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To Develop a Virtual Model of Microscopic Quantum Gravity

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Abstract: We would like to suggest that, by considering three virtual gravitational constants assumed to be associated with gravitational, electromagnetic and strong interactions along with a strongly interacting virtual nuclear elementary charge, a workable model of final unification can be developed. In a verifiable approach, Newtonian gravitational constant and Fermi's weak coupling constant can be interrelated via nuclear and electromagnetic gravitational constants.

Keywords: final unification; fermi's weak coupling constant; newtonian gravitational constant; virtual electromagnetic gravitational constant; virtual nuclear gravitational constant; virtual nuclear elementary charge

1. Introduction

The most desirable cases of any unified description are:

- **a)** To implement gravity in microscopic physics and to estimate the magnitude of Newtonian gravitational constant.
- **b)** To develop a model of microscopic quantum gravity.
- **c)** To simplify the complicated issues of known physics.
- **d)** To predict new effects, arising from a combination of the fields inherent in the unified description.

In this context, in our earlier publications [1-12] and references therein, we suggested the role of two new gravitational constants associated with strong and electromagnetic interactions. Proceeding further, we also suggested the role of a new elementary charge associated with nuclear interactions and strong coupling constant [13,14]. In this paper, by considering the word 'virtual' and by refining and re-arranging the old semi empirical relations, we make a bold attempt to fit the Fermi's weak coupling constant and Newtonian gravitational constant [15,16]. Estimated magnitudes are 1.44021×10^{-62} J.m^3 and 6.679856×10^{-11} $\text{m}^3\text{kg}^{-1}\text{sec}^{-2}$ respectively.

It may be noted that, success of any unified model either depends on its physical/mathematical back ground or depends on its wide range of applications. It is clear from the below proposed applications (1 to 53) that we could satisfactorily fit the nuclear, electroweak and Newtonian gravitational constants through unified semi-empirical relations. This sincere attempt is to be reviewed and ascertained by the scientific community. We would like to appeal that, with respect to currently believed String theory and Quantum gravity models, proposed semi empirical relations and proposed assumptions, can be given some consideration in developing a 'workable model' of TOE.

2. Nomenclature and magnitudes

1) $e_e \cong 1.602176565\times10^{-19}$ C = Elementary charge associated with electromagnetic interaction
2) $e_s \cong 4.72058686\times10^{-19}$ C = Estimated virtual nuclear elementary charge
3) $\varepsilon_0 \cong 8.854187817\times10^{-19}$ F/m = Permittivity of free space
4) $m_n \cong 1.674927471\times10^{-27}$ kg = Rest mass of neutron
5) $m_p \cong 1.672621777\times10^{-27}$ kg = Rest mass of proton
6) $m_e \cong 9.10938291\times10^{-31}$ kg = Rest mass of electron
7) $\hbar \cong 1.054571726\times10^{-34}$ J.sec. = Reduced Planck's constant
8) $\mu_p \cong \left(e_s\hbar/2m_p\right) \cong 1.488142\times10^{-26}$ J.Tesla^{-1} = Estimated magnetic dipole moment of proton
9) $\mu_n \cong \dfrac{\hbar}{2m_n}\left(e_s - e_e\right) \cong 9.8171\times10^{-27}$ J.Tesla^{-1} = Estimated magnetic dipole moment of neutron
10) $c \cong 2.99792458\times10^{8}$ m.sec^{-1} = Speed of light
11) $\alpha \cong 7.2973525698\times10^{-3}$ = Fine structure ratio
12) $\alpha_s \cong \left(e_e/e_s\right)^2 \cong 0.1151937095$ = Estimated strong coupling constant
13) $G_s \cong 3.32956087\times10^{28}$ m^{3}kg^{-1}sec^{-2} = Estimated virtual gravitational constant associated with nuclear or strong interaction
14) $G_e \cong 2.374335472\times10^{37}$ m^{3}kg^{-1}sec^{-2} = Estimated virtual gravitational constant associated with electromagnetic interaction
15) $G_N \cong 6.679856\times10^{-11}$ m^{3}kg^{-1}sec^{-2} = Estimated (virtual) gravitational constant associated with gravitational interaction
16) $G_F \cong 1.44021\times10^{-62}$ J.m^3 = Estimated Fermi's weak coupling constant
17) $R_0 \cong \left(2G_s m_p/c^2\right) \cong 1.239290976\times10^{-15}$ m = Estimated nuclear charge radius
18) $R_p \cong \left(\sqrt{2}G_s m_p/c^2\right) \cong 0.87631105\times10^{-15}$ m = Estimated root mean square radius of proton

3. Three basic assumptions of final unification

In our earlier publications, we proposed the following three assumptions. In this paper we review them with the word, 'virtual'.

Assumption-1: Magnitude of the virtual gravitational constant associated with the electromagnetic interaction is, $G_e \cong 2.374335472\times10^{37}$ m^{3}kg^{-1}sec^{-2}.

Assumption-2: Magnitude of the virtual gravitational constant associated with the strong interaction [17] is, $G_s \cong 3.32956087\times10^{28}$ m^{3}kg^{-1}sec^{-2}.

Assumption-3: There exists a strongly interacting virtual nuclear elementary charge, $e_s \cong \left(e_e/\sqrt{\alpha_s}\right) \cong 4.72058686\times10^{-19}$ C where 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'.

Note-1: G_e can be estimated with, $G_e \cong \left(\frac{1}{2\pi}\right)^2 \left(\frac{m_p}{m_e}\right)^2 \left(\frac{e_e^2}{4\pi\varepsilon_0 m_e^2}\right)$.

Note-2: G_s can be estimated with, $G_s \cong \frac{\hbar^2 c^2}{G_e m_p m_e^3} \cong \left(\frac{\hbar c}{G_e m_e^2}\right)\left(\frac{\hbar c}{m_e m_p}\right)$.

Note-3: G_N can be estimated with, $G_N \cong \left(\frac{m_e}{m_p}\right)^9 \left(\frac{G_s}{G_e}\right)\left(\frac{\hbar c}{m_p^2}\right)$.

