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Article

Revised Electroweak and Asymmetry Terms of the Strong and Electroweak Mass Formula Associated with 4G Model of Final Unification

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Abstract: Considering our 4G model of final unification, there exists a nuclear elementary charge of magnitude *2.9464e* and strong coupling constant, α_s, is the squared ratio of ordinary elementary charge to nuclear elementary charge. Nuclear elementary charge is having many applications in nuclear physics and other branches of physics like particle physics, super conductivity, condensed matter physics and unified physics. Starting from Z =1 to 137, by refining the general nuclear binding energy formula with 6 terms, there is a possibility for defining a set of binding energy coefficients assumed to be linked with the strong coupling constant. With reference to our 4G model of final unification, in our recent publications, we have developed a new formula for estimating nuclear binding energy in terms of strong and electroweak interactions. Our formula constitutes 4 simple terms and only one energy coefficient of magnitude 10.1 MeV. First term is a volume term, second term seems to be a representation of free nucleons associated with electroweak interaction, third term is a radial term and fourth one is an asymmetry term about the mean stable mass number. Common energy coefficient can be expressed as, $\left[(2.95e)^2/4\pi\varepsilon_0(1.24\text{ fm})\right]\cong 10.1\,\text{MeV}$. In this paper, we have revised our electroweak term and asymmetry term for a better understanding and applicability for the entire range of atomic nuclides. With reference to an advanced binding energy formula and considering (2Z-1) and (3.5Z) as the lower and upper mass limits, for the revised 4 term formula, RMS deviation is 13.5 MeV and for the 6 term semi empirical mass formula, RMS deviation is 3.2 MeV. Point of concern is that, current version of exploring nuclear structure is not 100% inline with strong and weak interaction concepts and we argue that, our approach is far better, simple and cohesive. It can be understood and confirmed from the Fermi gas model of nucleus. By fitting the maximum binding energy associated with stable mass numbers, we have provided solid support for the existence of the proposed nuclear elementary charge, $e_n \cong 2.9464e$ and the proposed electroweak coefficient, $\beta \cong 0.001605$ associated with beta decay.

Keywords: 4G model of final unification; nuclear elementary charge; strong coupling constant; nuclear binding energy; electroweak coefficient; beta decay and nuclear stability; strong and electroweak mass formula; revised electroweak and asymmetry terms; common energy coefficient; 6 term semi empirical mass formula; variable energy coefficients; Fermi gas model

1. Introduction

With reference to our 4G model of final unification, in our recent publications [1-12], we have developed a new formula for estimating nuclear binding energy [13-24] in terms of strong and electroweak interactions [25,26]. Our formula constitutes 4 simple terms and only one energy coefficient of magnitude 10.1 MeV. First term is a volume term, second term seems to be a representation of free nucleons associated with electroweak interaction, third term is a radial term

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and fourth one is an asymmetry term about the mean stable mass number. Considering this kind of approach, nuclear structure can be understood in terms of strong and weak interactions and complicated concepts like cold nuclear fusion can be understood in a theoretical approach positively.

In this paper, we have presented our revised electroweak and asymmetry terms applicable for the entire range of atomic nuclides, starting from Z=1 to 137. Accuracy point of view, it needs further study. Proceeding further, we have proposed a very simple relation for estimating the maximum binding energy associated with stable mass numbers and thus provided strong support for the existence of the proposed nuclear elementary charge and corresponding electroweak coefficient;

2. Three Assumptions of 4G Model of Final Unification

Following our 4G model of final unification [1-12]

1) There exists a characteristic electroweak fermion of rest energy, $M_{wf}c^2 \cong 584.725\text{ GeV}$. It can be considered as the zygote of all elementary particles.
2) There exists a nuclear elementary charge in such a way that, $\left(\frac{e}{e_n}\right)^2 \cong \alpha_s \cong 0.1152$ = Strong coupling constant and $e_n \cong 2.9464e$.
3) Each atomic interaction is associated with a characteristic large gravitational coupling constant. Their fitted magnitudes are,

$$G_e \cong \text{Electromgnetic gravitational constant} \cong 2.374335\times10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$
$$G_n \cong \text{Nuclear gravitational constant} \cong 3.329561\times10^{28}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$
$$G_w \cong \text{Electroweak gravitational constant} \cong 2.909745\times10^{22}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

It may be noted that,

1) Weak interaction point of view [25,26], following our assumptions, Fermi's weak coupling constant can be fitted with the following relations.

$$\left.\begin{array}{l} G_F \cong \left(\frac{m_e}{m_p}\right)^2 \hbar c R_0^2 \cong G_w M_{wf}^2 R_w^2 \cong 1.44021\times10^{-62}\ \text{J.m}^3 \\ \text{where,} \begin{cases} R_0 \cong \frac{2G_n m_p}{c^2} \cong 1.24\times10^{-15}\ \text{m} \\ R_w \cong \frac{2G_w M_{wf}}{c^2} \cong 6.75\times10^{-19}\ \text{m} \end{cases} \end{array}\right\} \quad (1)$$

2) In a unified approach, most important point to be noted is that [10],

$$\hbar c \equiv G_w M_{wf}^2 \quad (2)$$

Clearly speaking, based on the electroweak interaction, the well believed quantum constant $\hbar c$ seems to have a deep inner meaning. Following this kind of relation, there is a possibility to understand the integral nature of quantum mechanics with a relation of the form, $n^2\hbar \equiv \frac{G_w\left(nM_{wf}\right)^2}{c}$ where $n = 1,2,3,..$ It needs further study with reference to EPR argument [27-30] and [1,31]. String theory [32-36] can be made practical with reference to the three atomic gravitational constants associated with weak, strong and electromagnetic interaction gravitational

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constants. See Table 1. and Table 2. for sample string tensions and energies without any coupling constants.

Table 1. Charge dependent string tensions and string energies.

S.No	Interaction	String Tension	String energy
1	Weak	$\frac{c^4}{4G_w} \cong 6.94\times 10^{10}$ N	$\sqrt{\frac{e^2}{4\pi\varepsilon_0}\left(\frac{c^4}{4G_w}\right)} \cong 24.975$ GeV
2	Strong	$\frac{c^4}{4G_n} \cong 6.065\times 10^{4}$ N	$\sqrt{\frac{e_n^2}{4\pi\varepsilon_0}\left(\frac{c^4}{4G_n}\right)} \cong 68.79$ MeV
3	Electromagnetic	$\frac{c^4}{4G_e} \cong 8.505\times 10^{-5}$ N	$\sqrt{\frac{e^2}{4\pi\varepsilon_0}\left(\frac{c^4}{4G_e}\right)} \cong 874.3$ eV

Table 2. Quantum string tensions and string energies.

