GRAVITATIONAL CONSTANT IN NUCLEAR INTERACTIONS

U. V. S. Seshavatharam
Honorary faculty, I-SERVE
Alakapuri, Hyderabad-35, India
e-mail: seshavatharam.uvs@gmail.com
Prof. S. Lakshminarayana
Dep. of Nuclear Physics, Andhra University
Visakhapatnam-03, India
e-mail: lnsrirama@yahoo.com

Abstract

Till today no atomic principle implemented the gravitational constant in nuclear physics. Considering the electromagnetic and gravitational force ratio of electron and proton a simple semi empirical relation is proposed for estimating the strong coupling constant. Obtained value is $\alpha_s \cong 0.117378409$. It is also noticed that $\alpha_s \cong \ln(r_U r_D)$ where r_U and r_D are the geometric ratios of Up and Down quark series respectively. It is noticed that proton rest mass is equal to $\left(\frac{1}{\alpha}+\frac{1}{\alpha_s}\right)\sqrt{UD}$. With reference to the the electromagnetic and gravitational force ratio of electron, 137 can be fitted at r_U and 128 can be fitted at r_D. Finally semi empirical mass formula energy constants are fitted.

Keywords: Classical gravitational constant, grand unification, electron rest mass, proton rest mass, strong coupling constant, fine structure constant, up quark series, down quark series, nucleon rest masses and semi empirical mass formula.

1 Introduction

Unification means : finding the similarities, finding the limiting physical constants, finding the key numbers, coupling the key physical constants, coupling the key physical concepts, coupling the key physical properties, minimizing the number of dimensions, minimizing the number of inputs and implementing the key physical constant or key number in different branches of physics. This is a very lengthy process. In all these cases observations, interpretations, experiments and imagination play a key role. The main difficulty is with interpretations and observations. Strong motivation, good reasoning, nature friendly concepts, simplicity and applicability are the most favourable and widely accepted qualities of any new model.

Stephen Hawking [1] - in his famous book- says: It would be very difficult to construct a complete unified theory of everything in the universe all at one go. So instead we have made progress by finding partial theories that describe a limited range of happenings and by neglecting other effects or approximating them by certain numbers. (Chemistry, for example, allows us to calculate the interactions of atoms, without knowing the internal structure of an atomic nucleus.) Ultimately, however, one would hope to find a complete, consistent, unified theory that would include all these partial theories as approximations, and that did not need to be adjusted to fit the facts by picking the values of certain arbitrary numbers in the theory. The quest for such a theory is known as 'the unification of physics'. Einstein spent most of his later years unsuccessfully searching for a unified theory, but the time was not ripe: there were partial theories for gravity and the electromagnetic force, but very little was known about the nuclear forces. Moreover, Einstein refused to believe in the reality of quantum mechanics, despite the important role he had played in its development.

2 About the gravitational constant

In Astronomy the only one available characteristic physical constant is the gravitational constant. Without completing the charge-mass unification or final unification: one cannot say, whether it is an 'input to the unification' or 'output of unification'. The same idea can be applied to the atomic physical constants also. Till today no atomic model implemented the gravitational constant in the atomic or nuclear physics. Then, whatever may be its magnitude, measuring its value from existing atomic principles is impossible. Its value was measured in the lab within a range of 1 cm to 1 meter only where as the observed nuclear size is 1.2 fermi. The main object of unification is to understand the massive origin of elementary particles, magnetic moments and their forces. Right now and till today 'string theory' with 4 + 6 extra dimensions not in a position to explain the unification of gravitational and non-gravitational forces. More clearly speaking it is not in a position to bring down the planck scale to the nuclear size.

Abdus Salam [2], David Gross [3] and Tilman Sauer [4] presented their views on Einstein's works in unification. As the culmination of his life work, Einstein wished to see a unification of gravity and electromagnetism as aspects of one single force. In modern language he wished to unite electric charge with the gravitational charge (mass) into one single entity. Further, having shown that mass the 'gravitational charge' was connected with space-time curvature, he hoped that the electric charge would likewise be so connected with some other geometrical property of space-time structure. Einsteins goal was to generalize general relativity to include electromagnetism. If one wishes to unify electroweak, strong and gravitational interactions it is a must to implement the classical gravitational constant G in the sub atomic physics. By any reason if one implements the planck scale in elementary particle physics and nuclear physics automatically G comes into subatomic physics.

