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Applications of EM and Gravitational Force Strengths in Unification

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Abstract: By implementing the unified mass unit $M_c \cong \sqrt{e^2/4\pi\varepsilon_0 G}$, the authors made an attempt to fit and understand the key 'quantum' and 'nuclear' physical parameters. With M_C and by considering the electromagnetic and gravitational force ratio of proton and electron - the nuclear charge radius, the Planck's constant and the strong coupling constant can be fitted in a unified approach. Finally by considering the proton rest energy and the nuclear charge radius the authors made an attempt to fit the semi empirical mass formula energy coefficients and stable heavy elements in a very simple way.

Keywords: Gravity , Strong interaction, Unification, Nuclear charge radius, Planck's constant, Strong coupling constant, 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, concepts and properties, minimizing the number of dimensions and number of inputs. 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. At fundamental level understanding the observed new coincidences and confirming the observed coincidences seem to be a very tough job. Constructing semi empirical relations among the physical constants of various interdisciplinary branches of physics with all possible interpretations may help in resolving the issues. Which way/method is the best - will be decided by future experiments, observations and interpretations. As it is interconnected

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with all branches of physics, **semi empirical approach** seems be the easiest and shortcut way. It sharpens and guides human thinking ability in understanding the reality of unification. For any theoretical concept or mathematical model or semi empirical relation, 'workability' is more important than its inner beauty and 'workability' is the base of any semi empirical approach.

It is well known that e, c and G play a vital role in fundamental physics. With these three constants space-time curvature concepts at a charged particle surface can be studied. Similar to the Planck mass an interesting unified mass unit can be constructed in the following way.

$$\left(M_C\right)^{\pm} \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} \cong 1.859272\times 10^{-9}\ \text{Kg} \cong 1.042975\times 10^{18}\ \text{GeV/c}^2 \quad (1)$$

Note that $M_C \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}}$ plays a crucial role in microscopic physics as It was first introduced by the physicist George Johnstone Stoney [1]. He is most famous for introducing the term 'electron' as the 'fundamental unit quantity of electricity'. With this mass unit in unification program with a suitable proportionality it may be possible to represent the characteristic mass of any elementary charge. It can be considered as the seed of galactic matter or galactic central black hole. It can also be considered as the seed of any cosmic structure. If two such oppositely charged particles annihilates, a large amount of energy can be released. It is well assumed that free space is a reservoir for pair particles creation. If so under certain extreme conditions at the vicinity of massive stars or black holes, a very high energy radiation can be seen to be emitted by the virtue of pair annihilation of M_C. Note that the basic concept of M_C unification is to understand the origin of mass of any particle. Mass is the basic property in 'gravitation' and charge is the basic property in 'atomicity'. So far no model established a cohesive relation in between electric charge and mass of any elementary particle. From astrophysics point of view the fundamental questions to be answered are: 1) Without charge, is there any independent existence to 'mass' of any star? 2) Is black hole – a neutral body or electrically a neutralized body? To understand these questions the authors made an attempt to construct the above unified mass unit.

2. TO FIT THE NUCLEAR CHARGE RADIUS, THE PLANCK'S CONSTANT AND THE STRONG COUPLING CONSTANT

The subject of final unification is having a long history. After the nucleus was discovered in 1908, it was clear that a new force was needed to overcome the electrostatic repulsion of the positively charged protons. Otherwise the nucleus could not exist. Moreover, the force had to be strong enough to squeeze the protons into a volume of size 10^{-15} meter. In general the word strong is used since the strong interaction is the "strongest" of the four fundamental forces. Its observed strength is around 10^2 times that of the electromagnetic force, some 10^5 times as great as that of the weak force, and about 10^{39} times that of gravitation. The aim of unification is to understand the relation that connects gravity, mass, charge and the 'microscopic space-time curvature'. Many scientists addressed this problem in different ways [2–4]. The authors also made many attempts in their previously published papers [5–11]. Experimentally observed nuclear charge radius [12–15] can be fitted with the following strange and simple unified relation.

$$R_c \cong \sqrt{\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\cdot\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)}\cdot\left(\frac{2GM_C}{c^2}\right) \cong 1.252 \text{ fermi} \tag{2}$$

Here $\frac{2GM_C}{c^2}$ can be considered as the Schwarzschild radius [16,17] of the proposed new mass unit M_C.

$$\frac{R_c c^2}{2GM_C} \cong \sqrt{\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\cdot\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)} \tag{3}$$

Whether the expression $\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right) \cong 90.62$, playing a key unified role or only a fitting role to be confirmed. With a great accuracy the famous Planck's constant can be fitted with the following relation.

$$\begin{aligned} h &\cong \frac{1}{2}\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\cdot\left(\sqrt{m_p m_e}\cdot c\cdot R_c\right) \\ &\cong \ln\sqrt{\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}}\cdot\left(\sqrt{m_p m_e}\cdot c\cdot R_c\right) \cong 6.63862\times 10^{-34} \text{ J s} \end{aligned} \tag{4}$$

