Exploration

Fermi's Weak Coupling Constant & Newtonian Gravitational Constant in Light of Potential Final Unification

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Abstract

In early publications on potential final unification, the authors suggested that: 1) There exists a strong interaction elementary charge of magnitude, *es*~4.72058686E-19 C and squared ratio of electromagnetic and strong interaction charges is equal to the strong coupling constant; 2) Like quarks, the strong interaction elementary charge is experimentally undetectable and can be called as 'invisible elementary nuclear charge'; 3) There exists a gravitational constant associated with strong interaction, *Gs*~3.32956087E28 m3/kg/sec2; and 4) There exists a gravitational constant associated with electromagnetic interaction, *Ge*~2.374335472E37 m3/kg/sec2. Based on these concepts, the authors in this paper make an attempt to fit the magnitudes of Fermi's weak coupling constant, Fine structure constant and Newtonian gravitational constant in a unified approach.

Keywords: Final unification, Fermi's weak coupling constant, Newtonian gravitational constant.

1. Introduction

In the earlier publications[1,2,3,4] and references therein, the authors suggested and validated the role of two gravitational constants associated with strong and electromagnetic interactions. The authors strongly encourage the readers to go through the above references. Proceeding further, the authors also suggested and validated the role of a new elementary charge associated with nuclear physics and strong coupling constant [5,6]. In an integrated approach the authors also showed that, 'quantum of angular momentum' is a characteristic result of the combined effects of gravitational constants associated with proton and electron. In this paper, the authors made a bold attempt to fit the magnitude of the Fermi's weak coupling constant and Newtonian gravitational constant.

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2. Three basic assumptions of final unification

In the earlier publications [1,2,3,4] the authors proposed and established the following three assumptions.

Assumption-1: Magnitude of the gravitational constant associated with the electromagnetic interaction is, $G_e \cong 2.374335472 \times 10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$.

Assumption-2: Magnitude of the gravitational constant associated with the strong interaction is, $G_s \cong 3.32956087 \times 10^{28}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$.

Assumption-3: There exists a strong elementary charge, $e_s \cong \left(e_e/\sqrt{\alpha_s}\right) \cong 4.72058686 \times 10^{-19}$ C where e_s is the assumed strong interaction elementary charge, e_e is the currently believed electromagnetic elementary charge and α_s is the currently believed strong coupling constant. Like quarks, the strong interaction elementary charge is experimentally undetectable and can also be called as 'invisible elementary nuclear charge'.

3. Important results(taken from earlier publications)

Considering the following 10 semi empirical results one can understand and validate the role of the proposed three assumptions.

A) Ratio of rest mass of proton and electron: It can be understood as follows.

$$\left(\frac{m_p}{m_e}\right) \cong \left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e_e^2}\right) \Bigg/ \left(\frac{4\pi\varepsilon_0 G_s m_p^2}{e_s^2}\right)$$
$$\Rightarrow \frac{m_p}{m_e} \cong \left(\frac{G_e e_s^2}{G_s e_e^2}\right)^{\frac{1}{3}} \tag{1}$$

B) Strong coupling constant: It can be understood as follows.

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

C) Magnetic moment of proton: It can be understood as follows.

$$\mu_p \cong \frac{e_s \hbar}{2m_p} \tag{3}$$

D) Magnetic moment of neutron: It can be understood as follows.

$$\mu_n \cong \frac{e_s \hbar}{2m_n} - \frac{e_e \hbar}{2m_n} \cong \frac{\hbar}{2m_n}\left(e_s - e_e\right) \tag{4}$$

E) Nuclear charge radius: It can be understood as follows.

$$R_0 \cong \frac{2G_s m_p}{c^2} \tag{5}$$

F) Root mean square radius of proton: It can be understood as follows.

$$R_p \cong \frac{\sqrt{2}G_s m_p}{c^2} \tag{6}$$

G) Fine structure ratio: It can be understood as follows.

$$\alpha \cong \frac{e_s e_e}{4\pi\varepsilon_0 G_s m_p^2} \tag{7}$$

H) Reduced Planck's constant: It can be understood as follows.

