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Short communication

Final unification with three gravitational constants associated with nuclear, electromagnetic and gravitational interactions

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Abstract

By introducing two large pseudo gravitational constants assumed to be associated with strong and electromagnetic interactions, we make an attempt to combine the old Abdus Salam's 'strong gravity' concept with 'Newtonian gravity' and try to understand the constructional features of nuclei, atoms and neutron stars in a unified approach. From the known elementary atomic and nuclear physical constants, estimated magnitude of the Newtonian gravitational constant is (6.66 to 6.70) x10^{-11} $m^3/kg/sec^2$. Finally, by eliminating the proposed two pseudo gravitational constants, we inter-related the Newtonian gravitational constant, Fermi's weak coupling constant and Strong coupling constant, in a generalized approach.

Keywords: *Final Unification; Gravitational Constants Associated with Strong and Electromagnetic Interactions.*

1. Introduction

Even though 'String theory' models' [1], [2] are having a strong mathematical back ground and sound physical basis, they are failing in implementing the Newtonian gravitational constant in atomic and nuclear physics and thus seem to fail in developing a 'workable' model of final unification. It clearly indicates our lack of understanding and uncertain assumptions on which our current physics is being built up. The main issue is: to understand the basics of final unification from hidden, unknown and un-identified physics! Based on the old and ignored scientific assumption put forward by Nobel laureate Abdus Salam [3], we propose two large pseudo gravitational constants assumed to be associated with strong and electromagnetic interactions [4,5,6].With them, currently believed generalized physical constants like, proton-electron mass ratio, neutron life time, weak coupling constant, strong coupling constant, nuclear charge radius, root mean square radius of proton, Planck's constant, Bohr radius of hydrogen atom, molar mass constant, Avogadro number and Newtonian gravitational constant etc and concepts like nuclear binding energy, nuclear stability, nuclear charge radii and atomic radii can be reviewed in a unified approach. In addition, neutron star mass and radius can be understood with the ratio of nuclear to Newtonian gravitational constants.

2. Two basic assumptions of final unification

Assumption-1: Magnitude of the gravitational constant associated with the electromagnetic interaction is,

$$G_e \cong (2.375 \pm 0.002)\times 10^{37}\ \mathrm{m^3kg^{-1}sec^{-2}}$$

Assumption-2: Magnitude of the gravitational constant associated with the strong interaction is

$$G_s \cong (3.328 \pm 0.002)\times 10^{28}\ \mathrm{m^3kg^{-1}sec^{-2}}$$

Note: We chose (G_e, G_s) in such a way that,

$$\frac{m_p}{m_e} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{G_e m_e^2}{\hbar c}\right) \tag{1}$$

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

3. Relation between m_p and m_e

Based on the Planck mass, $M_{pl} \cong \sqrt{\hbar c/G_N}$

$$m_p \cong \left(\frac{G_N}{G_e}\right)^{1/6}\sqrt{M_{pl} m_e} \tag{3}$$

If nuclear Planck mass is defined as,

$$m_{npl} \cong \sqrt{\hbar c/G_s} \approx 546.7\ \mathrm{MeV/c^2},$$

$$m_e \cong \left(\frac{m_p^5 m_{npl}^2}{M_{pl}}\right)^{1/6} \cong \left(\left(\frac{G_N}{G_s}\right) m_{npl}^2 m_p^{10}\right)^{1/12} \tag{4}$$

$$m_p \cong \left(\frac{m_e^6 M_{pl}}{m_{npl}^2}\right)^{1/5} \cong \left(\left(\frac{G_s}{G_N}\right)\frac{m_e^{12}}{m_{npl}^2}\right)^{1/10} \quad (5)$$

$$\hbar \cong \left(\frac{G_s}{G_N}\right)\left(\frac{m_e}{m_p}\right)^{10}\left(\frac{G_s m_e^2}{c}\right) \quad (6)$$

4. To fix the magnitudes of G_s, G_e and G_N

It is possible to obtain the following relation.

$$h \cong \sqrt{\frac{m_p}{m_e}}\sqrt{\left(\frac{G_s m_p^2}{c}\right)\left(\frac{e^2}{4\pi\varepsilon_0 c}\right)} \quad (7)$$

