On the Role of Newtonian Gravitational Constant in Estimating Proton-Electron Mass Ratio and Baryon Mass Spectrum

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Abstract: *To understand the strong interaction, from 1974 to 1993, Tennakone, De Sabbata, Gasperini, Abdus Salam, Sivaram and K.P. Sinha [1-4] tried to introduce a large nuclear gravitational coupling constant. To understand the weak interactions, in 2013, Roberto Onofrio [5] introduced a large electroweak gravitational coupling constant. In our 2011 and 2012 papers [6,7] and recently published papers [8-18], we introduced a very large electromagnetic gravitational coupling constant. In this paper, with respect to the three atomic gravitational coupling constants and proton-electron mass ratio, we propose a simple relation for estimating the Newtonian gravitational constant. By refining the relation with reference to a model of baryons discrete mass spectrum and Penrose mechanism of energy extraction from a black hole, proton-electron mass ratio can be fitted with a model relation of the form,* $\frac{m_p}{m_e} \cong \left(1-\frac{1}{\sqrt{2}}\right)^{-1}\left(\frac{\hbar c}{G_N m_p^2}\right)^{1/14}$ *where* G_N *is the Newtonian gravitational constant. Estimated* $\left(m_p/m_e\right)$ *is 9.277 ppm higher than the CODATA-2014* $\left(m_p/m_e\right)$ *value and needs further investigation with respect to CODATA-2014* G_N *value. Proceeding further, we noticed a common relation for interaction range,* $r_x \approx \left(M_x/m_p\right)\sqrt{G_x \hbar/c^3}$ *where* M_x, m_p, G_x *represent the characteristic mass of interaction, proton mass and characteristic gravitational constant respectively.*

Keywords: *Four gravitational constants; Proton-Electron mass ratio; Interaction range; Baryon mass spectrum;*

1. INTRODUCTION

Even though celestial objects that show gravity are confirmed to be made up of so many atoms, so far scientists could not find any relation in between gravity and the atomic interactions. It clearly indicates that, something is missing from the net and needs a review at basic level. To understand the mystery, we propose the following bold concept.

Bold idea: The four basic interactions can be allowed to have four different gravitational constants.

With this concept, it seems possible to have many applications. We have discussed them in our earlier publications [8-18]. Main advantage is that, Newtonian gravitational constant can be estimated in a *verifiable approach*. We appeal that, by considering our bold idea [19,20], it may be possible to understand the combined role of the four gravitational constants in understanding the vector and tensor nature of fundamental forces and their interaction ranges.

2. QUANTITATIVE *REFERENCE* RELATIONS

Let, Newtonian gravitational constant = G_N

Electromagnetic gravitational constant= G_e

Nuclear gravitational constant= G_s

Weak gravitational constant = G_w

The following set of four semi empirical relations can be considered as REFERENCE relations. Interesting point to be noted is that, the four relations are interconnected with Proton-Electron mass ratio and need further investigation.

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

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

$$\frac{m_p}{m_e} \cong \frac{G_s^3}{G_w^2 G_e} \quad (3)$$

$$\frac{m_p}{m_e} \cong \left(\frac{G_w}{G_N}\right)^{\frac{1}{10}} \quad (4)$$

Based on these first three relations,

$$G_e \cong 2.374335\times10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$
$$G_s \cong 3.329561\times10^{28}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$
$$G_w \cong 2.909745\times10^{22}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

3. QUANTITATIVE AND QUALITATIVE INTERPRETATION

We would like to appeal that, $(\hbar c)$ can be considered as a compound physical constant. It can be addressed with the following relations.

$$\left.\begin{array}{l} A)\ \hbar c \cong \left(\dfrac{G_w}{G_s}\right) G_e m_p m_e \\ B)\ \hbar c \cong \sqrt{\left(G_s m_p m_e\right)\left(G_e m_e^2\right)} \\ C)\ \hbar c \cong \dfrac{\left(G_e^2 G_N\right)^{1/3} m_p^4}{m_e^2} \end{array}\right\} \quad (5)$$

It needs further investigation.