$$\hbar \cong \left(\frac{e_e}{e_s}\right)\left(\frac{G_s m_p^2}{c}\right) \cong \sqrt{\frac{m_e}{m_p}}\sqrt{\left(\frac{G_s m_p^2}{c}\right)\left(\frac{G_e m_e^2}{c}\right)} \tag{8}$$

I) Bohr radius of electron: It can be understood as follows.

$$a_0 \cong \left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e_e^2}\right)\left(\frac{G_s m_p}{c^2}\right) \tag{9}$$

J) Planck's constant: It can be understood as follows.

$$h \cong \sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0 c}\right)\left(\frac{G_e m_e^2}{c}\right)} \cong \sqrt{\left(\frac{m_p}{m_e}\right)\left(\frac{e_e^2}{4\pi\varepsilon_0 c}\right)\left(\frac{G_s m_p^2}{c}\right)} \tag{10}$$

$$\text{If}\begin{cases} e \cong 1.602\ 176\ 565(35)\times 10^{-19}\ \text{C},\ \varepsilon_0 \cong 8.854187817\times 10^{-19}\ \text{F/m} \\ m_n \cong 1.674\ 927\ 471(21)\times 10^{-27}\ \text{kg},\ m_p \cong 1.672\ 621\ 777(74)\times 10^{-27}\ \text{kg} \\ m_e \cong 9.109\ 382\ 91(40)\times 10^{-31}\ \text{kg},\ \hbar \cong 1.054\ 571\ 726(47)\times 10^{-34}\ \text{J.sec.} \\ \alpha \cong 7.297\ 352\ 5698(24)\times 10^{-3} \end{cases}$$

From above relations,

$$\begin{cases} G_s \cong 3.32956087\times 10^{28}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_e \cong 2.374335472\times 10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \end{cases} \begin{cases} \alpha_s \cong 0.1151937095, \\ e_s \cong 4.72058686\times 10^{-19}\ \text{C} \end{cases} \begin{cases} R_0 \cong 1.239290976\times 10^{-15}\ \text{m}, \\ R_p \cong 0.87631105\times 10^{-15}\ \text{m} \end{cases}$$

4. Fitting & Understanding Fermi's weak coupling constant

According to Roberto Onofrio [7,8], weak interactions are peculiar manifestations of quantum gravity at the Fermi scale, and that the Fermi coupling constant is related to the Newtonian constant of gravitation. In his opinion, at atto-meter scale, Newtonian gravitational constant seems to reach a magnitude of $8.205\times10^{22}\text{m}^3\text{kg}^{-1}\text{sec}^{-2}$. With reference to the proposed assumptions, quantitatively it is noticed that,

$$\left(\frac{m_p}{m_e}\right)\left(\frac{G_s^2}{G_e}\right)\cong 8.573153693\times10^{22}\text{m}^3\text{kg}^{-1}\text{sec}^{-2} \tag{11}$$

This magnitude is very close to the magnitude as suggested by Roberto Onofrio. Proceeding further, quantitatively the famous Fermi's weak coupling constant can be fitted with the following relation.

$$\begin{aligned} F_W &\cong 4\left(\frac{e_e}{e_s}\right)\left(\frac{m_p}{m_e}\right)\left(\frac{\hbar}{c}\right)^2\left(\frac{G_s^2}{G_e}\right) \\ &\cong 1.44021005\times10^{-62}\ \text{m}^5\text{kg sec}^{-2} \end{aligned} \tag{12}$$

This can be compared with the recommended [5,6] value of F_W. Here, factor 4 can be understood in the following way. When distance between two protons is close to $R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.239290976\ \text{fm}$, gravitational force of attraction between them can be expressed as,

$$\frac{G_s m_p m_p}{R_0^2} \cong \frac{G_s m_p^2}{R_0^2} \cong \left(\frac{c^4}{4G_s}\right) \tag{13}$$

Based on this idea and with respect to electron-proton mass ratio, F_W can be expressed in the following way.