Based on this relation [3],

$$G_s \cong \frac{4\pi\varepsilon_0 h^2 c^2 m_e}{e^2 m_p^3} \cong 3.329560807\times 10^{28}\ \frac{m^3}{kg.sec^2} \quad (8)$$

$$G_e \cong \left(\frac{e^2 m_p^2}{16\pi^3 \varepsilon_0 m_e^4}\right) \cong 2.374335471\times 10^{37}\ \frac{m^3}{kg.sec^2} \quad (9)$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{14}\left(\frac{4\pi\varepsilon_0}{e^2}\right)^2\left(\frac{2\pi h^3 c^3}{m_p^2}\right) \quad (10)$$

$$\cong 6.679856051\times 10^{-11}\ m^3 kg^{-1} sec^{-2}$$

5. To fit neutron life time and strong coupling constant

Let, t_n be the life time of neutron. Quantitatively it is possible to show that [7],

$$\frac{(m_n - m_p)}{m_n} \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_n}{c^3 t_n}\right) \quad (11)$$

where $\sqrt{\frac{G_e}{G_N}} \cong 5.96\times 10^{23} \approx$ Avogadro number.

$$t_n \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_n^2}{(m_n - m_p)c^3}\right) \approx 896 \text{ sec} \quad (12)$$

With reference to the Weak coupling constant G_F and the proposed G_s,

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{7/2} \frac{\sqrt{G_s G_F}}{2t_n (m_n - m_p)c} \quad (13)$$

If one is willing to define the strong coupling constant [7] as,

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

$$t_n \cong \sqrt{\frac{G_e}{G_N}}\sqrt{\frac{1}{\alpha_s}}\left(\frac{\hbar}{(m_n - m_p)c^2}\right) \cong \frac{303.42 \text{ sec}}{\sqrt{\alpha_s}} \quad (14)$$

If, $\alpha_s \cong 0.1185 \pm 0.0006$, $t_n \cong 881.422$ sec

$$G_N \cong \frac{1}{\alpha_s}\left(\frac{\hbar}{t_n (m_n - m_p)c^2}\right)^2 G_e \cong 6.6991\times 10^{-11}\ \frac{m^3}{kg.sec^2} \quad (15)$$

Where, $\alpha_s \cong 0.1185 \pm 0.0006$, $t_n \cong (880.3 \pm 1.1)$ sec.

6. To fit the nuclear charge radius and root mean square radius of proton

Nuclear charge radius can be expressed with the following relation.

$$R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.24\times 10^{-15}\ \text{m} \quad (16)$$

Root mean square radius of proton [7] can be expressed with the following relation.

$$R_p \cong \frac{\sqrt{2}G_s m_p}{c^2} \approx 0.876\times 10^{-15}\ \text{m} \quad (17)$$

Based on relations (16) and (17),

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{12}\left[\left(\frac{c^3 R_0^2}{4\hbar}\right) \text{Or} \left(\frac{c^3 R_p^2}{2\hbar}\right)\right] \quad (18)$$

7. Nuclear binding energy close to stable mass numbers.

It is noticed that,

$$\left.\begin{aligned} -\left(\frac{3}{5}\left[e^2/4\pi\varepsilon_0 R_p\right]\right) &\cong -0.986 \text{ MeV} \\ -\left(\frac{3}{5}\left[G_s m_p^2/R_p\right]\right) &\cong -398.0 \text{ MeV} \end{aligned}\right\} \quad (19)$$

Seem to represent the respective self-binding energies. Then for $(Z \geq 5)$, nuclear binding energy [8], [9] close to stable mass numbers can be expressed with,

$$(BE)_{As} \cong -\left[Z - \left(2 - \sqrt{\frac{Z}{30}}\right)\right]\sqrt{\left(\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 R_p}\right)\left(\frac{3}{5}\frac{G_s m_p^2}{R_p}\right)}$$
$$\cong -\left[Z - \left(2 - \sqrt{\frac{Z}{30}}\right)\right]\times(19.75 \text{ to } 19.8) \text{ MeV} \quad (20)$$

We are working on refining the ad-hoc expression $\left[Z - \left(2 - \sqrt{Z/30}\right)\right]$. See column-2 of table-1 prepared with 19.75 MeV. With this binding energy constant stable mass number A_s can be estimated with,

$$A_s \approx X + \left(Y^2 + Y\right) \quad (21)$$

$$\left.\begin{array}{l}\text{where, } X \approx \left(Z+\sqrt{\frac{Z}{30}}-2\right)\left(\frac{19.75 \text{ MeV}}{8.8 \text{ MeV}}\right) \\ \text{and } Y \approx \left[(X-2Z)^2/Z\right]\end{array}\right\}$$

Considering 8.8 MeV as the maximum binding energy per nucleon, X can be referred to the lowest possible imaginary stable mass number and $\left(A_s - X\right) \approx \left(Y^2 + Y\right)$

Corrections in estimated A_s :

If Z is even and estimated A_s is even,

$$\text{Corrected } A_s \text{ range} \cong \left\{\text{Estimated } A_s \pm 2\right\} \tag{22}$$