We now have direct evidence for the unification of all forces dreamed by Einstein. Perhaps the most important feature of the extrapolation of the standard models forces is that the energy at which they appear to unify is very close, if not identical, to the point at which gravity becomes equally strong. This indicates that the next stage of unification should include, as Einstein expected, unification of the non-gravitational forces and gravity.

3 To fit the strong coupling constant α_s

Till today no atomic principle implemented the gravitational constant. Physicists say - if strength of strong interaction is unity, with reference to the strong interaction, strength of gravitation is 10^{-39}. Please note that in his large number hypothesis [5] Dirac suggested that ratio of cosmic size and classical radius of electron is the order of electromagnetic and gravitational force ratio of electron and proton. Such ideas are useful in understanding and developing grand unified ideas. It is noticed that electromagnetic and gravitational force ratio of electron and proton plays an interesting role in strong interaction. Semi empirically strong coupling constant can be expressed as

$$\frac{1}{\alpha_s} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_e m_p}\right)} - 1 \cong 8.519454331. \tag{1}$$

Here, m_e=mass of electron, m_p=mass of proton and G= gravitational constant. Thus $\alpha_s \cong 0.117378409$. This may be a coincidence or may be an indication of gravitational and non-gravitational unification.

PDG recommended value of the strong coupling constant in the year 2010 is $\alpha_s(m_Z) \cong 0.1184(7)$ and in the year 2007 [6-9] is $\alpha_s(m_Z) \cong 0.1176(20)$. Another crucial validation is provided by the successful comparison of the strong coupling constant obtained from lattice calculations. $\alpha_s(m_Z) = 0.1170 \pm 0.0012$, with the world average from other methods (in which a_s is determined by matching perturbative QCD predictions to collider results at high energies) $a_s(m_Z) = 0.1185 \pm 0.0015$. Considering electromagnetic and gravitational force ratio of electron only, α_s can be expressed as

$$\frac{1}{\alpha_s} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_e^2}\right)} - 1 \cong 8.906333251 \cong X_S \quad (say) \tag{2}$$

Thus $\alpha_s \cong 0.112279652$. Considering electromagnetic and gravitational force ratio of proton only, α_s can be expressed as

$$\frac{1}{\alpha_s} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_p^2}\right)} - 1 \cong 8.116171512. \tag{3}$$

Thus $\alpha_s \cong 0.123210801$. Considering electromagnetic and gravitational force ratio of electron and the charged weak boson $W^{\pm}$ α_s can be expressed as

$$\frac{1}{\alpha_s} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_e m_W}\right)} - 1 \cong 8.282741555. \tag{4}$$

Thus $\alpha_s \cong 0.120732971$. Considering electromagnetic and gravitational force ratio of charged weak boson $W^{\pm}$ only, α_s can be expressed as

$$\frac{1}{\alpha_s} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_W^2}\right)} - 1 \cong 7.614124627. \tag{5}$$

Thus $\alpha_s \cong 0.131334861$. How to interpret these relations? From equation (1) it is clear that : there exists a definite relation in between the gravitational constant and nuclear physical constants. By knowing the correct value of α_s, magnitude of the gravitational constant G can be obtained accurately. Authors are working in this new direction [10-17].