S.No	Interaction	String Tension	String energy
1	Weak	$\frac{c^4}{4G_w} \cong 6.94\times 10^{10}$ N	$\sqrt{\hbar c\left(\frac{c^4}{4G_w}\right)} \cong 292.36$ GeV
2	Strong	$\frac{c^4}{4G_n} \cong 6.065\times 10^{4}$ N	$\sqrt{\hbar c\left(\frac{c^4}{4G_n}\right)} \cong 273.3$ MeV
3	Electromagnetic	$\frac{c^4}{4G_e} \cong 8.505\times 10^{-5}$ N	$\sqrt{\hbar c\left(\frac{c^4}{4G_e}\right)} \cong 10234.77$ eV

2.1. Understanding the Electroweak Coefficient and Nuclear Stability

Our basic idea is that, all the nucleons are not participating in the nuclear binding energy scheme and non-participating nucleons can be called as 'Free nucleons'. These free nucleons revolve round the nuclear core. Each free nucleon reduces the nuclear binding energy by 10.1 MeV. Protons and neutrons jointly play a crucial role in fixing the number of free nucleons. Electroweak interaction is having a key role in understanding free nucleons and nuclear stability against beta decay. In this context, we noticed that,

$$\frac{m_p}{M_{wf}} \cong \frac{938.272\text{ MeV}}{584.725\text{ GeV}} \cong 0.001605 \tag{3}$$

$$\frac{\sqrt{\left(m_\pi c^2\right)^{\pm}\left(m_\pi c^2\right)^{0}}}{\sqrt{\left(m_w c^2\right)^{\pm}\left(m_z c^2\right)^{0}}} \cong \frac{\sqrt{139.57\times 134.98}\text{ MeV}}{\sqrt{80379.0\times 91187.6}\text{ MeV}} \cong 0.001603 \tag{4}$$

Here ratio of rest mass of proton to the assumed electroweak fermion is equal to the ratio of mean mass of pions to the mean mass of electroweak bosons. Based on this unique and concrete observation, we are very confident to say that, strong and weak interactions play a vital role exploring the secrets of nuclear structure. Thus, qualitatively and quantitatively, electroweak coefficient can be defined as,

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$$\frac{m_p}{M_{wf}} \cong \frac{\sqrt{\left(m_\pi c^2\right)^{\pm}\left(m_\pi c^2\right)^0}}{\sqrt{\left(m_w c^2\right)^{\pm}\left(m_z c^2\right)^0}} \cong \beta \cong 0.001605$$
$$\cong \text{Electroweak coefficient} \tag{5}$$

Based on this electroweak coefficient $\beta \cong 0.001605$, stability corresponding to nuclear beta decay can be understood with the following relation.

$$A_s \cong 2Z + \beta(2Z)^2$$
$$\cong 2Z + 0.00642Z^2 \cong 2Z + \beta_s Z^2 \tag{6}$$
$$\text{where } \beta_s \cong 4\beta \cong 0.00642 \cong \text{Beta stability factor}$$

One can find a similar relation in the literature [16]. This relation can be well tested for Z=21 to 92. For example,

$$\frac{45-(2\times 21)}{4(21)^2} \cong 0.00170; \quad \frac{63-(2\times 29)}{4(29)^2} \cong 0.00149; \quad \frac{89-(2\times 39)}{4(39)^2} \cong 0.00181;$$
$$\frac{109-(2\times 47)}{4(47)^2} \cong 0.0017; \quad \frac{169-(2\times 69)}{4(69)^2} \cong 0.00163; \quad \frac{238-(2\times 92)}{4(92)^2} \cong 0.001595;$$

This is one best practical and quantitative application of our proposed electroweak fermion and bosons. Following this relation and based on various semi empirical mass formulae [13-21], by knowing any stable mass number, its corresponding proton number can be estimated with,

$$Z \cong \frac{A_S}{1+\sqrt{1+0.0064A_S}} \cong \frac{A_S}{2+0.0153A_S^{2/3}} \tag{7}$$

$$\text{where } \frac{a_c}{2a_{asy}} \cong \frac{0.71\text{ MeV}}{2\times 23.21\text{ MeV}} \cong \frac{0.6615\text{ MeV}}{2\times 21.6091\text{ MeV}} \cong 0.0153$$

Considering this relation, we are working on understanding the stable super heavy elements.

2.2. Revised Strong and Electroweak Mass Formula

In this section, we present our revised strong and electroweak mass formula. It needs a review for accuracy and further simplicity. Point of interest and concern is that, in our approach, there exists only one common energy coefficient of magnitude 10.1 MeV. It can be understood in two different ways. One way of considering it as a form of potential. It may also be noted that, understanding nuclear binding energy for a wide range of proton numbers and neutron numbers with four terms and only one energy coefficient is a really a challenging and complicated task.

$$B_0 \cong -\frac{e_n^2}{4\pi\varepsilon_0 R_0} \cong -\left(\frac{1}{\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 R_0} \cong 10.1\text{ MeV}$$
$$\text{where}$$
$$e_n \cong \text{Nuclear elementary charge} \tag{8}$$
$$\alpha_s \cong \text{Strong coupling constant} \cong 0.115 \text{ to } 0.12\,[37]$$
$$R_0 \cong (1.24 \text{ to } 1.25)\text{ fm}$$

Another way of understanding 10.1 MeV is associated with 3 up quarks and 3 down quarks [38].

$$B_0 \cong \frac{\left(2m_u c^2 + m_d c^2\right) + \left(m_u c^2 + 2m_d c^2\right)}{2} \cong \frac{3}{2}\left(m_u c^2 + m_d c^2\right)$$
$$\text{where } m_u c^2 \cong (2.16 \pm 0.07)\,\text{MeV}$$
$$\left(2m_u c^2 + m_d c^2\right) \cong \text{Baby Proton's rest energy} \quad (9)$$
$$m_d c^2 \cong (4.70 \pm 0.07)\,\text{MeV}$$
$$\left(m_u c^2 + 2m_d c^2\right) \cong \text{Baby Neutron's rest energy}$$

Proceeding further, for Z=1 to 137, nuclear binding energy cab be understood with the following relation.

$$BE \cong T_{vol} - T_{free} - T_{radial} - T_{asy}$$
$$\cong \left(A - A_{free} - A_{radial} - A_{asy}\right) \times 10.1\,\text{MeV} \quad (10)$$

where, $A \times 10.1$ MeV represents the volume term

$A_{free} \times 10.1$ MeV represents the electroweak term linked with the number of free nucleons or loosely bound nucleons

$A_{radial} \times 10.1$ MeV represents the radial term

$A_{asym} \times 10.1$ MeV represents the asymmetry term

Here, first, third and fourth terms are simple to understand and follow. The second term (assumed be linked with electroweak interaction and number of free or loosely bound nucleons) seems to be complicated to understand and follow. Considering an error of $\pm(5 \text{ to } 10)\,\text{MeV}$, there is a possibility for understanding our efforts in developing the formulae.