If Z is even and estimated A_s is odd,

$$\text{Corrected } A_s \text{ range} \cong \left\{\left(\text{Estimated } A_s - 1\right) \pm 2\right\} \tag{23}$$

If Z is odd and estimated A_s is odd,

$$\text{Corrected } A_s \text{ range} \cong \left\{\text{Estimated } A_s \pm 2\right\} \tag{24}$$

If Z is odd and estimated A_s is even,

$$\text{Corrected } A_s \text{ range} \cong \left\{\left(\text{Estimated } A_s - 1\right) \pm 2\right\} \tag{25}$$

Table 1: To Estimate Medium, Heavy and Super Heavy Atomic Nuclides and Their Binding Energy

Proton number	Estimated Binding energy close to A_s (MeV)	Estimated stable mass number with even-odd correction	Actual (stable and long living) isotopes
21	391.8	45 ±2	45
25	472.3	53 ±2	55
31	592.8	69 ±2	69,71
35	673.1	79 ±2	79,81
41	793.3	93 ±2	93
47	913.5	109 ±2	107,109
51	993.5	119 ±2	121,123
55	1073.5	131 ±2	133
59	1153.4	141 ±2	141
60	1173.4	144 ±2	142,144, 146, 143,145, 148,150
65	1273.3	159 ±2	159
69	1353.2	169 ±2	169
75	1473.0	187 ±2	187,185
81	1592.7	205 ±2	205,203
86	1692.4	220 ±2	222
92	1812.1	238 ±2	238,235
100	1971.6	262 ±2	257

In this table, estimated stable mass numbers can be understood with the following relation.

$$A_s \approx 2Z + k\left(2Z\right)^2 \approx Z + 0.0064Z^2 \tag{26}$$

$$\text{where, } k \cong \left(\frac{G_s m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_e m_e^2}\right) \cong 1.605\times10^{-3},$$

Quantitatively this relation can be compared with the computationally proposed relation (8) of reference [8] which takes the following form.

$$N_s \cong 0.968051Z + 0.00658803Z^2 \tag{27}$$

where N_s is the neutron number of a nucleus with atomic number Z on the line of beta stability. Based on 'mass number', relation (27) can also be expressed in the following form.

$$Z \approx \frac{\sqrt{4kA+1}-1}{4k} \tag{28}$$

where A is any mass number. This relation (28) can be compared with existing stability relation,

$$Z \approx \frac{A}{2+\left(a_c/2a_a\right)A^{2/3}} \tag{29}$$

where $\left(a_c/2a_a\right) \cong 0.0157$. Keeping 'workability' point of view and 'final unification' point of view, proposed two assumptions, can be recommended for further research and analysis.

8. To fit Fermi's weak coupling constant and Newtonian gravitational constant

To a great surprise, it is noticed that [7],

$$G_F \cong \left(\frac{m_e}{m_p}\right)^2 \hbar c R_0^2 \tag{30}$$

From above relations,

$$G_F \cong \left(\frac{m_e}{m_p}\right)^2 \left(\frac{4G_s^2 m_p^2 \hbar}{c^3}\right) \cong \left(\frac{4G_s^2 m_e^2 \hbar}{c^3}\right) \cong 1.44\times10^{-62} \text{ J.m}^3 \tag{31}$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{10} \left(\frac{G_F c^2}{4\hbar^2}\right) \cong 6.66\times10^{-11} \frac{\text{m}^3}{\text{kg.sec}^2} \tag{32}$$

where, $G_F \cong 1.1663787\times10^{-5}\left(\hbar c\right)^3 \text{ GeV}^{-2}$

9. Mass and radius of neutron star

Let $\left(M_{NS}, \text{R}_{\text{NS}}\right)$ represent mass and radius of neutron star [10], [11] respectively. It is noticed that,

$$\frac{G_N M_{NS} m_n}{\hbar c} \approx \sqrt{\frac{G_s}{G_N}} \tag{33}$$

$$M_{NS} \approx \sqrt{\frac{G_s}{G_N}}\left(\frac{\hbar c}{G_N m_n}\right) \approx 3.17 \text{ Solar mass} \tag{34}$$

$$\frac{R_{NS}}{\left(\sqrt{G_N \hbar/c^3}\right)} \approx \frac{G_s}{G_N} \tag{35}$$

$$R_{NS} \approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{\hbar G_N}{c^3}} \approx \sqrt{\frac{G_s}{G_N}}\sqrt{\frac{\hbar G_s}{c^3}} \approx 8.1 \text{ km} \rightarrow \frac{R_{NS}}{\sqrt{\hbar G_s/c^3}} \simeq \sqrt{\frac{G_s}{G_N}} \tag{36}$$