Recommended value of h is $6.6260695729\times 10^{-}$ J s and the error is 0.189%. From equations (1) and (2) above relation can be simplified into the following simple form.

$$h \cong \left[\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\right]^{3/2} \left\{\sqrt{\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}}\left(\frac{G M_C \sqrt{m_p m_e}}{c}\right)\right\}$$
$$\cong \left[\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\right]^{3/2} \left(\frac{e^2}{4\pi\varepsilon_0 c}\right) \tag{5}$$

Comparing this with the standard definition,

$$\left(\frac{2\pi}{\alpha}\right) \cong \frac{4\pi\varepsilon_0 hc}{e^2} \cong \left[\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)\right]^{3/2} \tag{6}$$

where α is the fine structure ratio.

Let $$X = \frac{e^2}{4\pi\varepsilon_0 G m_p m_e} \quad \text{and} \quad \ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right) = \ln(X) \tag{7}$$

Proceeding further qualitatively and quantitatively currently believed strong coupling constant [18] can be fitted with the following relation.

$$\alpha_s \cong \left[\sqrt{\ln\left(\frac{e^2}{4\pi\varepsilon_0 G m_p m_e}\right)} - 1\right]^{-1} \cong \left[\sqrt{\ln(X)} - 1\right]^{-1} \cong 0.11738 \tag{8}$$

Its recommended value is 0.11847 and uncertainty is 5.9×10^6 ppb. Now the characteristic nuclear force can be expressed as follows.

$$\frac{e^2}{4\pi\varepsilon_0 R_c^2} \cong \frac{1}{4X\ln(X)}\left(\frac{c^4}{G}\right) \cong \frac{1}{4\ln(X)} \cdot \frac{4\pi\varepsilon_0 \left(m_p c^2\right)\left(m_e c^2\right)}{e^2} \tag{9}$$

Note that $\left(c^4 / G\right)$ can be considered as the limiting magnitude of any kind of force. Similarly $\left(c^5 / G\right)$ can be considered as the limiting magnitude of any kind of power [1,20,21].

3. TO FIT AND CO-RELATE THE SEMI EMPIRICAL MASS FORMULA ENERGY COEFFICIENTS

In nuclear physics, the semi-empirical mass formula is used to approximate the mass and various other properties of an atomic nucleus. As the name suggests, it is based partly on theory and partly on empirical measurements [23–24]. The theory is based on the liquid drop model proposed by George Gamow, which can account for most of the terms in the formula and gives rough estimates for the values of the coefficients. It was first formulated in 1935 by German physicist Carl Friedrich von Weizsacker, and although refinements have been made to the coefficients over the years, the structure of the formula remains the same today. In the following formulae, let *A* be the total number of nucleons, *Z* the number of protons, and *N* the number of neutrons. The mass of an atomic nucleus is given by

$$m = Zm_p + Nm_n - \left(B/c^2\right) \tag{10}$$

where m_p and m_n are the rest mass of a proton and a neutron, respectively, and *B* is the binding energy of the nucleus. The semi-empirical mass formula states that the binding energy will take the following form.

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} + \delta(A,Z) \tag{11}$$

Its modern representation is

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} \pm \frac{a_p}{\sqrt{A}} \tag{12}$$

Here a_v = volume energy coefficient, a_s is the surface energy coefficient, a_c is the coulomb energy coefficient, a_a is the asymmetry energy coefficient and a_p is the pairing energy coefficient. By maximizing *B(A,Z)* with respect to *Z*, one can find the number of protons *Z* of the stable nucleus of atomic weight *A* as,

$$Z \cong \frac{A}{2 + \left(a_c / 2a_a\right) A^{2/3}}. \tag{13}$$

This is roughly $A/2$ for light nuclei, but for heavy nuclei there is an even better agreement with nature. Now with the following two energy units semi empirical mass formula energy coefficients can be fitted in the following way.

$$\text{Let} \qquad E_c \cong \frac{e^2}{4\pi\varepsilon_0 R_c} \cong 1.152\,\text{MeV} \tag{14}$$

where, $R_c \cong 1.25$ fm.

$$E_x \cong \sqrt{m_p c^{2*} E_c} \cong 32.88\,\text{MeV} \tag{15}$$

a) The coulombic energy coefficient can be expressed as

$$a_c \cong \frac{3}{5} E_c \cong 0.69\,\text{MeV} \tag{16}$$

b) The asymmetry energy coefficient can be expressed as

$$a_a \cong \frac{2}{3} E_x \cong 21.91\,\text{MeV} \tag{17}$$

c) The pairing energy coefficient can be expressed as

$$a_p \cong \frac{1}{2} a_a \cong \frac{1}{3} E_x \cong 10.95\,\text{MeV} \tag{18}$$

d) The surface energy coefficient can be expressed as

$$a_s \cong \left(a_a^2 a_p\right)^{1/3} \cong 17.39\,\text{MeV} \tag{19}$$

e)The volume energy coefficient can be expressed as

$$a_v \cong \left(a_a a_p\right)^{1/2} \cong 15.49\,\text{MeV} \tag{20}$$

$$\text{Thus } a_v + a_s \cong a_p + a_a \cong 3a_p \tag{21}$$

For light and heavy atoms (including super heavy stable isotopes), proton-nucleon stability relation can be expressed with the following semi empirical relation. Clearly speaking, by considering Z its corresponding stable mass number can be estimated directly.