Volume term can be expressed as,

$$T_{vol} \cong A \times 10.1\,\text{MeV} \quad (11)$$

In this section, in a trial-error method, revised formula for Z=1 to 137 can be expressed as,

$$T_{free} \cong A_{free} \times 10.1\,\text{MeV}$$
$$\cong \frac{1}{2} + \beta_Z \left[Z^2 + N^2 + \frac{Z^7}{2N^5} - Z\sqrt{ZN}I^2 \right] 10.1\,\text{MeV}$$
$$\text{where } \beta_Z \cong (2 - Z\beta_s)^{0.3} \times 0.001605 \quad (12)$$
$$\beta_s \cong 4 \times 0.001605 \cong 4\beta \cong 0.00642$$
$$I \cong \left(\frac{N-Z}{A}\right)^2 \text{ and}$$
$$(2 - Z\beta_s)^{0.3} \cong \text{Electroweak factor of Z}$$

With reference to the proposed electroweak coefficient, $\beta \cong 0.001605$, and considering the entire range of atomic nuclides, for lower proton numbers, β_Z seems to be higher than β and for higher proton numbers, β_Z seems to approach β. This is the very important point to be noted in this paper. The newly developed 'electroweak factor of Z, $(2 - Z\beta_s)^{0.3}$ seems to be a very good approximation and needs fine tuning for light and medium atomic nuclides. See the following Fig.1 for understanding the decreasing trend of $(2 - Z\beta_s)^{0.3}$ for the increasing trend of Z=1 to 137. It can be reviewed and reformulated for better accuracy.

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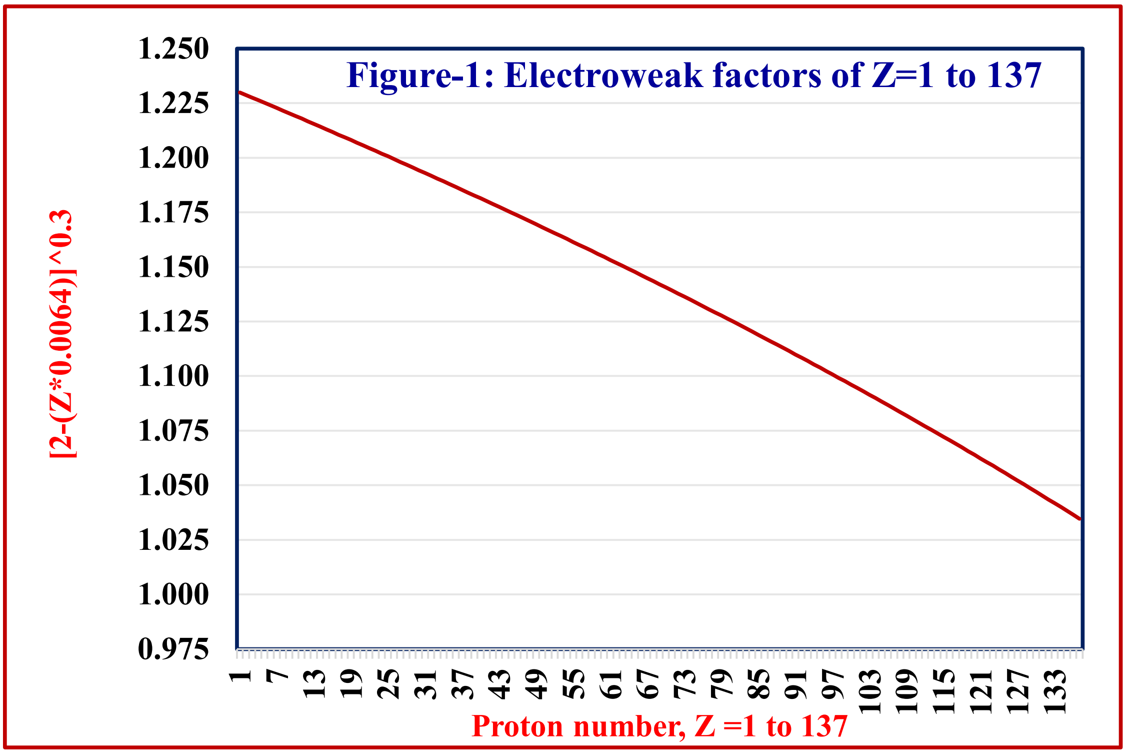

In addition to that, the expression, $\frac{Z^7}{2N^5}$ is also an approximation for reducing the binding energy of lower isotopes of any proton number having $N \approx Z$. We are working in this direction. With a deep theoretical study, we are sure that, a correct expression can be developed for understanding the number of free nucleons associated with electroweak interaction.

Radial term can be expressed as,

$$T_{radial} \cong A_{radial} \times 10.1\,\text{MeV} \cong A^{1/3} \times 10.1\,\text{MeV} \tag{13}$$

Revised asymmetry term can be expressed as

$$T_{asy} \cong A_{asy} \times 10.1\,\text{MeV} \cong \gamma^k \left[\frac{(A_s - A)^2}{A_s}\right] \times 10.1\,\text{MeV}$$
$$\text{where } \gamma \cong 1 - \left(\frac{N-Z}{A}\right)^2 \text{ and } k \cong \left(\frac{N}{Z}\right)^{1/3} \tag{14}$$

For evaluating the effectiveness of relations (5) to (14), we consider the following advanced relation as a reference [19].

$$BE \cong \left\{ \left\{\left[1 + \left(\frac{4k_v}{A^2}\right)|T_z|\left(|T_z|+1\right)\right] a_v * A\right\} + \left\{\left[1 + \left(\frac{4k_s}{A^2}\right)|T_z|\left(|T_z|+1\right)\right] a_s * A^{\frac{2}{3}}\right\} + \left\{a_c * \left(\frac{Z^2}{A^{1/3}}\right)\right\} + \left\{f_p * \frac{Z^2}{A}\right\} + E_p \right\} \tag{15}$$