4. Important and interesting results

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

A) Ratio of rest mass of proton to electron:

With reference to G_e :

$$\left(\frac{m_p}{m_e}\right) \cong 2\pi\sqrt{\frac{4\pi\varepsilon_0 G_e m_e^2}{e_e^2}} \tag{1}$$

With reference to $(G_s \text{ and } G_e)$:

$$\begin{aligned}
&\left(\frac{m_p}{m_e}\right) \cong \left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e_e^2}\right) \Big/ \left(\frac{4\pi\varepsilon_0 G_s m_p^2}{e_s^2}\right) \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{G_e m_e^2}{\hbar c}\right) \\
&\rightarrow \frac{m_p}{m_e} \cong \left(\frac{G_e e_s^2}{G_s e_e^2}\right)^{\frac{1}{3}} \cong \left(\left(\frac{G_e}{G_s}\right)\left(\frac{1}{\alpha_s}\right)\right)^{\frac{1}{3}} \cong \left(\left(\frac{G_e}{\hbar c}\right)\left(\frac{G_s}{\hbar c}\right) m_p^4\right)^{\frac{1}{3}} \\
&\Rightarrow m_p \cong \left(\left(\frac{\hbar c}{G_e}\right)\left(\frac{\hbar c}{G_s}\right)\frac{1}{m_e^3}\right) \text{ and } m_e \cong \left(\left(\frac{\hbar c}{G_e}\right)\left(\frac{\hbar c}{G_s}\right)\frac{1}{m_p}\right)^{\frac{1}{3}}
\end{aligned} \tag{2}$$

With reference to $(G_e \text{ and } G_N)$:

$$\begin{aligned}
&\left(\frac{m_p}{m_e}\right) \cong \left(\frac{G_N}{G_e}\right)^{\frac{1}{6}} \left(\frac{\hbar c}{G_N m_e^2}\right)^{\frac{1}{4}} \\
&\rightarrow m_p \cong \left(\frac{G_N}{G_e}\right)^{\frac{1}{6}} \sqrt{m_e \sqrt{\frac{\hbar c}{G_N}}} \text{ and } m_e \cong \left(\frac{G_e}{G_N}\right)^{\frac{1}{3}} m_p^2 \sqrt{\frac{G_N}{\hbar c}}
\end{aligned} \tag{3}$$

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With reference to $(G_e, G_s \text{ and } G_N)$:

$$\left(\frac{m_p}{m_e}\right) \cong \left(\frac{G_s}{G_N^{2/3} G_e^{1/3}}\right)^{\frac{1}{7}} \tag{4}$$

B) Electron and proton rest masses with respect to Planck mass :

$$m_p \cong \left(\frac{G_N^3}{G_e^2 G_s}\right)^{\frac{1}{7}} \sqrt{\frac{\hbar c}{G_N}} \tag{5}$$

$$m_e \cong \left(\frac{G_N^{11}}{G_s^6 G_e^5}\right)^{\frac{1}{21}} \sqrt{\frac{\hbar c}{G_N}} \tag{6}$$

C) Strong coupling constant [13]:

$$\alpha_s \cong \left(\frac{e_e}{e_s}\right)^2 \cong \frac{G_e m_e^3}{G_s m_p^3} \cong \left(\frac{m_e}{m_p}\right)\left(\frac{G_e m_e^2}{G_s m_p^2}\right) \cong \left(\frac{\hbar c}{G_s m_p^2}\right)^2 \tag{7}$$

This can be compared with a broad range of quoted values, 0.113 to 0.12 pertaining to various measurements.

D) Magnetic moment of proton [14]:

$$\mu_p \cong \frac{e_s \hbar}{2m_p} \cong 1.488142 \times 10^{-26} \text{ J.Tesla}^{-1} \tag{8}$$

This can be compared with the recommended value of $1.4106067873 \times 10^{-26}$ 燡Tesla^{-1}

E) Magnetic moment of neutron[14]:

$$\mu_n \cong \frac{e_s \hbar}{2m_n} - \frac{e_e \hbar}{2m_n} \cong \frac{\hbar}{2m_n}(e_s - e_e) \cong 9.8171 \times 10^{-27} \text{ J.Tesla}^{-1} \tag{9}$$

This can be compared with the recommended value of 9.66237×10^{-27} 燡Tesla^{-1}

F) Nuclear charge radius:

$$R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.239291 \times 10^{-15} \text{ m} \tag{10}$$

G) Root mean square radius of proton [13,14,18,19]:

$$R_p \cong \frac{\sqrt{2} G_s m_p}{c^2} \cong 0.8763111 \times 10^{-15} \text{ m} \tag{11}$$

This can be compared with the recommended value of $(0.8751 \pm 0.0061) \times 10^{-15}$ 爉

H) Weak coupling angle [13]:

$$\sin^2\theta_W \cong \frac{4\pi\varepsilon_0 G_s m_p m_e}{e^2} \cong 0.219893. \tag{12}$$

This can be compared with electroweak model definition of, $\sin^2\theta_W \cong \left\{1-\left(\frac{M_W^2}{M_Z^2}\right)\right\} \cong 1-\left(\frac{80385\text{ MeV}}{91187\text{ MeV}}\right)^2 \cong 0.22289.$

I) Up and down quark mass ratio [13]:

$$\left(\frac{m_u}{m_d}\right) \cong \sqrt{\frac{4\pi\varepsilon_0 G_s m_p m_e}{e^2}} \cong \sin\theta_W \cong 0.468353. \tag{13}$$

Note: With reference to PDG [13], $m_u \cong 2.2^{+0.6}_{-0.4}$ M eV and $m_d \cong 4.7^{+0.5}_{-0.5}$ M eV. Corresponding $\left(\frac{m_u}{m_d}\right) \cong 0.38 \text{ to } 0.58.$ It is noticed that, $\sqrt{0.38\times 0.58} \cong 0.4695.$

J) Ground state potential energy of electron in Hydrogen atom:

$$\left(E_{pot}\right)_{ground} \cong \left(\frac{e_e^2}{4\pi\varepsilon_0 G_s m_p m_e}\right)\left(\frac{e_e^2}{4\pi\varepsilon_0\left(G_e m_e/c^2\right)}\right) \cong -\left(\frac{e_e^2}{4\pi\varepsilon_0 G_s m_p m_e}\right)\left(\frac{e_e^2 c^2}{4\pi\varepsilon_0 G_e m_e}\right) \tag{14}$$

Note: Considering $\left(\frac{1}{2n^2}\right)$ as a probability of finding electron in any orbit labeled with $n = 1, 2, 3, ..$ further research can be carried out. Bohr radius can be addressed with,

$$a_0 \cong \left(\frac{4\pi\varepsilon_0 G_e m_e^2}{e_e^2}\right)\left(\frac{G_s m_p}{c^2}\right) \cong \left(\frac{4\pi\varepsilon_0 G_s m_p m_e}{e_e^2}\right)\left(\frac{G_e m_e}{c^2}\right) \tag{15}$$

K) Planck's constant:

$$\begin{gathered} h \cong \sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0 c}\right)\left(\frac{G_e m_e^2}{c}\right)} \cong \left(\frac{e_s}{e_e}\right)\sqrt{\left(\frac{e_e^2}{4\pi\varepsilon_0 c}\right)\left(\frac{G_e m_e^2}{c}\right)} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\sqrt{\left(\frac{e_e^2}{4\pi\varepsilon_0 c}\right)\left(\frac{G_e m_e^2}{c}\right)} \\ \to hc \cong \sqrt{\left(2\pi G_s m_p^2\right)\sqrt{\left(\frac{e_e^2}{4\pi\varepsilon_0}\right)\left(G_e m_e^2\right)}} \end{gathered} \tag{16}$$

Note: $\left(2\pi G_s m_p^2\right)$ can be considered as characteristic constant connected with atomic nucleus and $\sqrt{\left(\frac{e_e^2}{4\pi\varepsilon_0}\right)\left(G_e m_e^2\right)}$ can be can be considered as characteristic constant connected with revolving electron.