10. 'System of units' independent Avogadro number and Molar mass unit

If, atoms as a whole believed to exhibit electromagnetic interaction, then both molar mass constant and Avogadro number can be understood with:

$$G_e \left(m_{atom}\right)^2 \cong G_N \left(M_{mole}\right)^2 \tag{37}$$

where, m_{atom} is the unified atomic mass unit and M_{mole} is the molar mass unit or gram mole. If so,

$$\frac{M_{mole}}{m_{atom}} \cong \sqrt{\frac{G_e}{G_N}} \cong \text{Avogadro number} \tag{38}$$

where $\sqrt{\frac{G_e}{G_N}} \cong 5.96\times10^{23}$ and $\left(0.00099 > M_{mole} < 0.001\right)$ kg

$$M_{mole} \cong \sqrt{\frac{G_e}{G_N}} \times m_{atom} \tag{39}$$

11. To fit and understand the atomic radii

Considering the geometric mean of the two assumed gravitational constants associated with proton and 'atom as whole', atomic radii can be fitted in the following way. By following the periodic arrangement of atoms and their electronic arrangement, accuracy can be improved.

$$R_{atom} \cong A_s^{1/3} \sqrt{\left(\frac{2G_s m_n}{c^2}\right)\left(\frac{2G_e m_{atom}}{c^2}\right)} \cong A_s^{1/3} * 33.0 \text{ pico.meter} \tag{40}$$

where

$$\left.\begin{aligned} \left(\frac{2G_s m_n}{c^2}\right) &\cong 1.24\times10^{-15}\,\text{m}; \\ \left(\frac{2G_e m_{atom}}{c^2}\right) &\cong 8.776\times10^{-7}\ \text{m}; \end{aligned}\right\} \tag{41}$$

A_s is the stable mass number of the atom, m_n is the average mass of nucleon and m_{atom} is the unified atomic mass unit. Note that, this relation resembles the famous relation for estimating nuclear radius [12], [13]. See the following table-2.

Table.2: Estimated Atomic Radii

Proton number	Stable Mass number	Estimated atomic radii (pico meter)	Reference data [14] (pico meter)
1	1	33.0	31
6	12	75.6	76
16	32	104.8	105
27	57	127.0	126
28	62	130.6	124
29	63	131.3	132
30	66	133.4	122
40	90	147.9	175
47	107	156.7	145
60	142	172.2	201
70	172	183.5	187
81	203	193.9	145
89	227	201.3	215
92	238	204.5	196

12. Generalized relations

Based on the above relations and by eliminating the proposed two pseudo gravitational constants, we pulled-out the following two interesting relations.

Result-1: Proton-electron mass ratio,

$$\left(\frac{m_p}{m_e}\right) \cong \left(\frac{G_F}{\hbar c R_{pl}^2}\right)^{\frac{1}{10}} \cong \left(\frac{G_F c^2}{4G_N \hbar^2}\right)^{\frac{1}{10}} \tag{42}$$

where G_F is the Fermi's weak coupling constant and

$$R_{pl} \cong \frac{2G_N M_{pl}}{c^2} \cong 2\sqrt{\frac{G_N \hbar}{c^3}} \text{ where } M_{pl} \cong \sqrt{\frac{\hbar c}{G_N}}$$

Result-2: Strong coupling constant,

$$\alpha_s \cong \frac{4\hbar^3 m_e^2}{G_F m_p^4 c} \tag{43}$$

where α_s is the strong coupling constant.

Based on these two results,

$$\left(\frac{m_p}{m_e}\right) \cong \left(\frac{\hbar c}{\alpha_s G_N m_p^2}\right)^{\frac{1}{12}} \cong \left(\frac{1}{\alpha_s}\right)^{\frac{1}{12}} \left(\frac{\hbar c}{G_N m_p^2}\right)^{\frac{1}{12}} \tag{44}$$

$$\alpha_s G_F \cong \frac{4\hbar^3 m_e^2}{m_p^4 c} \tag{45}$$

$$G_F \cong \left(\frac{1}{\alpha_s}\right)\left\{\frac{4\hbar^3 m_e^2}{m_p^4 c}\right\} \cong \frac{1.659031433\times10^{-63}}{\alpha_s}\ \text{J.m}^3 \tag{46}$$