where, $T_z \cong$ 3rd component of isospin $= \frac{1}{2}(Z-N)$

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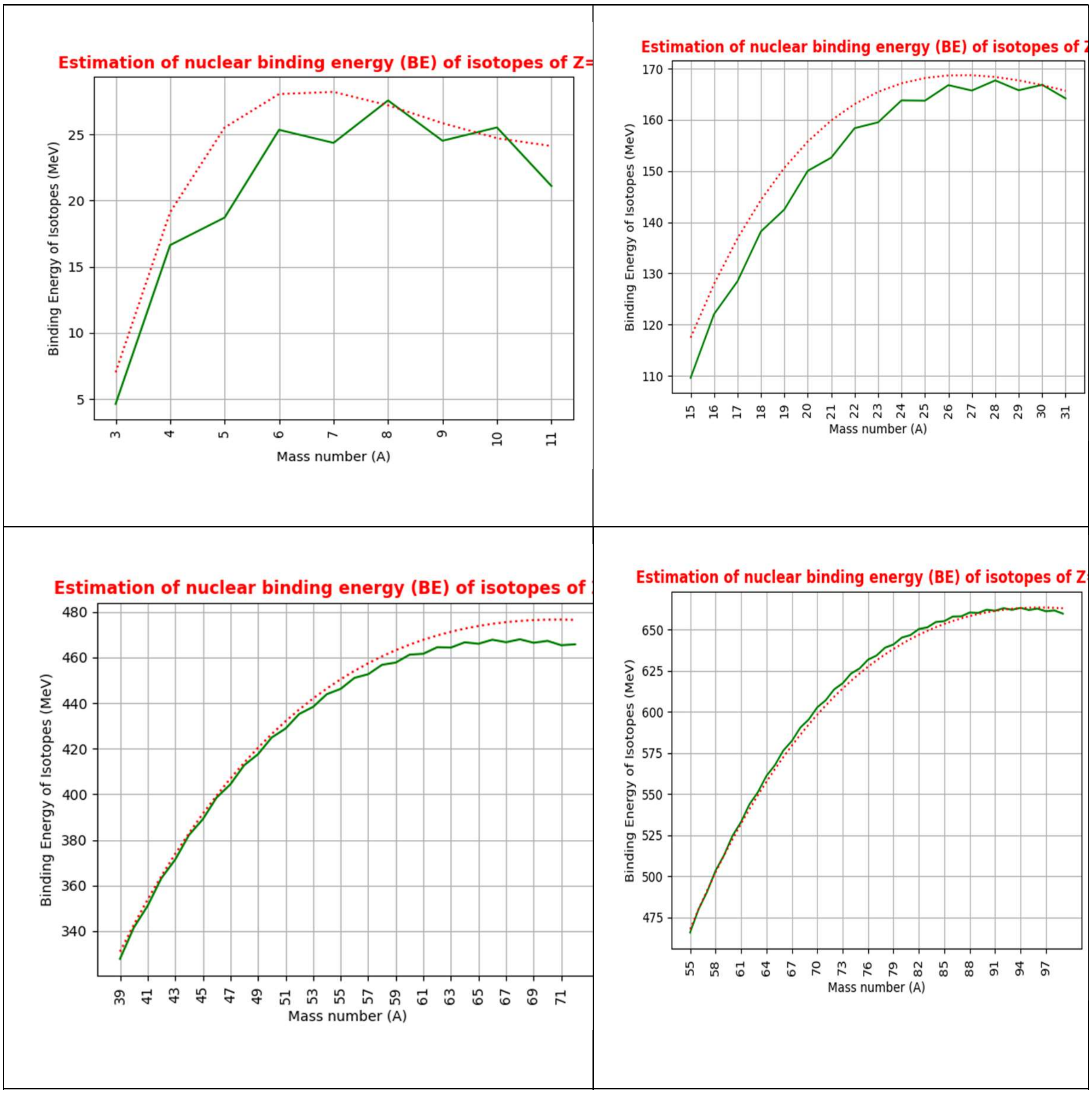
$$\left\{\begin{array}{l} a_v = -15.4963 \text{ MeV}, \; a_s = 17.7937 \text{ MeV} \\ k_v = -1.8232, \; k_s = -2.2593 \\ a_c = 0.7093 \text{ MeV}, f_p = -1.2739 \text{ MeV} \\ d_n = 4.6919 \text{ MeV}, \; d_p = 4.7230 \text{ MeV} \\ d_{np} = -6.4920 \text{ MeV} \end{array}\right\} \text{ and } \left\{\begin{array}{l} \text{for } (Z,\, N) \text{ Odd, } E_p \cong \frac{d_n}{N^{1/3}} + \frac{d_p}{Z^{1/3}} + \frac{d_{np}}{A^{2/3}} \\ \text{for } (\text{Odd } Z,\, \text{Even } N),\, E_p \cong \frac{d_p}{Z^{1/3}} \\ \text{for } (\text{Even } Z,\, \text{Odd } N),\, E_p \cong \frac{d_n}{N^{1/3}} \\ \text{for } (\text{Even } Z,\, \text{Even } N),\; E_p \cong 0 \end{array}\right\}$$

See the following Table 3 prepared for estimating the nuclear binding energy of isotopes of Z=2,8,20,28, 50,70,82,100,118 and 137. Red curve is our fit and green curve is the reference binding energy curve [19]. Starting from Z=1 to 137, lower and upper mass numbers have been taken as (2Z)-1 and (3.5Z) respectively.

Table 3. Fitting the binding energy curves for Z=2,8,20,28,50,70,82,100,118 and 137 based on relations (10) & (15).



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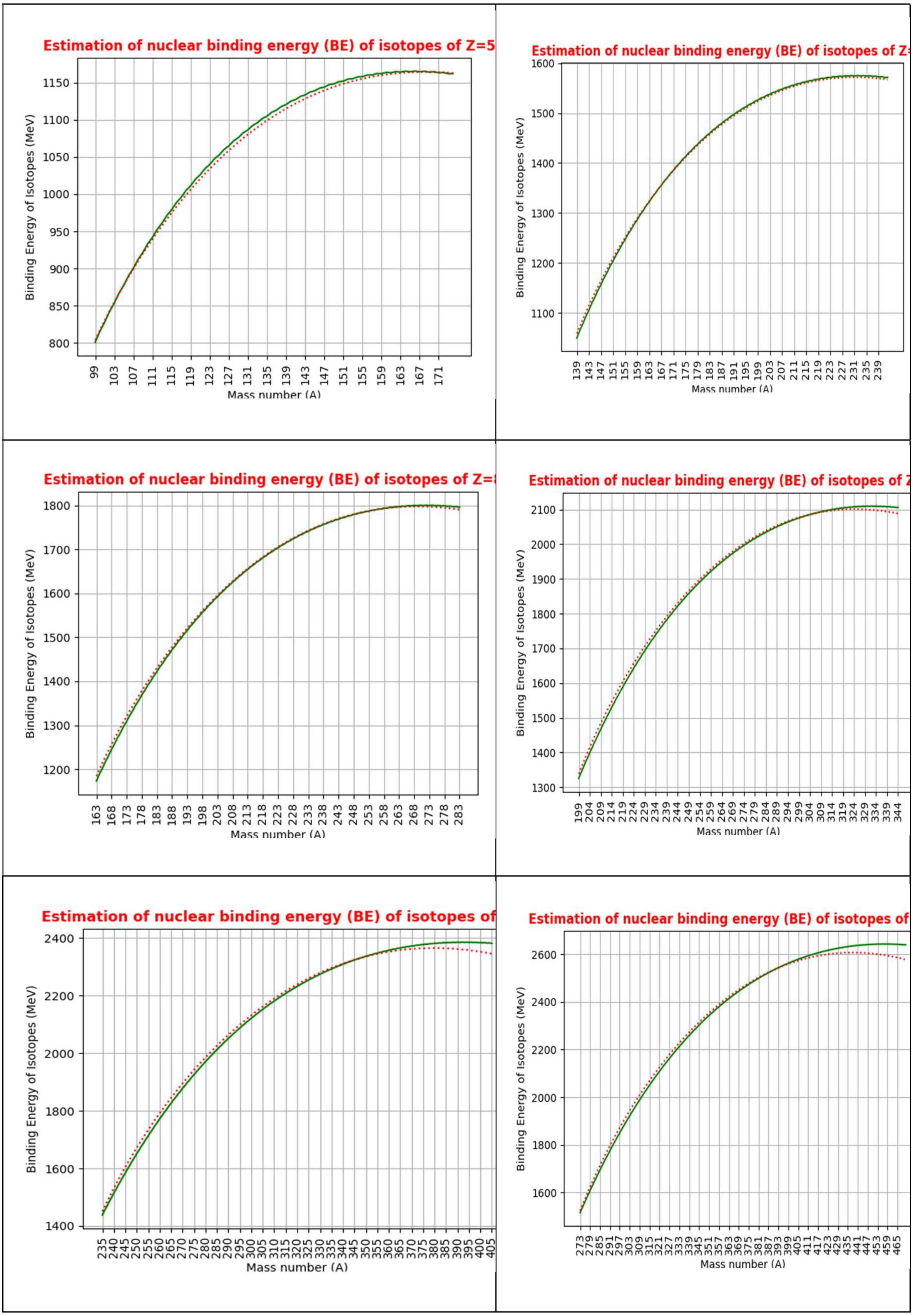

For our crude approximation, with reference to relation (15), for a wide range of protons and neutrons, relation (10) is having a root mean square deviation of 13.47 MeV. Error seems to be linked with the binding energy of higher mass numbers of heavy and super heavy proton numbers. Keeping this difficulty in view, based on the energy coefficient 10.1 MeV, we have developed a 6 term semi empirical relation (16) with a mean square deviation of 3.22 MeV where lower and upper mass limits are, (2Z)-1 and (3.5Z) respectively. See section 3.