L) Magnetic flux quantum in super conductivity [20]:

$$\Phi_0 \cong \frac{h}{2e_e} \cong \frac{1}{2}\sqrt{\left(\frac{m_p}{m_e}\right)\left(\frac{\mu_0}{4\pi}\right)\left(G_s m_p^2\right)} \tag{17}$$

M) Atomic radii [21]:

Let, $m_U \cong 1.66054\times 10^{-27}$ kg $=$ Unified atomic mass unit.

$A =$ Atomic mass number.

$$\begin{aligned} &\text{1) Characteristic atomic radius, } R_{atom} \cong \frac{2\sqrt{G_s G_e m_U}}{c^2} \cong 32.86 \text{ pm} \\ &\text{2) Characteristic atomic radii, } R_A \approx A^{\frac{1}{3}}\left(\frac{2\sqrt{G_s G_e m_U}}{c^2}\right) \approx A^{\frac{1}{3}} \times 32.86 \text{ pm} \end{aligned} \tag{18}$$

By considering the periodic arrangement of atoms, further research can be carried out.

N) Photoelectric work functions [22]:

Let, $W_Z =$ Photoelectric work function of Z.

$$W_Z \approx -f \times A^{\frac{1}{3}} \sqrt{\frac{G_s m_p^2}{G_e m_e^2}}\left(\frac{e_e^2}{8\pi\varepsilon_0 R_A}\right) \tag{19}$$

where R_A is the radius of atom, A is the atomic mass number and factor $f \cong (3 \pm 0.5)$. See table-1. For the preparation of table, we consider, $f \cong 3.0$. From the table, it is possible to say that,

1) As atomic number increases, factor f starts from ~3.5 and gradually reaches to ~2.5.
2) Actual atomic radii for light atoms seem to be less than the reference values and for heavy atoms, actual atomic radii seem to be higher than the reference values.

O) Earth's magnetic dipole moment

Planet's earth's magnetic dipole moment can be understood with:

$$\mu_{earth} \cong \left(\frac{G_N}{G_e}\right)^{\frac{1}{4}} * \left(\frac{e_e G_e M_{earth}}{c}\right) \cong \left(\frac{e_e \left(G_e^3 G_N\right)^{\frac{1}{4}} M_{earth}}{c}\right) \tag{20}$$

$$\cong 9.8253\times 10^{22} \text{ J.Tesla}^{-1}$$

This can be compared with the estimated order of magnitude of Earth's magnetic dipole moment 8.2×10^{22} J.Tesla^{-1}. Based on this relation, other solar planets, exo-planets and neutron star's "mass dependent" order of magnitude of 'magnetic dipole moments' can be estimated [23]. See table-3. It may be noted that, for 30 hot Jupiters, on an average, estimated value is roughly 0.21 times the reference values. See table -2.

P) Neutron star mass and radius

1) If (M_{NS}, m_n) represent the masses of neutron star [24] and neutron, then,

$$\frac{G_N M_{NS} m_n}{\hbar c} \approx \sqrt{\frac{G_s}{G_N}} \rightarrow M_{NS} \approx 3.175 M_{\odot} \tag{21}$$

Note: By considering $\left(\frac{\hbar}{2}\right)$, mass of neutron star can be estimated to be $1.5875 M_{\odot}$. This is just greater than the famous Chandrasekhar mass limit of $1.4 M_{\odot}$.

2) If R_{NS} represents the neutron star radius, then,

$$\frac{R_{NS}}{\left(\sqrt{G_s \hbar / c^3}\right)} \approx \sqrt{\frac{G_s}{G_N}} \rightarrow R_{NS} \approx 8.06 \text{ km} \tag{22}$$

5. To understand proton's melting point

With reference to Hawking black hole temperature formula [25], melting point of proton [26] can be understood with:

$$T_{proton} \cong \frac{\hbar c^3}{8\pi k_B G_s m_p} \cong 0.15 \times 10^{12} \text{ K} \tag{23}$$

Based on this relation and with reference to up quark, other quark melting points can be expressed with the following kind of relation.

$$T_{quark} \cong \left(\frac{m_q}{m_{up}}\right) \frac{\hbar c^3}{8\pi k_B G_s m_{up}} \tag{24}$$

where $\left(\frac{m_q}{m_{up}}\right)$ represents the ratio of mass of any quark to mass of up quark. Based on this relation, for up quark of rest energy 2 MeV, its corresponding $T_{up} \cong 69 \textit{ Tera K}$ and $8\pi k_B T_{up} \cong 236 \text{ MeV}$. This energy can be compared with currently believed QCD energy scale of 270 MeV.

6. Fitting medium, heavy and super heavy nuclear charge radii

For medium, heavy and super heavy atomic nuclei, nuclear charge radii [27,28,29] can be fitted with the following simple relation.

$$\begin{aligned} R_{(Z,A)} &\cong \left\{ Z^{1/3} + \left(\sqrt{Z(A-Z)}\right)^{1/3} \right\} \left(\frac{G_s m_p}{c^2}\right) \\ &\cong \left\{ Z^{1/3} + \left[Z(A-Z)\right]^{1/6} \right\} \left(\frac{G_s m_p}{c^2}\right) \end{aligned} \tag{25}$$

where $Z = (2 \text{ to } 100)$ and $\left(G_s m_p / c^2\right) \cong 0.62 \text{ fm}$

It may be noted that, this relation is free from arbitrary numbers and can be compared with the following relation available in recent literature. See table-3.

$$R_{(Z,N)} \cong \left\{1 - 0.349\left(\frac{N-Z}{N}\right)\right\} N^{\frac{1}{3}}\ 1.262 \text{ fm} \tag{26}$$

7. Fitting and Understanding Fermi's weak coupling constant

Quantitatively the famous Fermi's weak coupling constant [13,14] can be fitted with the following relation.

When distance between two protons is close to $R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.234 \text{ fm}$, gravitational force of attraction between them can be expressed as,

$$\frac{G_s m_p m_p}{R_0^2} \cong \frac{G_s m_p^2}{R_0^2} \cong \left(\frac{c^4}{4G_s}\right) \tag{27}$$

Based on this idea, F_W can be expressed in the following ways.

$$\begin{aligned} G_F &\cong \left(\frac{e_e}{e_s}\right)\left(G_s m_p^2\right)\left(G_s m_e^2\right)\left(\frac{c^4}{4G_s}\right)^{-1} \cong \left(\frac{e_e}{e_s}\right)\left(G_s m_e^2 R_0^2\right) \\ &\cong \sqrt{\alpha_s}\left(G_s m_e^2 R_0^2\right) \cong \left(\frac{m_e}{m_p}\right)^2\left(\hbar c R_0^2\right) \cong \hbar c\left(\frac{2G_s m_e}{c^2}\right)^2 \\ &\cong \left[\left(G_e m_p^2\right)^2\left(G_N m_p^2\right)\right]^{\frac{1}{3}}\left(\frac{2G_s m_p}{c^2}\right)^2 \\ &\cong 1.44021 \times 10^{-62} \text{ J.m}^3 \end{aligned} \tag{28}$$