$$\begin{aligned} F_W &\cong \left(\frac{e_e}{e_s}\right)\left(\frac{m_e}{m_p}\right)^2\left(G_s m_p^2\right)^2\left(\frac{G_s m_p^2}{R_0^2}\right)^{-1} \\ &\cong \left(\frac{e_e}{e_s}\right)\left(\frac{m_e}{m_p}\right)^2\left(G_s m_p^2\right)^2\left(\frac{c^4}{4G_s}\right)^{-1} \\ &\cong \left(\frac{e_e}{e_s}\right)\frac{\left(G_s m_p^2\right)\left(G_s m_e^2\right)}{\left(c^4/4G_s\right)} \\ &\cong 1.44021005\times10^{-62}\ \text{m}^5\text{kg sec}^{-2} \end{aligned} \tag{14}$$

On further simplification,

$$F_W \cong \left(\frac{e_e}{e_s}\right)\left(G_s m_e^2 R_0^2\right) \cong \sqrt{\alpha_s}\left(G_s m_e^2 R_0^2\right) \tag{15}$$

It may be noted that, this relation is free from all numerical factors and accuracy mainly depends on $\left[\sqrt{\alpha_s} \text{ or } \left(\frac{e_e}{e_s}\right)\right]$ and R_0. It is for further study.

5. Fitting the magnitude of the Newtonian gravitational constant

It may be noted that, fitting the gravitational constant with elementary physical constants is a very challenging issue. G. Rosi et al say [9]: "There is no definitive relationship between G_N and the other fundamental constants, and there is no theoretical prediction for its value, against which to test experimental results. Improving the precision with which we know G_N has not only a pure metrological interest, but is also important because of the key role that G_N has in theories of gravitation, cosmology, particle physics and astrophysics and in geophysical models".

In this context, the authors would like to stress the fact, with currently available standard theoretical models, it may not be possible to fit and verify the Newtonian gravitational constant with elementary physical constants. With the following semi empirical relations and with further research, in a verifiable approach, it is certainly possible to explore the back ground physics of the role of the Newtonian gravitational constant.

Method 1: In a semi empirical approach it is noticed that,

$$G_N \approx \left(\frac{m_e}{m_p}\right)\left(\frac{G_s^5}{G_e^4}\right) \approx 7\times10^{-11} \text{ m}^3\text{kg}^{-1}\text{sec}^{-2}. \tag{16}$$

With reference to the recommended and experimental values of the Newtonian gravitational constant, with trial-error , it is noticed that,

$$\begin{aligned}&\left(\frac{G_s^5}{G_e^4 G_N}\right)-\left(\frac{m_p}{m_e}\right) \cong \left(1+\frac{1}{\alpha_s}\right)\\ &\to G_N \cong 6.671711363\times10^{-11} \text{ m}^3\text{kg}^{-1}\text{sec}^{-2}.\end{aligned} \tag{17}$$

This value of G_N can be compared with the recent experimental result [9,10] obtained from cold atoms, $G_N \cong (6.67191 \pm 0.00099) \times10^{-11} \text{ m}^3\text{kg}^{-1}\text{sec}^{-2}$.

Method 2: In a semi empirical approach it is also noticed that,

$$\begin{aligned}&\ln\left(\frac{G_s^4}{G_e^2 G_N^2}\right) \approx \ln\left[\left(\frac{G_s^2}{G_e^2}\right)\left(\frac{G_s^2}{G_N^2}\right)\right] \approx \frac{1}{\alpha}\\ &\to G_N \cong 8.170386042\times10^{-11} \text{ m}^3\text{kg}^{-1}\text{sec}^{-2}.\end{aligned} \tag{18}$$

With reference to the recommended and experimental values of the Newtonian gravitational constant, with trial-error, it is noticed that,

$$\ln\left(\frac{2G_s^4}{3G_e^2G_N^2}\right) \cong \frac{1}{\alpha} \tag{19}$$

$$\begin{aligned} G_N &\cong \sqrt{\left[\exp\left(\frac{1}{\alpha}\right)\right]^{-1} \times \frac{2G_s^4}{3G_e^2}} \\ &\cong \sqrt{\tfrac{2}{3}}\sqrt{\left[\exp\left(\frac{1}{\alpha}\right)\right]^{-1}\left(\frac{G_s^4}{G_e^2}\right)} \\ &\cong 6.671092268\times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}. \end{aligned} \tag{20}$$