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3. Revised 6 Term Semi Empirical Mass Formula

In our very recent preprint paper [39], we have presented a revised form of the semi empirical mass formula (SEMF) with surface, coulomb and asymmetric energy coefficients as variables. This can be considered as a hybrid form of available SEMF. With a single set of energy coefficients, it seems to work for Z=1 to 137 and needs fine tuning for heavy isotopes of light proton numbers. In this context, we would like to emphasize the point that, strong coupling constant plays a vital role in fitting the nuclear binding energy coefficients. Clearly speaking, strong coupling constant can be inferred from nuclear binding energy coefficients. Considering our strong and electroweak mass formula and considering the proposed (revised) 6 term semi empirical mass formula, there is a chance to identify the strong coupling constant as a fundamental building block of atomic nuclei.

With reference to relation (10) and considering surface, Coulomb and asymmetry energy coefficients as variables, we have presented the following 6 term semi empirical mass formula. All the energy coefficients are having an inherent correlation with the proposed 10.1 MeV (common) energy coefficient and the strong coupling constant [37].

Let, Volume energy coefficient, $a_v \cong \left(\frac{8}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 R_0} \cong 16.0\ \text{MeV}$

Asymmetry energy coefficient, $a_{asy} \cong \left[1-\frac{1}{\text{A}}\right]\left(\frac{12}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 R_0} \cong \left[1-\frac{1}{\text{A}}\right]\times 24.5\ \text{MeV}$

Surface energy coefficient, $a_s \cong \left[1-\left(\frac{\text{N}-\text{Z}}{\text{A}}\right)^2\right]\left(\frac{2a_v a_{asy}}{(a_v+a_{asy})}\right) \cong \left[1-\left(\frac{\text{N}-\text{Z}}{\text{A}}\right)^2\right]\times 19.4\ \text{MeV}$

Coulombic energy coefficient, $a_c \cong \left\{1-\left(\frac{\text{N}-\text{Z}}{\text{A}}\right)^2\right\}^{-x}\times 0.71\,\text{MeV}$ where $x \cong 0.75-\frac{Z}{2A}$

Pairing energy coefficient, $a_p \cong \left(\frac{1}{\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 R_0} \cong 10.0\,\text{MeV}$

Congruent energy coefficient, $a_{cg} \cong \left(\frac{1}{\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 R_0} \cong 10.0\,\text{MeV}$

Thus, 6 term semi empirical mass formula can be expressed as,

$$\left.\begin{aligned} BE \cong [16.0\times A]-\left[\gamma\times 19.4\times A^{2/3}\right]-\left[\frac{0.71\times Z^2}{\gamma^x A^{1/3}}\right] \\ -\left\{\left[\left(1-\frac{1}{A}\right)24.5\right]\frac{(A-2Z)^2}{A}\right\}\pm\left[\frac{10}{\sqrt{A}}\right]+\left[10\times\exp\left(-4.2\frac{|\text{N}-\text{Z}|}{\text{A}}\right)\right] \end{aligned}\right\} \quad (16)$$

$$\text{where } \gamma \cong 1-\left(\frac{N-Z}{A}\right)^2$$

It seems to work from Z=1 to 137 without any difficulty and needs fine tuning for heavy isotopes of very light proton numbers. See the following Table 4 for the binding energy curves prepared for magic numbers [40], Z=2,8,20,28,50,82,100 and 114. Red curve is our fit and green curve is the reference binding energy curve [19]. Starting from Z=1 to 137, lower and upper mass numbers have been taken as (2Z)-1 and (3.5Z) respectively. For our crude approximation, with reference to relation (10), for a wide range of protons and neutrons, relation (5) is having a root mean square deviation of 3.22 MeV.

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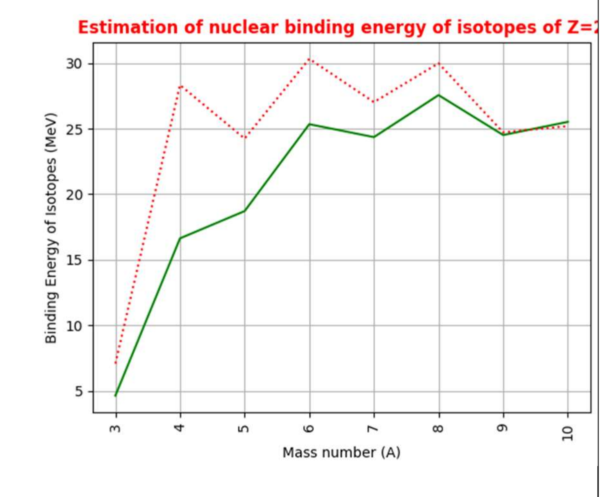
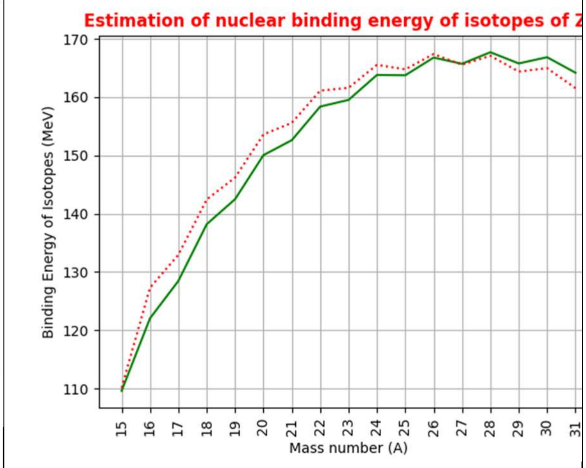
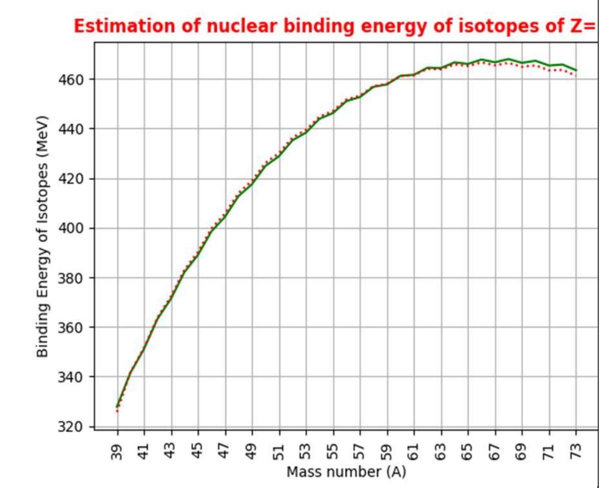
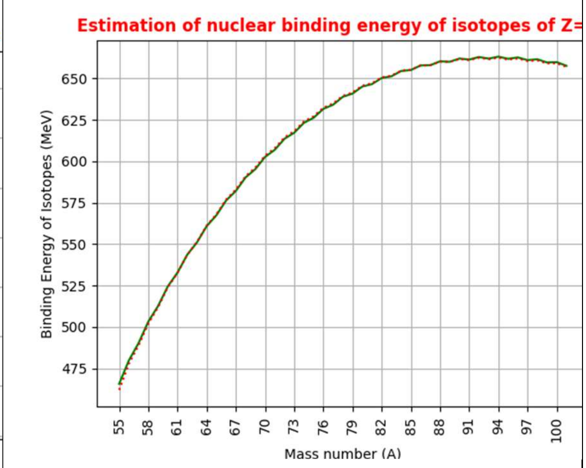
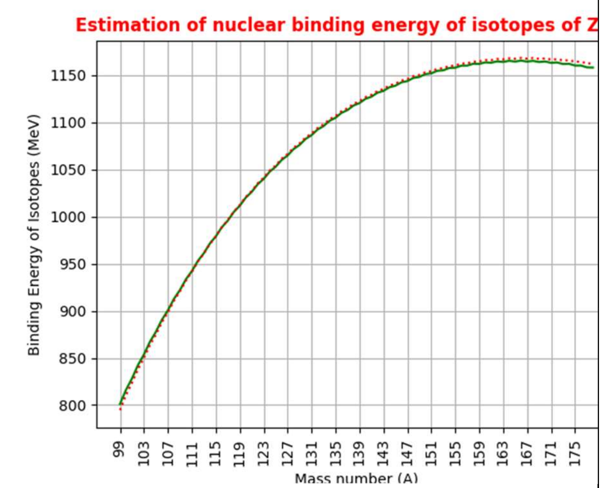
Table 4. Fitting the binding energy curves for Z=2,8,20,28,50,82,100 and 114 based on relations (15) & (16).