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. Based on these relations,

$$G_N \cong \frac{G_F^3 c^{12}}{64 G_e^2 G_s^6 m_p^{12}} \tag{29}$$

If, recommended $G_F \cong 1.435850984 \times 10^{-62} \text{ J.m}^3$, obtained $G_N \cong 6.619386 \times 10^{-11} \text{ m}^3\text{kg}^{-1}\text{sec}^{-2}$

8. Fitting & Understanding nuclear stability and binding energy

A) Proton-Neutron stability:

Let,

$$s \cong \left(\frac{G_s m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_e m_e^2}\right) \cong \left[\left(\frac{e_s}{m_p}\right) \Big/ \left(\frac{e_e}{m_e}\right)\right] \cong 1.604637101 \times 10^{-3} \tag{30}$$

Clearly speaking, s is the ratio of specific charge of proton associated with e_s to specific charge of electron associated with e_e. Using this ratio, proton-neutron stability relation can be fitted directly in the following way [30].

$$A_s \cong 2Z + k(2Z)^2 \cong 2Z + (4s)Z^2 \cong 2Z + 0.00641855Z^2 \tag{31}$$

where A_s is the estimated stable mass number of Z.

It is very interesting to note that, close to beta stability line, considering $(4s) \cong k \cong 0.00641855$, nuclear binding energy [31-36] can be estimated very easily.

B) Nuclear binding energy:

Nuclear binding energy potential can be expressed with the following relation.

$$\begin{aligned} B_0 &\cong \sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0 \hbar c}\right)\left(\frac{e^2}{4\pi\varepsilon_0 \hbar c}\right)}\left(\frac{G_s m_p^2}{R_0}\right) \cong \left(\frac{e_e e_s}{4\pi\varepsilon_0 \hbar c}\right)\left(\frac{G_s m_p^2}{R_0}\right) \\ &\cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{e_e e_s}{4\pi\varepsilon_0 R_0}\right) \cong \left(\frac{e_s^2}{4\pi\varepsilon_0 R_0}\right) \cong \left(\frac{e_s^2 c^2}{8\pi\varepsilon_0 G_s m_p}\right) \cong 10.0867 \text{ MeV} \end{aligned} \tag{32}$$

Based on the new integrated model proposed by N. Ghahramany et al [31,32] and with reference to relation (31), it is possible to show that, $Z \cong (40 \text{ to } 83)$, close to the beta stability line,

$$(B)_{A_s} \cong \left[A_s - \left(\frac{N_s^2 - Z^2}{3Z}\right)\right] \times 9.5 \text{ MeV} \cong \left[A_s - \left(\frac{kZA_s}{3}\right)\right] \times 9.5 \text{ MeV} \tag{33}$$

where, $\left[\frac{N_s^2 - Z^2}{Z}\right] \cong kZA_s$. Based on this strange and simple relation and with reference to our recent publication [37] and first four terms of the semi empirical mass formula (SEMF), close to the beta stability line, for $(Z = 2 \text{ to } 100)$, it is possible to show that,

$$(B)_{A_s} \cong \left[A_s - A_s^{1/3} - \frac{kA_s\sqrt{N_s Z}}{3.40} - 1\right] \times (B_0 \cong 10.09 \text{ MeV}) \tag{34}$$

This can be compared with first four terms of the semi empirical mass formula where : $a_v \cong 15.77$ MeV, $a_s \cong 18.34$ MeV, $a_a \cong 23.21$ MeV and $a_c \cong 0.71$ MeV. See table-4. For relation (34), see figure 1 (dashed red curve) for the estimated binding energy per nucleon close to beta stability line of Z= 2 to 100 compared with first four terms of the semi empirical mass formula (Green curve).

For $Z = 50$ and $A = 100 \text{ to } 136$, estimated binding energy range is (857 to 1140) MeV and can be compared with reference binding energy [38] range of (806 to 1105) MeV. It is for further study. With reference to SEMF, close to the beta stability line, it is also possible to show that,

$$\frac{(A_s - 2Z)^2}{A_s} \cong \left(k^2 A_s N_s \sqrt{Z}\right) \tag{35}$$

Let, $\left\{\begin{matrix} a_v \cong a_s \cong a_a \approx 14.8 \text{ MeV} \approx (3/2) \times 10.0 \text{ MeV} \\ \text{and } \; a_c \cong 0.71 \text{ MeV} \end{matrix}\right\}$.

If so,

$$(B)_{A_s} \approx \left[A_s - A_s^{2/3} - 0.0473\left[\frac{Z(Z-1)}{A_s^{1/3}}\right] - \left(k^2 A_s N_s \sqrt{Z}\right)\right] \times 14.8 \text{ MeV} \tag{36}$$

In comparison with SEMF, by replacing A_s with A and N_s with $(A-Z)$ in relation (36) and by considering a multiplication factor of the kind $(A_s/A)^{1-(Z/A)}$ associated with each term, binding energy of A can be estimated approximately.

9. Neutron life time and Avogadro number

Neutron life time [39] can be fitted in the following way,

$$\begin{aligned} &(m_n - m_p)c^2 \times t_n \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_n^2}{c}\right) \\ &\to t_n \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_n^2}{(m_n - m_p)c^3}\right) \cong 896.8 \text{ sec} \end{aligned} \tag{37}$$

where, $\sqrt{\frac{G_e}{G_N}} \cong 5.964517556 \times 10^{23}$ is very close to the Avogadro number, N_A [40,41].

By considering the unified atomic mass unit $m_U \cong 1.66054 \times 10^{-27}$ kg ,

$$\to t_n \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_U^2}{(m_n - m_p)c^3}\right) \cong 878.6 \text{ sec} \tag{38}$$

By considering the unified atomic mass unit $m_U \cong 1.66054 \times 10^{-27}$ kg as well as neutron proton rest masses,

$$\to t_n \cong \sqrt{\frac{G_e}{G_N}}\left(\frac{G_s m_U \sqrt{m_p m_n}}{(m_n - m_p)c^3}\right) \cong 888.5 \text{ sec} \tag{39}$$

In this way, results of bottle experiments and beam experiments both can be fitted [13].