With reference to the recommended value of G_F ,

$$\alpha_s \cong \left\{\frac{4\hbar^3 m_e^2}{m_p^4 c G_F}\right\} \cong \frac{1.659031433\times10^{-63}}{1.435850984\times10^{-62}} \cong 0.115542236 \tag{47}$$

$$\alpha_s G_N \cong \left(\frac{m_e}{m_p}\right)^{12} \left(\frac{\hbar c}{m_p^2}\right) \tag{48}$$

$$G_N \cong \left(\frac{1}{\alpha_s}\right)\left\{\left(\frac{m_e}{m_p}\right)^{12}\left(\frac{\hbar c}{m_p^2}\right)\right\} \cong \frac{7.694773265\times10^{-12}}{\alpha_s}\ \text{m}^3.\text{kg}^{-1}\text{sec}^{-2} \tag{49}$$

With reference to the recommended value of G_N ,

$$\alpha_s \cong \left(\frac{m_e}{m_p}\right)^{12}\left(\frac{\hbar c}{G_N m_p^2}\right) \cong \frac{7.694773265\times10^{-12}}{6.67408\times10^{-11}} \cong 0.115293393 \tag{50}$$

Quantitatively, independent of the strong coupling constant, it is possible to show that,

$$G_F \cong \left(\frac{m_p}{m_e}\right)^{10}\left(\hbar c\left(\frac{2G_N M_{pl}}{c^2}\right)^2\right) \cong \left\{\left(\frac{m_p}{m_e}\right)^{10}\right\}\left(\frac{4G_N \hbar^2}{c^2}\right) \quad (51)$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{10}\left(\frac{G_F c^2}{4\hbar^2}\right) \quad (52)$$

From these relations, we would like to say that,

1) Quantum gravity plays a vital role in weak interactions.
2) By fixing the magnitude of G_N, from relation (51), magnitude of G_F can be estimated and from relation (50), magnitude of α_s can also be estimated.
3) By fixing the magnitude of G_F, from relation (52), magnitude of G_N can be estimated and from relation (47), magnitude of α_s can also be estimated.
4) With reference to the proposed relations, magnitude of α_s seems to be around 0.1153. The same conclusion can also be extracted from Particle data group's (PDG) review on Quantum chromodynamics [15]. See the following table-3.

Table 3: Magnitude of α_s Close To 0.1153

1	$\alpha_s\left(M_Z^2\right) = 0.1161^{+0.0041}_{-0.0048}$
2	$\alpha_s\left(M_Z^2\right) = 0.1151^{+0.0093}_{-0.0087}.$
3	$\alpha_s\left(M_Z^2\right) = 0.1148 \pm\ 0.0014(exp.) \pm\ 0.0018(PDF)^{+0.0050}_{-0.0000}$
4	$\alpha_s\left(M_Z^2\right) = 0.1134 \pm 0.0011,$
5	$\alpha_s\left(M_Z^2\right) = 0.1142 \pm 0.0023,$
6	$\alpha_s\left(M_Z^2\right) = 0.1151^{+0.0033}_{-0.0032}$
7	$\alpha_s\left(M_Z^2\right) = 0.1158 \pm 0.0035.$
8	$\alpha_s\left(M_Z^2\right) = 0.1154 \pm 0.0020.$
9	$\alpha_s\left(M_Z^2\right) = 0.1131^{+0.0028}_{-0.0022}$
10	$\alpha_s\left(M_Z^2\right) \cong 0.1156^{+0.0021}_{-0.0022}$
11	$\alpha_s\left(M_Z^2\right) \cong 0.1156^{+0.0041}_{-0.0034}$
12	$\alpha_s\left(M_Z^2\right) \cong 0.1151^{+0.0093}_{-0.0087}$

13. Discussion and conclusion

In an advanced and in a semi empirical approach, we proposed peculiar relations (1) to (52). Whether to 'consider them' or 'ignore them', we are leaving the decision to the readers and science community. But it is sure that in final unification point of view, at any 'one' stage of their serious research, one must develop such kind of relations by using which 'gravity' and 'microscopic physics' can be unified. From relations (21) and (32), estimated magnitude of the Newtonian gravitational constant seems to be $(6.66 \text{ to } 6.70)\times 10^{-11}\ \text{m}^3.\text{kg}^{-1}.\text{sec}^{-2}$.

Considering the wide applicable range of the proposed two assumptions, we are confident to say that, with further research and analysis, 'hidden and left over physics' can easily be explored. In this context, we would also like to stress the fact that, with current understanding of String theory [1,2] qualitatively or quantitatively, one cannot implement the Newtonian gravitational constant in microscopic physics. This 'drawback' can be considered as a characteristic 'inadequacy' of modern unification paradigm. Proceeding further, with reference to String theory models, proposed two pseudo gravitational constants and presented semi empirical relations can be given some consideration in developing a 'workable model' of 'final unification'.

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