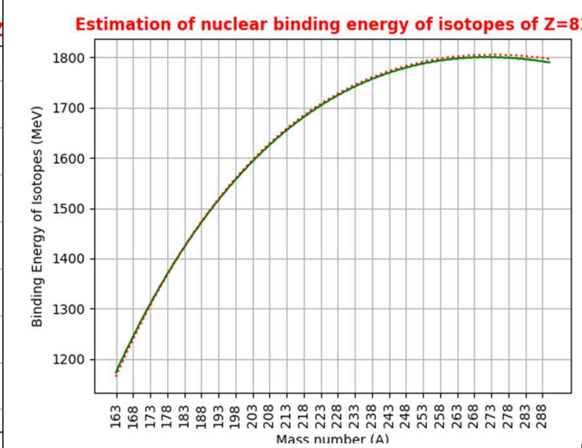












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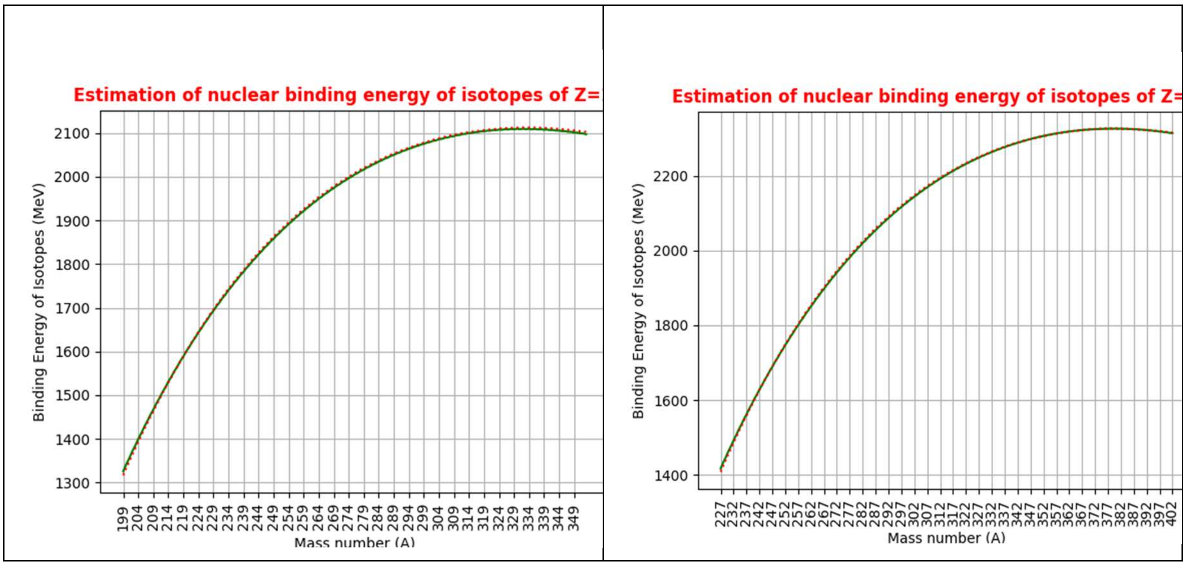

4. Nuclear Binding Energy Linked with Fermi Gas Model, Beta Stability, Strong Coupling Constant and Root Mean Square Radius of Proton

According to Fermi gas model of the nucleus [41], nucleons are weakly coupled to each other and total energy of any nucleus is,

$$E_{tot} \cong \frac{3}{10}\left(\frac{9\pi}{4}\right)^{2/3}\left(\frac{\hbar}{m_n R_0^2}\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{2/3}}\right) \tag{17}$$

Based on this relation, close to beta stability, for medium and heavy atomic nuclides, nuclear binding energy [42] can be expressed as,

$$E_B \approx \left(\frac{Z}{A}\right)E_{tot} \cong \frac{3}{10}\left(\frac{9\pi}{4}\right)^{2/3}\left(\frac{\hbar}{m_n R_0^2}\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right)Z \tag{18}$$

Considering our 4G model of unification, above relations can be re-written as,

$$E_{tot} \cong (0.27624)\times\left(\alpha_s m_n c^2\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{2/3}}\right)$$

$$\text{where,}\left(\frac{\hbar c}{G_n m_n^2}\right)^2 \cong \left(\frac{e}{e_n}\right)^2 \cong \alpha_s \text{ and } R_0 \cong \frac{2G_n m_n}{c^2} \cong 1.24\text{ fm.} \tag{19}$$

Considering our 4G model of unification, close to beta stability, for medium and heavy atomic nuclides, nuclear binding energy can be approximated with,

$$(BE)_{A_s} \approx (0.27624)\times\left(Z\alpha_s m_n c^2\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right)$$

$$\approx 0.032\times\left(Z m_n c^2\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right) \approx (Z)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right)\times 30.0\text{ MeV} \tag{20}$$

where $A_s \approx 2Z + 0.00642Z^2$

Close to beta stability, for light atomic nuclides, nuclear binding energy can be approximated with,