The ad-hoc fitting factor $(2/3)$ needs a detailed explanation and is for further study. Considering the proposed strong elementary charge, the factor $(2/3)$ can be expressed as, $\left(\frac{2}{3}\right) \cong 2\left(\frac{1}{3}\right) \cong 2\left(\frac{e_e}{e_s}\right)$. Above relation can be expressed as,

$$\ln\left(\left(\frac{e_e}{e_s}\right)\frac{2G_s^4}{G_e^2G_N^2}\right) \cong \frac{1}{\alpha} \tag{21}$$

and

$$\begin{aligned} G_N &\cong \sqrt{\left[\exp\left(\frac{1}{\alpha}\right)\right]^{-1} \times \left(\frac{e_e}{e_s}\right)\frac{2G_s^4}{G_e^2}} \\ &\cong \sqrt{2}\sqrt{\left[\exp\left(\frac{1}{\alpha}\right)\right]^{-1} \times \left(\frac{e_e}{e_s}\right)\left(\frac{G_s^4}{G_e^2}\right)} \\ &\cong 6.6731547264\times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}. \end{aligned} \tag{22}$$

6. Interrelation in between G_N and F_W

From above relations, it is possible to inter-relate the Newtonian gravitational constant and the Fermi's weak coupling constant in the following way.

Let,

$$\begin{aligned} k &\cong \left(\frac{G_s m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_e m_e^2}\right) \cong \left[\left(\frac{e_s}{m_p}\right)\Big/\left(\frac{e_e}{m_e}\right)\right] \\ &\cong 1.604637101\times 10^{-3} \end{aligned} \tag{23}$$

Clearly speaking, k is the ratio of specific charge of proton associated with e_s and specific charge of electron associated with e_e. Using this ratio, proton-neutron stability relation can be fitted directly in the following way [1,2].

$$A_s \cong 2Z + k(2Z)^2 \tag{24}$$

where A_s is the estimated stable mass number of Z.

With reference to factor $(2/3)$ and k,

$$\left.\begin{array}{l} \left[\left(\dfrac{e_s}{m_p}\right)\Big/\left(\dfrac{e_e}{m_e}\right)\right]^2\left(\dfrac{c}{\hbar}\right)^4\left(\dfrac{F_W^2c^4}{24\hbar^4G_N^2}\right) \cong \exp\left(\dfrac{1}{\alpha}\right) \\ \rightarrow \left(\dfrac{e_s}{e_e}\right)^2\left(\dfrac{m_e}{m_p}\right)^2\left(\dfrac{F_W^2c^4}{24\hbar^4G_N^2}\right) \cong \exp\left(\dfrac{1}{\alpha}\right) \\ \Rightarrow \left(\dfrac{1}{\alpha_s}\right)\left(\dfrac{m_e}{m_p}\right)^2\left(\dfrac{F_W^2c^4}{24\hbar^4G_N^2}\right) \cong \exp\left(\dfrac{1}{\alpha}\right) \end{array}\right\} \tag{25}$$

Interesting point to be noted is that, above relation (25) seems to constitute all the characteristic conventional physical constants that are assumed to be connected with final unification.

Combining relations (15) and (25), it is noticed that,

$$\begin{array}{l} \left(\dfrac{G_s}{G_N}\right) \cong \sqrt{24\exp\left(\dfrac{1}{\alpha}\right)}\left(\dfrac{m_p}{m_e}\right)\left[\dfrac{\hbar}{m_eR_0c}\right]^2 \\ \rightarrow G_N \cong \left\{\left[24\exp\left(\dfrac{1}{\alpha}\right)\right]^{-\frac{1}{2}}\left(\dfrac{m_e}{m_p}\right)\left[\dfrac{m_eR_0c}{\hbar}\right]^2\right\}G_s \\ \text{where } R_0 \cong (1.2395 \pm 0.0002)\ \text{fm} \end{array} \tag{26}$$

7. Conclusion

Even though 'String theory' and 'Quantum gravity' models are having a strong mathematical back ground and sound physical basis, both the models are failing in implementing the Newtonian gravitational constant in microscopic physics. At fundamental level, proposed assumptions and relations seem to play a vital role in understanding the basics of final unification. If one is willing to explore the possibility of incorporating the proposed assumptions either in String theory models or in Quantum gravity models, certainly, back ground physics assumed to be connected with proposed semi empirical relations can be understood and in near future, a 'workable' or 'practical' model of "everything" can be developed.

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