4. TO ESTIMATE THE NEWTONIAN GRAVITATIONAL CONSTANT IN VERIFIABLE APPROACH

We would like to suggest that,

A) In a direct approach, based on relations (1) to (4),

$$\begin{aligned} G_N &\cong \left(\frac{m_e}{m_p}\right)^{14}\left(\frac{16\pi^4 \hbar c}{\alpha^2 m_p^2}\right) \\ &\cong 6.679855429 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \end{aligned} \quad (6)$$

It is 865 ppm higher than the CODATA-2014 recommended value and needs further investigation.

B) In a verifiable approach,

a) Based on relations (1) and (2), (G_e, G_s) can be estimated.

b) With reference to CODATA-2014 recommended G_N and based on relation (4), G_w can be estimated.

c) By inserting the values of (G_e, G_s, G_w) in relation (3), $\left(\frac{m_p}{m_e}\right)$ can be estimated.

d) Calculating the %error in the estimated (m_p/m_e), error in CODATA-2014 G_N can be reviewed.

$$\frac{m_p}{m_e} \cong \left\{\frac{4\pi^2}{\alpha}\sqrt{\frac{\hbar c}{G_N m_p^2}}\right\}^{\frac{1}{7}} \quad (7)$$

Estimated $(m_p/m_e) \cong 1836.266122$ is 62 ppm higher than the CODATA recommended $(m_p/m_e) \cong 1836.152674$.

5. COMMON FORMULA FOR INTERACTION RANGE

The basic question to be answered is: How do the invoked four gravitational constants address the issues pertaining to vector forces of electromagnetism, tensor forces of gravity and vector-axial vector forces of weak interaction and gluons of strong interaction? In this context, 'Range of four interactions' can be expressed with a model relation of the form,

$$r_x \approx \left(M_x/m_p\right)\sqrt{G_x \hbar / c^3} \quad (8)$$

where M_x, m_p, G_x represent the characteristic mass of interaction, proton mass and characteristic gravitational constant respectively. As most of the atomic matter is characterised by protons, this relation can be given some consideration.

a) Strong interaction range,

$$r_s \approx \sqrt{G_s \hbar / c^3} \approx 0.361 \times 10^{-15}\ \text{m} \quad (9)$$

b) Weak interaction range,

$$\begin{aligned} r_w &\approx \left(80400\ \text{MeV}/938.272\ \text{MeV}\right)\sqrt{G_w \hbar / c^3} \\ &\approx 2.892 \times 10^{-17}\ \text{m} \end{aligned} \quad (10)$$

c) Electromagnetic interaction range at atomic level,

$$\begin{aligned} r_{em} &\approx \left(931.5\ \text{MeV}/938.272\ \text{MeV}\right)\sqrt{G_e \hbar / c^3} \\ &\approx 9.57 \times 10^{-12}\ \text{m} \approx 9.57\ \text{pm} \end{aligned} \quad (11)$$

d) Gravitational interaction range for Sun,

$$\begin{aligned} r_{sun} &\approx \left(2.0\times10^{30}\text{kg}/1.673\times10^{-27}\text{kg}\right)\sqrt{G_N \hbar / c^3} \\ &\approx 1.933 \times 10^{22}\ \text{m} \end{aligned} \quad (12)$$

6. ROUGH ESTIMATION OF BARYONS DISCRETE MASS SPECTRUM

Based on relation (7), baryon mass spectrum can be fitted and estimated [21,22]. Numerically, we noticed that,

$$\left\{\frac{4\pi^2}{\alpha}\right\}^{\frac{1}{7}} \cong 3.414393 \cong 2 + \sqrt{2} \quad (13)$$

Based on this observation, approximately baryons discrete mass spectrum can be fitted with the following simple relation.