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$$(BE)_{A_s} \approx \left(\frac{Z}{30}\right)^{\alpha_s} (0.27624)\times\left(Z\alpha_s m_n c^2\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right)$$
$$\approx \left(\frac{Z}{30}\right)^{\alpha_s} 0.032\times\left(Zm_n c^2\right)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right) \approx \left(\frac{Z}{30}\right)^{\alpha_s} (Z)\left(\frac{N^{5/3}+Z^{5/3}}{A^{5/3}}\right)\times 30.0\text{ MeV} \quad (21)$$
where $(3 \geq Z \leq 30)$, $\alpha_s \cong 0.1152$, $A_s \approx 2Z + 0.00642Z^2$

Proceeding further, considering $\frac{N^{5/3}+Z^{5/3}}{A^{5/3}} \leq \frac{2}{3}$, close to the beta stability, for light atomic nuclides, nuclear binding energy can be approximated with,

$$(BE)_{A_s} \cong \left(\frac{Z}{30}\right)^{\alpha_s}\left[1-(Z\beta)^2\right](Z-1)\times 20.0\text{ MeV}$$
where $(3 \geq Z \leq 30)$, $\alpha_s \cong 0.1152, \beta \cong 0.001605$ (22)
and $A_s \approx 2Z + 0.00642Z^2$

Close to beta stability, for medium and heavy atomic nuclides, nuclear binding energy can be approximated with,

$$(BE)_{A_s} \cong \left[1-(Z\beta)^2\right](Z-1)\times 20.0\text{ MeV} \quad (23)$$
where $Z > 30$ and $A_s \approx 2Z + 0.00642Z^2$

Following the concepts of Fermi gas model and our proposal, it seems that, all the nucleons are not strongly bound in the nucleus. Clearly speaking, some kind of weak interaction is playing a mysterious role among the nucleons. Proceeding further, it seems that, Fermi gas model seems to be associated with an energy unit [43] of $\alpha_s m_n c^2 \cong (108.0 \text{ to } 111.0)\text{ MeV}$. This energy unit seems to be roughly (0.3 to 0.5) times the QCD lambda value [44]. In a unified approach, further research can be carried out.

With reference to assumed or observed stable mass numbers, for medium and heavy atomic nuclides, binding energy can be estimated as follows. Readers are encouraged to refer our paper published in 2015 [45].

$$(BE)_{A_s} \cong A_s \times\left(1-\left(\frac{\exp(A_s\beta)-1}{3}\right)\right)\times(9.1\pm 0.05)\text{ MeV}$$
where $A > 56$, $\beta \cong 0.001605$
$$\left(\frac{3}{5}\right)\frac{e_n^2}{4\pi\varepsilon_0 R_p} \cong \left(\frac{3}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0(0.83\text{ fm})} \cong 9.04\text{ MeV} \quad (24)$$
$R_p \cong$ Root mean square radius of proton [46] $\cong 0.83$ fm
$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}}$$

With reference to stable mass numbers, for light atomic nuclides, binding energy can be estimated as follows.

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$$(BE)_{A_s} \cong \left(\frac{A}{56}\right)^{\alpha_s} A_s \times \left(1-\left(\frac{\exp(A_s\beta)-1}{3}\right)\right) \times (9.1 \pm 0.05)\,\text{MeV}$$

where $A < 56,\ \beta \cong 0.001605, \alpha_s \cong 0.1152$

$$\left(\frac{3}{5}\right)\frac{e_n^2}{4\pi\varepsilon_0 R_p} \cong \left(\frac{3}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 (0.83\text{ fm})} \cong 9.04\text{ MeV} \quad (25)$$

$R_p \cong$ Root mean square radius of proton [45] $\cong 0.83$ fm

$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}}$$

Here, point of concern is that, close to beta stability, normally considered asymmetry term can be approximated with [45].

$$\frac{(A_s-2Z)^2}{A}(23.2\text{ MeV}) \cong \left(\frac{\exp(A_s\beta)-1}{3}\right) A_s \times (9.1 \pm 0.05)\,\text{MeV}$$

$$\text{where } \beta \cong 0.001605,\ Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}} \quad (26)$$

Thus, for medium and heavy stable mass numbers, nuclear binding energy can be approximated with,

$$(BE)_{A_s} \cong [A_s \times (9.1 \pm 0.05)\,\text{MeV}] - \left[\left(\frac{\exp(A_s\beta)-1}{3}\right) A_s \times (9.1 \pm 0.05)\,\text{MeV}\right]$$

$$\text{where, } Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}},\ \beta \cong 0.001605 \quad (27)$$

For light and stable mass numbers, nuclear binding energy can be approximated with,

$$(BE)_{A_s} \cong \left(\frac{A_s}{56}\right)^{\alpha_s} \left\{[A_s \times (9.1 \pm 0.05)\,\text{MeV}] - \left[\left(\frac{\exp(A_s\beta)-1}{3}\right) A_s \times (9.1 \pm 0.05)\,\text{MeV}\right]\right\}$$

where $A < 56,\ \ \alpha_s \cong 0.1152,\ \beta \cong 0.001605$

$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}}$$

(28)

One important point point to be noted here is that, self attractive (potential) energy of proton having a nuclear charge of $e_n \cong 2.9464e$ and root mean square radius of 0.83 fm, can be expressed as,

$$\left(\frac{3}{5}\right)\frac{e_n^2}{4\pi\varepsilon_0 R_p} \cong \left(\frac{3}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0 (0.83\text{ fm})} \cong 9.04\text{ MeV} \quad (29)$$

With reference to the nuclear binding energy scheme, maximum binding energy per nucleon observed in the cases of Iron and Nickel atomic nuclei is around 8.8 MeV. Thus,

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$$\left\langle \frac{BE}{A} \right\rangle_{max} \cong \left[1 - \frac{\exp(A_s\beta)-1}{3}\right] \times (9.1 \pm 0.05)\,\text{MeV}$$
$$\text{where } A > 56,\ Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}} \qquad (30)$$

Maximum binding energy per nucleon for light atomic nuclides can be expressed as,

$$\left\langle \frac{BE}{A} \right\rangle_{max} \cong \left(\frac{A_s}{56}\right)^{\alpha_s} \left[1 - \frac{\exp(A_s\beta)-1}{3}\right] \times (9.1 \pm 0.05)\,\text{MeV}$$
$$\text{where } 4 \geq A \leq 56,\ \alpha_s \cong 0.1152,\ \beta \cong 0.001605 \qquad (31)$$
$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}}$$

Accuracy point of view, for light, medium and heavy atomic nuclides, energy coefficient seems to be around 9.15 MeV and for super heavy atomic nuclides, energy coefficient seems to be around 9.05 MeV. See the following figure 2 and table 5 prepared with relations (30) and (31). Relations (30) and (31) help in estimating the maximum binding energy per nucleon independent of total binding energy.