10. Strange results connected with Planck scale Schwarzschild radius

A) **Conceptual thought**: Schwarzschild radius of Planck mass plays a vital role in electroweak and strong interactions.

$$\text{Planck mass} = M_{pl} \cong \sqrt{\frac{\hbar c}{G_N}} \tag{40}$$

$$R_{pl} \cong \text{Schwarzschild radius of Planck mass}$$

$$\cong \frac{2G_N M_{pl}}{c^2} \cong 2\sqrt{\frac{G_N \hbar}{c^3}} \tag{41}$$

B) Strange result connected with $\left(G_F \text{ and } G_N\right)$

It is noticed that

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

Based on this relation,

$$G_F \cong \left(\frac{m_p}{m_e}\right)^{10} \left(\frac{4G_N \hbar^2}{c^2}\right) \tag{43}$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{10} \left(\frac{G_F c^2}{4\hbar^2}\right) \tag{44}$$

If, recommended $G_F \cong 1.435850984 \times 10^{-62}$ J.m^3, obtained $G_N \cong 6.65963739 \times 10^{-11}$ m^{3}kg^{-1}sec^{-2}

If, estimated $G_F \cong 1.44021 \times 10^{-62}$ J.m^3, obtained $G_N \cong 6.679856 \times 10^{-11}$ m^{3}kg^{-1}sec^{-2}

If, $G_N \cong \left(\frac{m_e}{m_p}\right)^9 \left(\frac{G_s}{G_e}\right)\left(\frac{\hbar c}{m_p^2}\right)$, from relation (43), it is also possible to show that,

$$G_F \cong \left(\frac{\hbar c}{G_e m_p m_e}\right) \hbar c \left(2\sqrt{\frac{G_s \hbar}{c^3}}\right)^2 \cong \left(\frac{G_s}{G_e}\right)\left(\frac{4\hbar^3}{m_p m_e c}\right) \cong \left(\frac{G_s}{G_e}\right) 4\hbar c \left(\frac{\hbar}{m_p c}\right)\left(\frac{\hbar}{m_e c}\right) \tag{45}$$

where, $2\sqrt{\frac{G_s \hbar}{c^3}} \cong 0.722 \text{ fm} = \text{ Schwarzschild radius of} \sqrt{\frac{\hbar c}{G_s}} \cong \frac{2G_s}{c^2}\sqrt{\frac{\hbar c}{G_s}}$.

C) Strange result connected with Proton-electron mass ratio

From above relations,

$$\frac{R_0}{R_{pl}} \cong \left(\frac{m_p}{m_e}\right)^6 \quad \text{(Or)} \quad \frac{\pi R_0^2}{\pi R_{pl}^2} \cong \left(\frac{m_p}{m_e}\right)^{12} \tag{46}$$

$$\begin{aligned} &R_0 \cong \frac{2G_s m_p}{c^2} \cong \left(\frac{m_p}{m_e}\right)^6 R_{spl} \cong \left(\frac{m_p}{m_e}\right)^6 \left(2\sqrt{\frac{G_N \hbar}{c^3}}\right) \\ &\rightarrow G_N \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{m_e}{m_p}\right)^{12} G_s \cong \left(\frac{1}{\sqrt{\alpha_s}}\right)\left(\frac{m_e}{m_p}\right)^{12} G_s \end{aligned} \tag{47}$$

If $\left(\frac{1}{\sqrt{\alpha_s}}\right) \cong \left(\frac{G_s m_p^2}{\hbar c}\right)$, obtained, $G_N \cong 6.6798563 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$

11.‘System of units’ independent Avogadro number and Molar mass unit

If, atoms as a whole believed to exhibit electromagnetic interaction, then molar mass constant and Avogadro number, both can be understood with the following simple relation.

$$G_e \left(m_{atom}\right)^2 \cong G_N \left(M_{mole}\right)^2 \tag{48}$$

Where m_{atom} is the unified atomic mass unit and M_{mole} is the molar mass unit or gram mole.

Thus it is very clear to say that, directly and indirectly ‘gravity’ plays a key role in understanding the molar mass unit.

$$\frac{M_{mole}}{m_{atom}} \cong \sqrt{\frac{G_e}{G_N}} \rightarrow M_{mole} \cong \sqrt{\frac{G_e}{G_N}} \times m_{atom} \tag{49}$$

$$\text{where } \sqrt{\frac{G_e}{G_N}} \cong 5.96 \times 10^{23} \cong \text{Avogadro number, } N_A$$

$$\text{and } \left(0.00099 > M_{mole} < 0.001\right) \text{ kg}$$

Based on these relations, “independent of system of units” and “independent of ad-hoc selection of exactly one gram or one kilogram”, it may be possible to explore the correct physical meaning of the famous ‘Molar mass unit’ and ‘Avogadro number’ in a unified approach. It may be noted that, Avogadro number and ‘gram mole’ are having many applications in solid state physics, gas dynamics/thermodynamics and basic chemistry/electrochemistry. By considering the following relation, it is possible to couple the Avogadro number with the observed fundamental interactions.

$$\sqrt{\frac{M_{pl} * m_e}{m_p^2}} \cong \left(\frac{G_e}{G_N}\right)^{\frac{1}{6}} \cong N_A^{1/3} \tag{50}$$

12. Relation in between $(G_s, G_e, G_N \text{ and } \alpha)$:

It may be noted that, fitting the gravitational constant with elementary physical constants is a very challenging issue. G. Rosi et al say [15]: “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, we 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 in microscopic physics.

In a semi empirical approach it is also noticed that,

$$\begin{aligned} &\ln\left(\frac{G_s^4}{G_e^2 G_N^2}\right) \approx \ln\left[\left(\frac{G_s^2}{G_e^2}\right)\left(\frac{G_s^2}{G_N^2}\right)\right] \cong 137.44057 \approx \frac{1}{\alpha} \\ &\rightarrow G_N \cong 8.170389\times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}. \end{aligned} \tag{51}$$

With reference to the recommended and experimental values of the Newtonian gravitational constant, with trial-error and by introducing an ad hoc factor of $(3/2)$, it is noticed that,

$$\left(\frac{G_s^4}{G_e^2 G_N^2}\right) \cong \frac{3}{2}\exp\left(\frac{1}{\alpha}\right) \tag{52}$$

$$G_N \cong \sqrt{\left(\frac{2}{3}\right)\left[\exp\left(\frac{1}{\alpha}\right)\right]^{-1} \times \frac{G_s^4}{G_e^2}} \cong 6.6710946\times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}. \tag{53}$$

The ad-hoc fitting factor $(3/2)$ needs a detailed explanation and is for further study.

13.Discussion

It is true that, unless stringent requirements are met, in general, speculative alternatives to currently accepted theories cannot be accepted or published. Scientific papers having content that lie outside the mainstream of current research must justify by including a clear, detailed discussion of the motivation for the new speculation, with reasons for introducing any new concepts. If the new formulation results are in contradiction with the accepted theory, then there must both be a discussion of which experiments could be done to verify that the conventional theory needs improvement, and also an analysis showing the consistency of the new theory with the existing experiments. In this context, we appeal that,

1) Subject of final unification is having a long unsuccessful history. Clearly speaking, so far, no model succeeded in implementing the Newtonian gravitational constant or Planck scale in nuclear and electroweak interactions.

2) Even though, the basic idea of String theory [42,43] is very simple, very interesting and highly intuitive, there are no concrete new predictions on low energy scales and high energy scale predictions are beyond the reach of current technology.