$$\left.\begin{aligned} \left[m_{Bay}c^2\right]_n &\cong \left(n+\sqrt{n}\right)\left\{\sqrt{\frac{\hbar c}{G_N m_p^2}}\right\}^{1/7} m_e c^2 \\ &\cong \left(n+\sqrt{n}\right) \times 537.8 \times m_e c^2 \\ &\cong \left(n+\sqrt{n}\right) \times 274.82\ \text{MeV} \\ &\text{where, } n = 1, 2, 3, 4, .. \end{aligned}\right\} \quad (14)$$

It may be noted that, vector sum of (n) and $(\sqrt{n})$ is $\sqrt{n^2+n} \cong \sqrt{n(n+1)}$. At $n = 1$,

$$\left[m_{Bay}c^2\right]_{n=1} \cong 2\times 274.82 \text{ MeV} \\ \cong 549.63\text{MeV} \cong \sqrt{\frac{\hbar c^5}{G_s}} \cong 546.62 \text{ MeV} \tag{15}$$

Another interesting idea is that, sublevels can be estimated with the following relation.

$$\left[m_{Bay}c^2\right]_{(n,l)} \cong \left(n+\sqrt{l}\right)\times 274.82 \text{ MeV} \\ \text{where, } l = 1,2,3,..(n-1) \tag{16}$$

With reference to $\sqrt{\hbar c^5/G_s}$ and in a simplified form [15], considering the case of two colliding protons,

$$\left.\begin{array}{l}\left[m_{Bay}c^2\right]_n \cong \left(n+\sqrt{n}\right)\alpha^{1/2}\alpha_s^{-1/4}\left(2m_pc^2\right) \\ \text{where}\begin{cases}\alpha \cong \text{Fine structure ratio and} \\ \alpha_s \cong \text{Strong coupling constant}\end{cases}\end{array}\right\} \tag{17}$$

$$\left[m_{Bay}c^2\right]_{(n,l)} \cong \left(n+\sqrt{l}\right)\alpha^{1/2}\alpha_s^{-1/4}\left(2m_pc^2\right) \tag{18}$$

Quantitatively,

$$\left.\begin{cases}2\alpha_s^{-1/4} \cong \alpha^{-1/4} \quad \text{and} \\ \alpha^{1/2}\left(2\alpha_s^{-1/4}\right) \cong \alpha^{1/4} \cong \left(1-\frac{1}{\sqrt{2}}\right) \cong 0.2929\end{cases}\right\} \tag{20}$$

With reference to Penrose mechanism of maximum energy that can be extracted from a massive rotating black hole [23],

$$\left[m_{Bay}c^2\right]_n \cong \left(n+\sqrt{n}\right)\left[\left(1-\frac{1}{\sqrt{2}}\right)\left(m_pc^2\right)\right] \tag{21}$$

$$\left[m_{Bay}c^2\right]_{(n,l)} \cong \left(n+\sqrt{l}\right)\left[\left(1-\frac{1}{\sqrt{2}}\right)\left(m_pc^2\right)\right] \tag{22}$$

See Table 1 for the approximately estimated baryons discrete mass spectrum.

Table 1: *Baryons discrete mass spectrum*

(n)	$(\sqrt{n})$	$(n+\sqrt{n})$	$\left[m_{Bay}c^2\right]_n$ MeV
1	1.00	2.00	549.6
2	1.41	3.41	**938.3**
3	1.73	4.73	**1300.5**
4	2.00	6.00	**1648.9**
5	2.24	7.24	1988.6
6	2.45	8.45	2322.1
7	2.65	9.65	**2650.8**
8	2.83	10.83	2975.9
9	3.00	12.00	3297.8
10	3.16	13.16	**3617.3**
11	3.32	14.32	3934.5
12	3.46	15.46	4249.8
13	3.61	16.61	4563.5
14	3.74	17.74	4875.8
15	3.87	18.87	5186.7
16	4.00	20.00	5496.4
17	4.12	21.12	**5805.1**
18	4.24	22.24	**6112.7**
19	4.36	23.36	6419.5
20	4.47	24.47	6725.4

In our earlier published papers[24,25], we proposed that, with reference to Super Symmetry, fermion-boson mass ratio is very close to 2.26. Based on this idea and considering the combination of two baryons, meson mass spectrum can be estimated with the following relation.