$$\frac{A_S}{2Z} \cong 1 + \left[2Z\left(\frac{a_c}{a_s}\right)^2\right] \tag{22}$$

where A_S can be considered as the stable mass number of Z

$$A_S \cong 2Z + \left(Z^{2^*} 0.0063\right) \tag{23}$$

Please see table-1 for fitting the proton number and its corresponding stable mass number. See table-2 for the comparison of the semi empirical mass formula energy coefficients. See table-3 for the calculated semi empirical mass formula nuclear binding energy and please see table-4 for fitting the heavy proton number and its estimated super heavy stable mass number.

Table 1: To fit the stable mass numbers of Z

S. No	Z	A_S
1	21	44.8
2	29	63.3
3	37	82.6
4	47	107.9.
5	53	123.9
6	60	142.8
7	69	168.0
8	79	197.3
9	83	209.4
10	92	237.3
11	100	263.0
12	112	303.0
13	118	323.7

Table 2: Existing and proposed SEMF binding energy coefficients

Existing energy coefficients	Proposed energy coefficients
$a_v \cong 15.78$ MeV	$a_v \cong 15.49$ MeV
$a_v \cong 18.34$ MeV	$a_S \cong 17.39$ MeV
$a_c \cong 0.71$ MeV	$a_c \cong 0.69$ MeV
$a_a \cong 23.21$ MeV	$a_a \cong 21.91$ MeV
$a_p \cong 12.0$ MeV	$a_p \cong 10.95$ V

Table 3: To fit the SEMF binding energy with the proposed energy coefficients

Z	A	$(BE)_{cal}$ **in MeV**	$(BE)_{meas}$ **in MeV**
26	56	490.9	492.254
28	62	544.8	545.259
34	84	725.3	727.341
50	118	1005.6	1004.950
60	142	1184.3	1185.145
79	197	1562.9	1559.40
82	208	1634.8	1636.44
92	238	1818.9	1801.693

Table 4: To fit the super heavy stable mass numbers of heavy Z

Z	A_S	Z	A_S
93	240.5	106	282.8
94	243.7	107	286.1
95	246.8	108	289.5
96	250.0	109	292.8
97	253.3	110	296.2
98	256.5	111	299.6
99	259.7	112	303.0
100	263.0	113	306.4
101	266.3	114	309.9
102	269.5	115	313.4
103	272.8	116	316.8
104	276.1	117	320.24
105	279.5	118	323.7

4. DISCUSSION AND CONCLUSIONS

The main object of unification is to understand the origin of elementary particles rest mass, 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. Note that general relativity does not throw any light on the 'mass generation' of charged particles. It only suggests that space-time is curved near the massive celestial objects. More over it couples the cosmic (dust) matter with geometry. But how matter/dust is created? Why and how elementary particle possesses both charge and mass? Such types of questions are not being discussed in the frame work of general relativity. The first step in unification is to understand the origin of the rest mass of a charged elementary particle. Second step is to understand the combined effects of its electromagnetic (or charged) and gravitational interactions. Third step is to understand its behavior with surroundings when it is created. Fourth step is to understand its behavior with cosmic space-time or other particles. Right from its birth to death, in all these steps the underlying fact is that whether it is a strongly interacting particle or weakly interacting particle, it is having some rest mass. To understand the first two steps somehow one can implement the gravitational constant in sub atomic physics. In this regard $M_C \cong \sqrt{e^2/4\pi\varepsilon_0 G}$ can be considered as the nature's given unified mass unit. To bring down the Planck mass scale to the observed elementary particles mass scale certainly a large scale factor is required. In this regard, the electromagnetic and gravitational force ratio of proton and electron can be considered as the nature's given universal scale factor. Thinking positively the proposed relations for fitting the nuclear charge radius, the Planck's constant and strong the coupling constant can be considered for further analysis positively.

Understanding the origin of nuclear binding energy constants is a very interesting job. In this regard authors proposed the semi empirical relations (14) to (23) in a very simplified way. It needs further scientific, systematic and unified study. Authors are working on in minimizing the difference of the estimated binding energy and measured binding energy for low and high proton numbers. By guessing the atomic number and considering the squared ratio of the coulombic energy and surface energy coefficients of the semi empirical mass formula authors proposed a semi empirical relation using by which observed light and heavy stable elements can be fitted directly. Stable super heavy elements of higher atomic numbers can be also predicted with the same relation. Just close to the stable super heavy elements unstable super heavy elements that may initiate spontaneous nuclear fission can be guessed.

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