3) It may be noted that, since 1992, J. E Brandenburg is working on 'GEM unification theory'[44] and proposed an interesting and unified relation, $\frac{e^2}{4\pi\varepsilon_0 G_N m_p m_e} \cong \left(\frac{1}{\alpha}\right)\left\{\exp\sqrt{\frac{m_p}{m_e}}\right\}^2$. Compared to J. E Brandenburg and other available models of current unification theories, in this paper, with reference to Planck scale, we presented a variety of multipurpose arithmetic relations pertaining to nuclear, electroweak and astrophysical applications.

4) As the current unification paradigm is failing in developing a 'practical unification procedure', the point that we wish to emphasize here is that, by considering three new assumptions, we presented a number of applications connecting micro-macro physical systems and finally developed arithmetic relations for understanding the role of the Newtonian gravitational constant in microscopic physics. We appeal the mainstream physicists to see the possibility of considering the proposed relations for further investigation with respect to strong, electroweak and gravitational interactions collectively.

5) Following this kind of computational approach, it is certainly possible to reproduce another set of arithmetic relations by using which, in near future, it may be possible to find a set of absolute relations having sound physical reasoning and strong mathematical back up.

14.Conclusion

As it is inevitable to unite gravity and other three atomic interactions, if one is willing to explore the possibility of incorporating the proposed assumptions either in String theory models or in Quantum gravity models, certainly, background 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. Based on relations (28) and (29), Fermi's weak coupling constant and the three gravitational constants can be fitted in a unified approach and finally, Newtonian gravitational constant can be estimated accurately with microscopic physical constants.

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Table-1: To fit and estimate the photo electric work functions

Proton number	Mass number close to beta stability line	Symbol	Atomic Radius (pm)	Estimated work function(eV)	Experimental work function(eV)
3	7	Li	1.28E-10	2.22	2.9
4	9	Be	9.60E-11	3.22	4.98
5	10	B	8.40E-11	3.81	4.45
6	12	C	7.60E-11	4.47	5
11	23	Na	1.66E-10	2.54	2.36
12	25	Mg	1.41E-10	3.08	3.66
13	27	Al	1.21E-10	3.68	4.28
14	29	Si	1.11E-10	4.11	4.85
19	40	K	2.03E-10	2.50	2.29
20	43	Ca	1.76E-10	2.96	2.87
21	45	Sc	1.70E-10	3.11	3.5
22	47	Ti	1.60E-10	3.35	4.33
23	49	V	1.53E-10	3.55	4.3
24	52	Cr	1.39E-10	3.99	4.5
25	54	Mn	1.39E-10	4.04	4.1
26	56	Fe	1.32E-10	4.30	4.5
27	59	Co	1.26E-10	4.59	5
28	61	Ni	1.24E-10	4.71	5.15
29	63	Cu	1.32E-10	4.48	4.51
31	68	Ga	1.22E-10	4.97	4.32
33	73	As	1.19E-10	5.22	3.75
34	75	Se	1.20E-10	5.22	5.9
37	83	Rb	2.20E-10	2.94	2.26
38	85	Sr	1.95E-10	3.35	2.59
39	88	Y	1.90E-10	3.48	3.1
40	90	Zr	1.75E-10	3.80	4.05
41	93	Nb	1.64E-10	4.10	4.3
42	95	Mo	1.54E-10	4.40	4.6
44	100	Ru	1.46E-10	4.72	4.71
45	103	Rh	1.42E-10	4.90	4.98
46	106	Pd	1.39E-10	5.06	5.12
47	108	Ag	1.45E-10	4.88	4.26
48	111	Cd	1.44E-10	4.96	4.08
49	113	In	1.42E-10	5.06	4.09
50	116	Sn	1.39E-10	5.21	4.42
51	119	Sb	1.39E-10	5.26	4.55
52	121	Te	1.39E-10	5.28	4.95
55	129	Cs	2.44E-10	3.08	1.95
56	132	Ba	2.15E-10	3.52	2.7
57	135	La	2.07E-10	3.68	3.5
58	138	Ce	2.04E-10	3.76	2.9
60	143	Nd	2.01E-10	3.86	3.2
62	149	Sm	1.98E-10	3.98	2.7

63	151	Eu	1.98E-10	3.99	2.5
64	154	Gd	1.96E-10	4.06	3.17
65	157	Tb	1.94E-10	4.13	3.15
66	160	Dy	1.92E-10	4.20	3.25
67	163	Ho	1.92E-10	4.23	3.22
68	166	Er	1.89E-10	4.32	3.25
69	169	Tm	1.89E-10	4.34	3.1
70	171	Yb	1.87E-10	4.41	3
71	174	Lu	1.87E-10	4.43	3.3
72	177	Hf	1.75E-10	4.76	3.9
73	180	Ta	1.70E-10	4.93	4.25
74	183	W	1.62E-10	5.20	4.55
75	186	Re	1.51E-10	5.61	4.72
76	189	Os	1.44E-10	5.92	5.93
77	192	Ir	1.41E-10	6.08	5.27
78	195	Pt	1.36E-10	6.33	5.65
79	198	Au	1.36E-10	6.36	5.1
80	201	Hg	1.32E-10	6.59	4.49
81	204	Tl	1.45E-10	6.03	3.84
82	207	Pb	1.46E-10	6.02	4.25
83	210	Bi	1.48E-10	5.96	4.34
84	213	Po	1.40E-10	6.34	5
90	232	Th	2.06E-10	4.43	3.4
91	235	Pa	2.00E-10	4.58	3.7
92	238	U	1.96E-10	4.70	3.63
93	242	Np	1.90E-10	4.87	3.9
94	245	Pu	1.87E-10	4.97	3.6
95	248	Am	1.87E-10	4.99	3.7
96	251	Cm	1.69E-10	5.54	3.9

Table-2: To fit the mass dependent magnetic dipole moments of hot Jupiters

Hot Jupiter	**Mass** (kg)	**Magnetic dipole moment data taken from ref. [23] (J/tesla)**	**Estimated magnetic dipole moment from relation (20) (J/tesla)**	**Ratio of estimated value to ref. value**
HD 160691 d	7.98E+25	1.89E+24	1.31E+24	0.694
55 CnC e	8.55E+25	7.91E+24	1.40E+24	0.178
GJ 436 b	1.27E+26	1.31E+25	2.09E+24	0.159
HD 49674 b	2.28E+26	1.25E+25	3.75E+24	0.300
HD 76700 b	3.74E+26	2.76E+25	6.14E+24	0.223
HD 88133 b	4.18E+26	3.69E+25	6.87E+24	0.186
HD 168746 b	4.37E+26	1.93E+25	7.18E+24	0.372
HD 46375 b	4.73E+26	4.84E+25	7.77E+24	0.161
HD 63454 b	7.22E+26	8.35E+25	1.19E+25	0.142
HD 83443 b	7.79E+26	8.52E+25	1.28E+25	0.150
HD 75289 b	7.98E+26	7.31E+25	1.31E+25	0.179
51 Peg b	8.89E+26	6.71E+25	1.46E+25	0.218