$$\left.\begin{array}{l}\left[m_{Mes}c^2\right]_n \cong \left(n+\sqrt{n}\right)\left[\left(1-\frac{1}{\sqrt{2}}\right)\left(\frac{2m_pc^2}{2.26}\right)\right] \\ \cong 0.885*\left(n+\sqrt{n}\right)121.7 \text{ MeV} \\ \text{where, } \frac{\text{Fermion mass}}{\text{Boson mass}} \approx 2.26\end{array}\right\} \tag{23}$$

See Table 2 for the approximately estimated mesons discrete mass spectrum.

Table 2: *Mesons discrete mass spectrum*

(n)	$(\sqrt{n})$	$\left[m_{Bay}c^2\right]_n$ MeV	$\left[m_{Mes}c^2\right]_n$ MeV
1	2.00	549.6	486.4
2	3.41	938.3	830.4
3	4.73	1300.5	1150.9
4	6.00	1648.9	1459.3
5	7.24	1988.6	1759.9
6	8.45	2322.1	2055.0
7	9.65	2650.8	2346.0
8	10.83	2975.9	2633.6
9	12.00	3297.8	2918.6
10	13.16	3617.3	3201.3
11	14.32	3934.5	3482.0
12	15.46	4249.8	3761.1
13	16.61	4563.5	4038.7
14	17.74	4875.8	4315.0
15	18.87	5186.7	4590.2
16	20.00	5496.4	4864.3
17	21.12	5805.1	5137.5
18	22.24	6112.7	5409.8
19	23.36	6419.5	5681.3
20	24.47	6725.4	5952.0

Considering quantum relations like $\left[n(n+1)\right]^{1/4}$ and $\left[\frac{n(n+1)}{2}\right]^{1/4}$, excited levels can also be estimated [24,25].

7. NEWTONIAN GRAVITATIONAL CONSTANT WITH RESPECT TO PENROSE ANALOGY OF PROTON

Based on relations (7), (14) and (21),

$$\frac{m_p}{m_e} \cong \left(1-\frac{1}{\sqrt{2}}\right)^{-1}\left(\frac{\hbar c}{G_N m_p^2}\right)^{1/14} \tag{24}$$

Estimated $\left(m_p/m_e\right)$ is 9.277 ppm higher than the CODATA-2014 $\left(m_p/m_e\right)$ and needs further investigation with respect to CODATA-2014 G_N.

$$G_N \cong \left[\left(1-\frac{1}{\sqrt{2}}\right)\frac{m_p}{m_e}\right]^{-14}\left(\frac{\hbar c}{m_p^2}\right) \quad (25)$$

$$\cong 6.674946866\times10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

This estimated value is 130 ppm higher than the CODATA-2014 recommended value [26]. At the same time, it seems to lie in between HUST-AAF-2018 result of $6.674484\times10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$ and BIPM-2014 result of $6.67554\times10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$. See Table 3 for the historical results [27-32] of G_N.

Table 3: *Various experimental values of* G_N

Experiment/Year	$G_N/10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$
NIST-1982	6.67248
TR&D-1996	6.6729
LANL-1997	6.67398
UWash-2000	6.674255
BIPM-2001	6.67559
UWup-2002	6.67422
MSL-2003	6.67387
HUST-2005	6.67222
UZur-2006	6.67425
HUST-2009	6.67349
JILA-2010	6.6726
BIPM-2014	**6.67554**
LENS-2014	6.67191
UCI-2014	6.67435
HUST-TOS-2018	6.674184
HUST-AAF-2018	**6.674484**

8. CONCLUSION

Relation (7) seems to have wide applications in low energy as well as high energy nuclear physics. By implementing four such gravitational constants in String theory models [33], it may be possible to explore the hidden unified physics connected with different forms of forces [1-4] and gap between nuclear scale and Planck scale. Proceeding further, theoretical value of G_N can be defined as a standard reference for future nuclear, atomic and gravitational experiments.

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