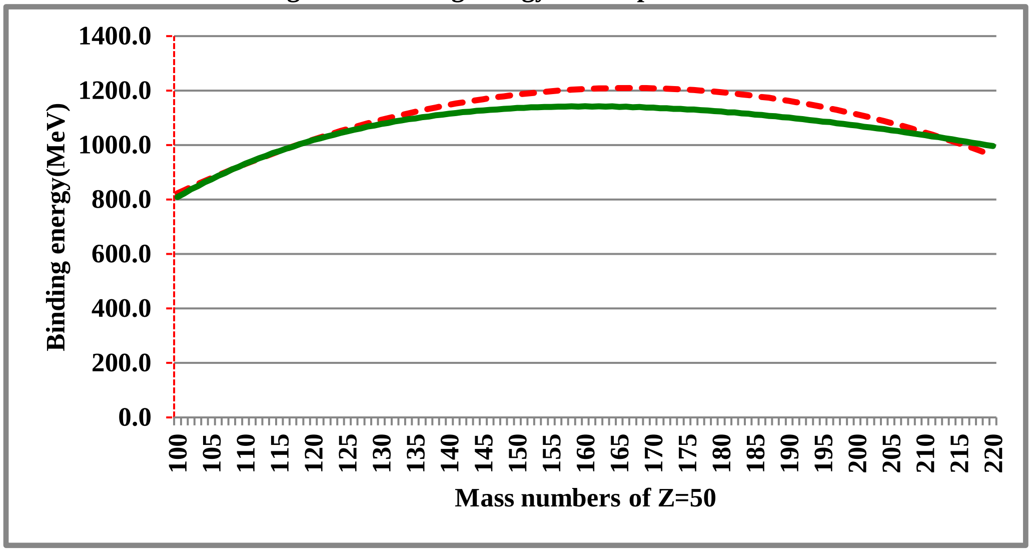


With trial and error, we have developed a third term of the form $\left[(A_s - A)^2 / A_s\right] \times 10.09$ MeV. Using this term, approximately, it is possible to fit the binding energy of isotopes in following way.

$$B_A \cong \left\{\left[A - \left(\frac{kAZ}{2.531} + 3.531\right)\right] - \left[\frac{(A_s - A)^2}{A_s}\right]\right\} \times 10.09 \text{ MeV} \quad (28)$$

See figure 2 for the estimated isotopic binding energy of Z=50. Dotted red curve plotted with relations (19) and (28) can be compared with the green curve plotted with SEMF. For Z=50 and A=100 to 130, with reference SEMF, there is no much more difference in the estimation of binding energy. With reference to SEMF, when $(A > 130)$, estimated binding energy seems to be increasing and when $(A \geq 212)$, estimated binding energy seems to be decreasing rapidly. It needs further study and refinement.

Figure 2: Binding energy of isotopes of Z=50



9. Understanding neutron life time with four gravitational constants

One of the key objectives of any unified description is to simplify or eliminate the complicated issues of known physics. In this context, in a quantitative approach, we noticed that, the four gravitational constants play a crucial role in understanding and estimating neutron life time. The following three strange relations can be given some consideration.

$$t_n \approx \left(\frac{G_e}{G_w}\right)\left(\frac{G_e m_n^2}{G_w\left(m_n - m_p\right)c^3}\right) \approx 874.94 \text{ sec} \tag{29}$$

$$t_n \approx \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_n^2}{\left(m_n - m_p\right)c^3}\right) \approx 896.45 \text{ sec} \tag{30}$$

Considering the geometric mean of relations (29) and (30), it is possible to show that,

$$t_n \cong \sqrt{\frac{G_s}{G_w}\sqrt{\frac{G_e}{G_N}}}\left(\frac{G_e m_n^2}{\left(m_n - m_p\right)c^3}\right) \cong 885.63 \text{ sec} \tag{31}$$

Relation (31) seems to constitute all the four gravitational constants. It needs further study.

10. Nuclear charge radii

As per the current literature [34], nuclear charge radii can be expressed with the following formulae.

$$R_c \cong \left\{1+\left[0.015\left(\frac{N-(N/Z)}{Z}\right)\right]\right\}Z^{1/3}\times 1.245 \text{ fm} \tag{32}$$

$$R_c \cong \left\{1-0.349\left(\frac{N-Z}{N}\right)\right\}N^{1/3}\times 1.262 \text{ fm} \tag{33}$$

$$R_c \cong \left\{1-\left[0.182\left(\frac{N-Z}{A}\right)\right]+\frac{1.652}{A}\right\}A^{1/3}\times 0.966 \text{ fm} \tag{34}$$

Our earlier proposed relation is,

$$R_{(Z,A)} \cong \left\{Z^{1/3}+\left(\sqrt{Z(A-Z)}\right)^{1/3}\right\}\left(\frac{G_s m_p}{c^2}\right) \tag{35}$$

Based on these relations and by considering the charge radii of stable atomic nuclides, R_0 and G_s can be estimated/fitted.

11. Discussion

1) With reference to G_s , the three atomic gravitational constants can be addressed with the following relations.

$$G_w \cong \frac{G_s^2 m_e^2}{\hbar c} \tag{36}$$

$$G_e \cong \frac{\hbar^2 c^2}{G_s m_p m_e^3} \tag{37}$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{10}\frac{G_s^2 m_e^2}{\hbar c} \tag{38}$$

2) We are working on understanding the direct of role of G_N in nuclear physics. Two simple relations seem to be,

$$G_F \cong \left[\left(G_e m_p^2\right)^2\left(G_N m_p^2\right)\right]^{\frac{1}{3}}\left(\frac{2G_s m_p}{c^2}\right)^2 \tag{39}$$

$$m_p \cong \left[\frac{\hbar c m_e^2}{\left(G_e^2 G_N\right)^{\frac{1}{3}}}\right]^{\frac{1}{4}} \tag{40}$$

3) In an alert native approach, it is very interesting to note that,

$$\frac{G_w}{G_s} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{G_e m_p^2}{\hbar c}\right)^{2/3}\left(\frac{G_N m_p^2}{\hbar c}\right)^{1/3} \tag{41}$$

$$\hbar c \cong 16\pi^4\left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e^2}\right)^2\left(G_e^2 G_N\right)^{1/3} m_e^2 \tag{42}$$

4) By considering the actual binding energy of stable atomic nuclides and by considering relation (27), magnitudes of $\frac{e_s^2}{8\pi\varepsilon_0\left(G_s m_p/c^2\right)} \cong \left(\frac{1}{\alpha_s}\right)\frac{e^2}{8\pi\varepsilon_0\left(G_s m_p/c^2\right)}$ and G_s can be estimated.
5) By considering Fermi's weak coupling constant and relations (11) and (13), magnitude of G_s can also be estimated.

12. Conclusion

With further study, a practical model of materialistic quantum gravity with possible physics can be developed and thereby magnitude of the Newtonian gravitational constant can be estimated in theoretical and semi experimental approaches bound to Fermi scale.

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