BD -10 3166 b	9.12E+26	8.54E+25	1.50E+25	0.175
HD 2638 b	9.12E+26	8.66E+25	1.50E+25	0.173
HD 187123 b	9.88E+26	1.06E+26	1.62E+25	0.153
OGLE-TR-111 b	1.01E+27	8.15E+25	1.66E+25	0.204
OGLE-TR-10 b	1.08E+27	1.18E+26	1.77E+25	0.150
TrES-1	1.16E+27	1.30E+26	1.91E+25	0.147
ups-And b	1.31E+27	9.35E+25	2.15E+25	0.230
HD 209458 b	1.31E+27	1.26E+26	2.15E+25	0.171
HD 330075 b	1.44E+27	1.48E+26	2.37E+25	0.160
HD 179949 b	1.86E+27	2.15E+26	3.06E+25	0.142
HD 130322 b	2.05E+27	6.04E+25	3.37E+25	0.558
OGLE-TR-132 b	2.26E+27	5.19E+26	3.71E+25	0.072
HD 217107 b	2.43E+27	1.15E+26	3.99E+25	0.347
OGLE-TR-113 b	2.56E+27	7.17E+26	4.21E+25	0.059
OGLE-TR-56 b	2.75E+27	9.34E+26	4.52E+25	0.048
HD 73256 b	3.55E+27	5.44E+26	5.83E+25	0.107
HD 68988 b	3.61E+27	2.04E+26	5.93E+25	0.291
Tau-Boo	7.84E+27	9.77E+26	1.29E+26	0.132
HD 162020 b	2.61E+28	1.32E+27	4.29E+26	0.325

Table-3: To fit nuclear charge radii

Proton number	Mass number	Neutron number	Estimated charge radii from relation (24) fm	Charge radii from relation (25) fm
2	4	2	1.5623	1.5900
3	6	3	1.7884	1.8201
4	8	4	1.9684	2.0033
5	10	5	2.1204	2.1580
6	12	6	2.2532	2.2932
7	14	7	2.3720	2.4141
8	16	8	2.4800	2.5240
9	19	10	2.6022	2.6240
10	21	11	2.6929	2.7176
11	23	12	2.7779	2.8052
12	25	13	2.8580	2.8877
13	27	14	2.9338	2.9658
14	29	15	3.0059	3.0399
15	31	16	3.0746	3.1107
16	34	18	3.1556	3.1791
17	36	19	3.2182	3.2438
18	38	20	3.2785	3.3060
19	40	21	3.3366	3.3660
20	43	23	3.4055	3.4256
21	45	24	3.4596	3.4814
22	47	25	3.5119	3.5356
23	49	26	3.5628	3.5881
24	52	28	3.6233	3.6411
25	54	29	3.6712	3.6906
26	56	30	3.7178	3.7389
27	59	32	3.7734	3.7881
28	61	33	3.8176	3.8339
29	63	34	3.8608	3.8786

30	66	36	3.9124	3.9246
31	68	37	3.9536	3.9673
32	71	39	4.0027	4.0116
33	73	40	4.0421	4.0524
34	75	41	4.0808	4.0924
35	78	43	4.1269	4.1342
36	80	44	4.1640	4.1726
37	83	46	4.2083	4.2130
38	85	47	4.2440	4.2500
39	88	49	4.2866	4.2891
40	90	50	4.3211	4.3247
41	93	52	4.3622	4.3627
42	95	53	4.3955	4.3971
43	98	55	4.4352	4.4339
44	100	56	4.4674	4.4672
45	103	58	4.5058	4.5029
46	106	60	4.5436	4.5382
47	108	61	4.5743	4.5699
48	111	63	4.6109	4.6043
49	113	64	4.6408	4.6351
50	116	66	4.6764	4.6686
51	119	68	4.7114	4.7016
52	121	69	4.7400	4.7311
53	124	71	4.7741	4.7633
54	127	73	4.8077	4.7952
55	129	74	4.8352	4.8235
56	132	76	4.8679	4.8547
57	135	78	4.9002	4.8854
58	138	80	4.9320	4.9159
59	140	81	4.9582	4.9428
60	143	83	4.9893	4.9725
61	146	85	5.0200	5.0020
62	149	87	5.0503	5.0312
63	151	88	5.0753	5.0568
64	154	90	5.1050	5.0853
65	157	92	5.1343	5.1136
66	160	94	5.1633	5.1416
67	163	96	5.1919	5.1693
68	166	98	5.2202	5.1968
69	168	99	5.2436	5.2207
70	171	101	5.2714	5.2476
71	174	103	5.2988	5.2743
72	177	105	5.3260	5.3007
73	180	107	5.3529	5.3269
74	183	109	5.3795	5.3528
75	186	111	5.4058	5.3785
76	189	113	5.4319	5.4040
77	192	115	5.4577	5.4293
78	195	117	5.4833	5.4544
79	198	119	5.5086	5.4792
80	201	121	5.5337	5.5038
81	204	123	5.5586	5.5282
82	207	125	5.5832	5.5524

83	210	127	5.6077	5.5765
84	213	129	5.6319	5.6003
85	216	131	5.6558	5.6239
86	219	133	5.6796	5.6474
87	222	135	5.7032	5.6706
88	226	138	5.7302	5.6969
89	229	140	5.7534	5.7198
90	232	142	5.7763	5.7425
91	235	144	5.7991	5.7651
92	238	146	5.8217	5.7875
93	241	148	5.8442	5.8097
94	245	151	5.8698	5.8349
95	248	153	5.8919	5.8568
96	251	155	5.9138	5.8785
97	254	157	5.9355	5.9001
98	257	159	5.9570	5.9215
99	261	162	5.9817	5.9459
100	264	164	6.0029	5.9670

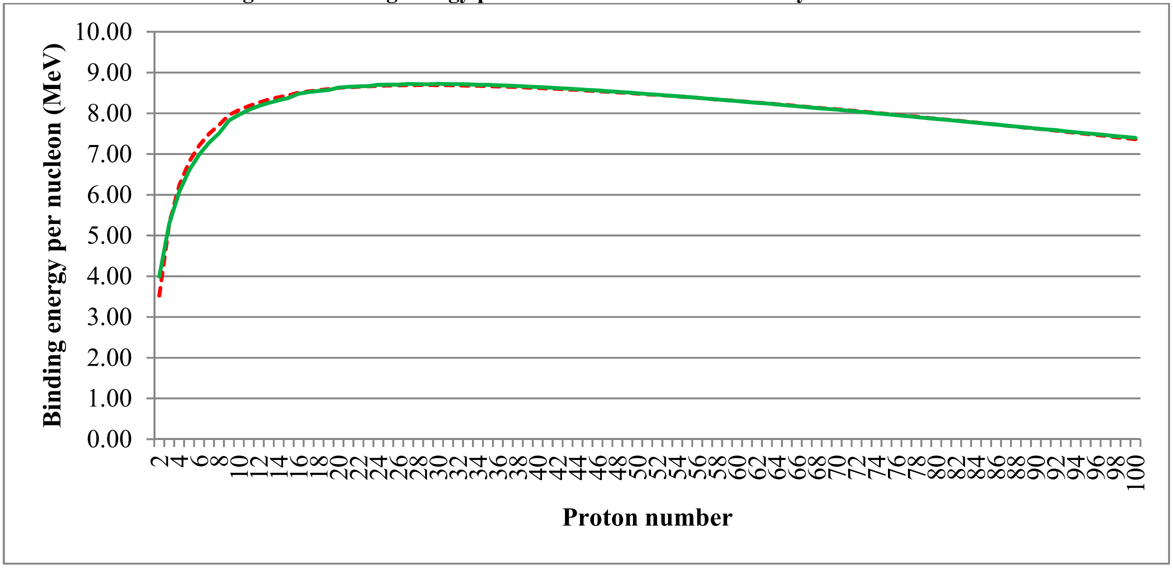
Table 4: To estimate nuclear binding energy close to beta stability line