4 Up & down quarks and the strong coupling constant

In the previous published paper [10] it is suggested that Up, strange and bottom quarks are in one geometric series and Down, charm and top quarks are in another geometric series. Interesting idea is that: ratio of up quark mass and down quark mass is nothing but $sin\theta_W$.

$$\frac{U}{D} \cong sin\theta_W. \tag{6}$$

Up quark mass mass can be obtained as

$$\ln\left(\frac{Uc^2}{m_e c^2}\right) \cong \frac{1}{sin\theta_W}. \tag{7}$$

Up quark series geometric ratio is

$$r_U \cong \left(\frac{D}{U} \times \frac{D+U}{D-U}\right)^2. \tag{8}$$

If Down quark series is the 'second' generation series, its geometric ratio can be obtained as

$$r_D \cong \left(2 \times \frac{D}{U} \times \frac{D+U}{D-U}\right)^2 \cong 4r_U. \tag{9}$$

Experimental value of the strong coupling constant can be expressed as

$$\frac{1}{\alpha_s} \cong \ln\left(r_U r_D\right) \cong \ln\left(4r_U^2\right) \cong \ln\left(\frac{r_D^2}{4}\right). \tag{10}$$

From experiments if $\alpha_s \cong 0.118$, one can obtain the values of r_U and r_D. $r_U \cong 34.61$ and $r_D \cong 138.44$

4.1 To fit the fine structure ratio α

It is noticed that strength of electromagnetic interaction α, depends on the electromagnetic and gravitational force ratio of electron and Up and Down quark series geometric ratios. Semi empirically α corresponding to the up quark series geometric ratio can be expressed as

$$\frac{1}{\alpha} \cong 2X_S^2 - \left(r_U\right)^{\frac{1}{4}} X_S. \cong \frac{1}{\alpha_u} \cong 137.043 \cong 137.036 \tag{11}$$

Here $X_S \cong \sqrt{\ln\left(\frac{e^2}{4\pi\epsilon_0 G m_e^2}\right)} - 1 \cong 8.906333251$ and $2X_S^2 \cong 158.645544$. Similarly α corresponding to the down quark series geometric ratio can be expressed as

$$\frac{1}{\alpha} \cong 2X_S^2 - \left(r_D\right)^{\frac{1}{4}} X_S. \cong \frac{1}{\alpha_d} \cong 128.095 \tag{12}$$

Now the very important questions are : What is the role of $2X_S^2$ in nuclear physics ? and How to estimate the value of $sin\theta_W$? It is noticed that

$$sin\theta_W \cong \frac{1}{2}\sqrt{\frac{1}{2X_S^2\alpha}} \cong 0.4647 \tag{13}$$

4.2 Rest mass of nucleons

If $sin\theta_w \cong 0.4647$, Up quark rest energy $= Uc^2 \cong 4.395\ MeV$.
Down quark rest energy $= Dc^2 \cong 9.458\ MeV$. If so it is noticed that

$$\left[\frac{1}{\alpha} + \frac{1}{\alpha_s}\right] \times \sqrt{UD}\ c^2 \cong 938.15\ MeV \cong m_p c^2. \tag{14}$$

This can be compared with the rest mass of proton. This is a very interesting relation. Both the coupling constants are participating in fitting the rest mass of proton. It is also noticed that

$$\frac{\sqrt{UD}\ c^2}{m_n c^2 - m_p c^2} \cong \ln\left(\frac{m_p c^2}{\sqrt{UD} c^2}\right) \cong \ln\left[\frac{1}{\alpha} + \frac{1}{\alpha_s}\right]. \tag{15}$$

where m_n is the rest mass of neutron. In this way, semi empirically nucleon rest masses can be fitted.

4.3 Semi empirical mass formula energy constants

The number $2X_S^2$ plays a crucial role in nuclear proton-neutron stability in $\beta-$ decay as

$$A_S \cong 2Z + \frac{Z^2}{2X_S^2}. \tag{16}$$

Here A_S is the stable mass number of Z. Neutron and proton mass difference can be expressed as

$$m_n c^2 - m_p c^2 \cong \ln\left(\sqrt{2X_S^2}\right) m_e c^2. \tag{17}$$

Here m_n, m_p and m_e are the rest masses of neutron, proton and electron respectively.
Pairing energy constant of the semi empirical mass formula [18] can be expressed as

$$E_p \cong \frac{m_p c^2 + m_n c^2}{2X_S^2} \cong 11.84\ MeV. \tag{18}$$

Asymmetry energy constant of the semi empirical mass formula can be expressed as

$$E_a \cong 2E_p \cong \frac{m_p c^2 + m_n c^2}{X_S^2} \cong 23.68\ MeV. \tag{19}$$