Proton number	**Mass number**	**Neutron number**	**Estimated binding energy Relation (34) (MeV)**	**Estimated binding energy per nucleon (MeV)**	**(1 to 4) terms of SEMF binding energy (MeV)**	**(1 to 4) terms of SEMF binding energy per nucleon (MeV)**
2	4	2	14.1	3.53	16.0	3.99
3	6	3	31.8	5.30	31.7	5.29
4	8	4	49.8	6.23	48.5	6.07
5	10	5	68.1	6.81	66.0	6.60
6	12	6	86.5	7.21	83.8	6.98
7	14	7	105.0	7.50	101.9	7.28
8	16	8	123.5	7.72	120.1	7.51
9	19	10	151.3	7.96	148.7	7.82
10	21	11	169.8	8.08	167.3	7.97
11	23	12	188.3	8.18	185.9	8.08
12	25	13	206.7	8.27	204.5	8.18
13	27	14	225.1	8.34	223.0	8.26
14	29	15	243.5	8.40	241.4	8.32
15	31	16	261.9	8.45	259.7	8.38
16	34	18	289.3	8.51	288.4	8.48
17	36	19	307.5	8.54	306.7	8.52
18	38	20	325.7	8.57	324.9	8.55
19	40	21	343.8	8.59	343.0	8.57
20	43	23	370.9	8.62	371.1	8.63
21	45	24	388.8	8.64	389.1	8.65
22	47	25	406.7	8.65	407.0	8.66
23	49	26	424.6	8.66	424.7	8.67
24	52	28	451.2	8.68	452.4	8.70
25	54	29	468.9	8.68	470.0	8.70
26	56	30	486.5	8.69	487.4	8.70
27	59	32	512.9	8.69	514.6	8.72

28	61	33	530.4	8.69	531.9	8.72
29	63	34	547.7	8.69	549.0	8.71
30	66	36	573.7	8.69	575.8	8.72
31	68	37	591.0	8.69	592.8	8.72
32	71	39	616.7	8.69	619.1	8.72
33	73	40	633.8	8.68	635.9	8.71
34	75	41	650.8	8.68	652.5	8.70
35	78	43	676.2	8.67	678.5	8.70
36	80	44	693.0	8.66	694.9	8.69
37	83	46	718.1	8.65	720.5	8.68
38	85	47	734.8	8.64	736.7	8.67
39	88	49	759.7	8.63	762.0	8.66
40	90	50	776.1	8.62	778.0	8.64
41	93	52	800.8	8.61	802.9	8.63
42	95	53	817.0	8.60	818.8	8.62
43	98	55	841.4	8.59	843.4	8.61
44	100	56	857.5	8.58	859.0	8.59
45	103	58	881.6	8.56	883.3	8.58
46	106	60	905.6	8.54	907.4	8.56
47	108	61	921.4	8.53	922.8	8.54
48	111	63	945.1	8.51	946.5	8.53
49	113	64	960.7	8.50	961.7	8.51
50	116	66	984.2	8.48	985.2	8.49
51	119	68	1007.5	8.47	1008.5	8.47
52	121	69	1022.8	8.45	1023.4	8.46
53	124	71	1045.8	8.43	1046.4	8.44
54	127	73	1068.7	8.41	1069.2	8.42
55	129	74	1083.7	8.40	1083.8	8.40
56	132	76	1106.3	8.38	1106.4	8.38
57	135	78	1128.8	8.36	1128.7	8.36
58	138	80	1151.1	8.34	1150.9	8.34
59	140	81	1165.7	8.33	1165.2	8.32
60	143	83	1187.8	8.31	1187.1	8.30
61	146	85	1209.6	8.29	1208.8	8.28
62	149	87	1231.3	8.26	1230.4	8.26
63	151	88	1245.6	8.25	1244.4	8.24
64	154	90	1267.0	8.23	1265.7	8.22
65	157	92	1288.3	8.21	1286.9	8.20
66	160	94	1309.4	8.18	1307.9	8.17
67	163	96	1330.4	8.16	1328.7	8.15
68	166	98	1351.2	8.14	1349.5	8.13
69	169	100	1371.9	8.12	1370.0	8.11
70	171	101	1385.4	8.10	1383.4	8.09
71	174	103	1405.7	8.08	1403.7	8.07
72	177	105	1426.0	8.06	1423.9	8.04
73	180	107	1446.0	8.03	1443.9	8.02
74	183	109	1466.0	8.01	1463.8	8.00
75	186	111	1485.7	7.99	1483.6	7.98
76	189	113	1505.3	7.96	1503.2	7.95
77	192	115	1524.8	7.94	1522.7	7.93
78	195	117	1544.0	7.92	1542.0	7.91
79	198	119	1563.2	7.89	1561.2	7.89
80	201	121	1582.1	7.87	1580.3	7.86

81	204	123	1600.9	7.85	1599.3	7.84
82	207	125	1619.6	7.82	1618.1	7.82
83	210	127	1638.1	7.80	1636.8	7.79
84	213	129	1656.4	7.78	1655.4	7.77
85	216	131	1674.6	7.75	1673.8	7.75
86	219	133	1692.6	7.73	1692.1	7.73
87	223	136	1716.6	7.70	1716.4	7.70
88	226	138	1734.3	7.67	1734.4	7.67
89	229	140	1751.8	7.65	1752.3	7.65
90	232	142	1769.1	7.63	1770.1	7.63
91	235	144	1786.3	7.60	1787.8	7.61
92	238	146	1803.3	7.58	1805.4	7.59
93	242	149	1826.1	7.55	1828.5	7.56
94	245	151	1842.7	7.52	1845.8	7.53
95	248	153	1859.2	7.50	1863.0	7.51
96	251	155	1875.5	7.47	1880.1	7.49
97	254	157	1891.7	7.45	1897.1	7.47
98	258	160	1913.4	7.42	1919.4	7.44
99	261	162	1929.2	7.39	1936.1	7.42
100	264	164	1944.8	7.37	1952.7	7.40

Figure 1: Binding energy per nucleon close to beta stability line of Z= 2 to 100



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