Volume energy constant E_v can be expressed as

$$\frac{E_a}{E_v} - 1 \cong \sin\theta_W. \tag{20}$$

If E_s is the surface energy constant,

$$E_v + E_s \cong E_a + E_p. \tag{21}$$

$$\sqrt{\frac{E_a^2 E_s}{E_c^3}} \cong 2X_S^2. \tag{22}$$

where E_c is the coulomb energy constant. Thus E_v=16.17 MeV, E_s =19.35 MeV and $E_c = 0.755$ MeV. Surprisingly it is noticed that if $\sqrt{\frac{E_s^2 E_a}{E_c^3}} \cong 2X_S^2$, obtained $E_c \cong 0.708\ MeV$.

5 To fit the charged lepton rest masses

From the above discussion let us define a new number β as

$$\alpha\beta \cong \frac{1}{sin\theta_W} \cong \frac{1}{\alpha} \times \frac{D}{U}. \tag{23}$$

$$\beta \cong \frac{1}{\alpha sin\theta_W} \cong 2\sqrt{\frac{2X_S^2}{\alpha}} \cong 294.8908321. \tag{24}$$

With this number β and considering the semi empirical mass formula energy constants, charged lepton masses can be fitted accurately. Semi empirically it is noticed that

$$m_l c^2 \cong \gamma\left[E_c^3 + \left(n^2\beta\right)^n \times E_a^3\right]. \tag{25}$$

where m_l is the charged lepton rest mass at $n = 0, 1, 2$. γ is a coefficient, greater than $\left(\frac{E_s}{E_a}\right)^2 \cong 0.668$ and less than $\frac{E_v}{E_a} \cong 0.683$.

Clearly speaking accuracy depends on the accuracy of the energy constants E_c, E_v, E_s and E_a. If $\gamma \leq 0.675$,
At $n = 0$, $m_l c^2 \cong 0.5096$ MeV and can be compared with the rest mass of electron. Its experimental value is 0.510998922 MeV.
At $n = 1$, $m_l c^2 \cong 106.4$ MeV and can be compared with the rest mass of muon. Its experimental value is 105.658369 MeV.
At $n = 2$, $m_l c^2 \cong 1784.4$ MeV and can be compared with the rest mass of tau. Its experimental value is 1776.84 ±0.17 MeV.
At $n = 3$, $m_l c^2 \cong 42421.8$ MeV. By any reason if one is able to confirm the existence of the quantum number $n = 4$, a heavy charged lepton can be predicted close to 42422 MeV.

5.1 Applications of β in grand unification

Application-1

It is noticed that

$$\left(e^{\sqrt{\beta}}\right)^3 \cong \frac{M_P}{m_e} \cong \sqrt{\frac{\hbar c}{G m_e^2}}. \tag{26}$$

Here M_P is the planck mass and m_e is the electron rest mass. Above expression can be expressed as

$$\sqrt{\beta} \cong \frac{1}{3}\ln\left(\frac{M_P}{m_e}\right) \cong \frac{1}{6}\ln\left(\frac{\hbar c}{G m_e^2}\right) \cong 17.17594702. \tag{27}$$

Hence $\beta \cong 295.0131562$.

Application-2

$$(\alpha\beta)^2 \cong \frac{1}{sin^2\theta_W} \cong \ln\left[\ln\left(\frac{\hbar c}{G m_e^2}\right)\right]. \tag{28}$$

$$(\alpha\beta) \cong \frac{1}{sin\theta_W} \cong \ln\left[\ln\left(\frac{\hbar c}{G m_e^2}\right)\right] \cong 2.15296759. \tag{29}$$

$$\beta \cong \frac{1}{\alpha}\sqrt{\ln\left[\ln\left(\frac{\hbar c}{Gm_e^2}\right)\right]} \cong 295.0340661. \tag{30}$$

Application-3

It is also noticed that

$$\beta^2 \cong \frac{e^2}{4\pi\epsilon_0 N^2 G m_e^2}. \tag{31}$$

Here N is the Avogadro number. If $N \cong 6.022141793 \times 10^{23}$,

$$\beta \cong N\sqrt{\frac{4\pi\epsilon_0 G m_e^2}{e^2}} \cong 295.0606338. \tag{32}$$

Application-4

Another interesting application is that in Bohr's theory of Hydrogen atom,

$$-\frac{e^2}{4\pi\epsilon_0 R_0} \cong -\beta^2 \times \frac{e^2}{8\pi\epsilon_0 a_0}. \tag{33}$$

Here, $R_0 \cong 1.21$ fermi and a_0 is the Bohr radius. Clearly speaking, to a very good accuracy in Hydrogen atom, ratio of nuclear potential and total energy of electron is equal to β^2. Thus

$$\frac{a_0}{R_0} \cong \frac{\beta^2}{2}. \tag{34}$$

$$\hbar \cong \sqrt{\frac{N^2 G m_e^3 R_0}{2}}. \tag{35}$$

How to find the physics in these equations? All these relations are related with planck scale and the present nuclear size.

Application-5

It is noticed that

$$\alpha\beta \cong \frac{1}{\sin\theta_W} \cong \frac{1}{3}\ln\left(\frac{N^2 G m_e^2}{\hbar c}\right). \tag{36}$$

Application-6

Since by the definition $e^{\frac{1}{\sin\theta_W}} \cong \frac{Uc^2}{m_e c^2}$, it can be suggested that

$$\left(\frac{Uc^2}{m_e c^2}\right) \cong \left(\frac{N^2 G m_e^2}{\hbar c}\right)^{\frac{1}{3}} \cong \left(\frac{2N^2 G m_e}{c^2 R_0}\right)^{\frac{1}{6}}. \tag{37}$$

$$\frac{Dc^2}{Uc^2} \cong \frac{1}{3}\ln\left(\frac{N^2 G m_e^2}{\hbar c}\right) \cong \frac{1}{6}\ln\left(\frac{N^2 G m_e}{c^2 R_0}\right). \tag{38}$$

Thus $Uc^2 \cong 4.39288$ MeV and $DC^2 \cong 9.45072$ MeV.
$\sin\theta_W \cong \ln\left(\frac{U}{D}\right) \cong 0.464819509$. Up quark series geometric ratio is

$$r_U \cong \left(\frac{D}{U} \times \frac{D+U}{D-U}\right)^2 \cong 34.67360428. \tag{39}$$

Down quark series geometric ratio is

$$r_D \cong \left(2 \times \frac{D}{U} \times \frac{D+U}{D-U}\right)^2 \cong 138.6944171. \tag{40}$$

Strong coupling constant can be given as

$$\alpha_s \cong [\ln(r_U r_D)]^{-1} \cong (8.478251789)^{-1} \cong 0.117948844. \tag{41}$$

Proton rest mass can be expressed as

$$\left(\frac{1}{\alpha} + \frac{1}{\alpha_s}\right)\sqrt{UD}\, c^2 \cong 937.589\ MeV. \tag{42}$$

The nuclear weak force magnitude can be expressed as

$$F_W \cong \frac{c^4}{N^2 G}. \tag{43}$$

Characteristic nuclear strong force magnitude can be expressed as

$$F_S \cong \left[2\pi \ln\left(N^2\right)\right]^2 F_W. \tag{44}$$

Characteristic electroweak energy scale can be expressed as

$$E_W \cong \frac{F_S}{F_W}\, m_e c^2. \tag{45}$$

Conclusion

In grand unification program it is very important to couple the fundamental physical constants. In this direction authors made an attempt to couple the gravitational constant, strong coupling constant and the fine structure constant. Up & down quark masses and nucleon rest masses studied in a unified way. Finally an attempt is made to fit the semi empirical mass formula energy constants. This proposal may be given a chance in understanding grand unification.

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