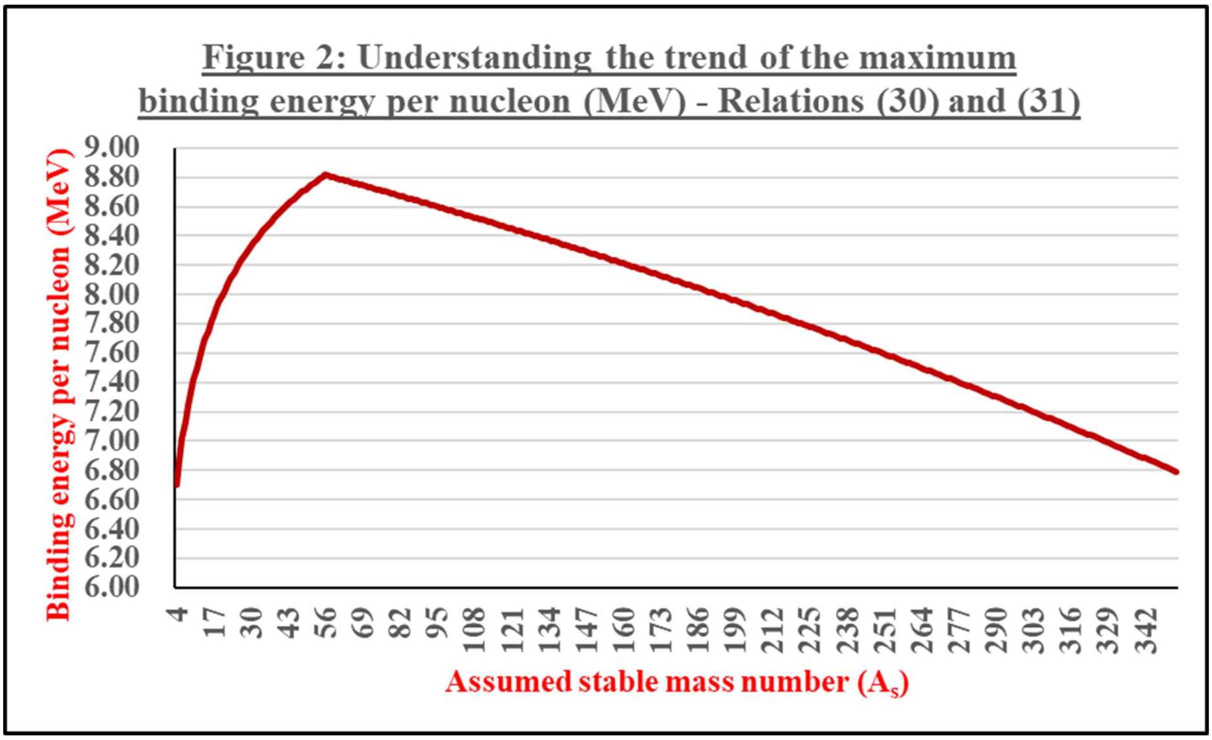

Table 5. Estimated maximum binding energy of assumed stable mass numbers.

Assumed stable mass number (A_s)	$(A_s\beta)$	Estimated maximum binding energy (MeV)	Estimated maximum binding energy per nucleon (MeV)	Assumed stable mass number (A_s)	$(A_s\beta)$	Estimated maximum binding energy (MeV)	Estimated maximum binding energy per nucleon (MeV)
4	0.00642	26.80	6.70	179	0.287295	1448.19	8.09
5	0.008025	34.35	6.87	180	0.2889	1455.11	8.08
6	0.00963	42.08	7.01	181	0.290505	1462.02	8.08

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7	0.011235	49.94	7.13
8	0.01284	57.93	7.24
9	0.014445	66.03	7.34
10	0.01605	74.22	7.42
11	0.017655	82.49	7.50
12	0.01926	90.85	7.57
13	0.020865	99.28	7.64
14	0.02247	107.77	7.70
15	0.024075	116.33	7.76
16	0.02568	124.94	7.81
17	0.027285	133.61	7.86
18	0.02889	142.32	7.91
19	0.030495	151.08	7.95
20	0.0321	159.89	7.99
21	0.033705	168.73	8.03
22	0.03531	177.62	8.07
23	0.036915	186.54	8.11
24	0.03852	195.50	8.15
25	0.040125	204.49	8.18
26	0.04173	213.51	8.21
27	0.043335	222.56	8.24
28	0.04494	231.64	8.27
29	0.046545	240.75	8.30
30	0.04815	249.88	8.33
31	0.049755	259.04	8.36
32	0.05136	268.22	8.38
33	0.052965	277.43	8.41
34	0.05457	286.65	8.43
35	0.056175	295.90	8.45
36	0.05778	305.17	8.48
37	0.059385	314.46	8.50
38	0.06099	323.76	8.52
39	0.062595	333.08	8.54
40	0.0642	342.42	8.56
41	0.065805	351.78	8.58
42	0.06741	361.15	8.60
43	0.069015	370.53	8.62
44	0.07062	379.93	8.63
45	0.072225	389.34	8.65
46	0.07383	398.77	8.67
47	0.075435	408.21	8.69
48	0.07704	417.66	8.70
49	0.078645	427.12	8.72
50	0.08025	436.59	8.73
51	0.081855	446.07	8.75
52	0.08346	455.56	8.76
53	0.085065	465.07	8.77
54	0.08667	474.58	8.79
55	0.088275	484.10	8.80
56	0.08988	493.63	8.81
57	0.091485	502.14	8.81

182	0.29211	1468.91	8.07
183	0.293715	1475.79	8.06
184	0.29532	1482.65	8.06
185	0.296925	1489.50	8.05
186	0.29853	1496.33	8.04
187	0.300135	1503.15	8.04
188	0.30174	1509.95	8.03
189	0.303345	1516.73	8.03
190	0.30495	1523.50	8.02
191	0.306555	1530.26	8.01
192	0.30816	1537.00	8.01
193	0.309765	1543.73	8.00
194	0.31137	1550.44	7.99
195	0.312975	1557.13	7.99
196	0.31458	1563.81	7.98
197	0.316185	1570.47	7.97
198	0.31779	1577.12	7.97
199	0.319395	1583.76	7.96
200	0.321	1590.37	7.95
201	0.322605	1596.98	7.95
202	0.32421	1603.56	7.94
203	0.325815	1610.13	7.93
204	0.32742	1616.69	7.92
205	0.329025	1623.23	7.92
206	0.33063	1629.75	7.91
207	0.332235	1636.26	7.90
208	0.33384	1642.75	7.90
209	0.335445	1649.22	7.89
210	0.33705	1655.68	7.88
211	0.338655	1662.13	7.88
212	0.34026	1668.56	7.87
213	0.341865	1674.97	7.86
214	0.34347	1681.36	7.86
215	0.345075	1687.74	7.85
216	0.34668	1694.11	7.84
217	0.348285	1700.46	7.84
218	0.34989	1706.79	7.83
219	0.351495	1713.10	7.82
220	0.3531	1719.40	7.82
221	0.354705	1725.68	7.81
222	0.35631	1731.95	7.80
223	0.357915	1738.20	7.79
224	0.35952	1744.43	7.79
225	0.361125	1750.65	7.78
226	0.36273	1756.85	7.77
227	0.364335	1763.04	7.77
228	0.36594	1769.20	7.76
229	0.367545	1775.35	7.75
230	0.36915	1781.49	7.75
231	0.370755	1787.61	7.74
232	0.37236	1793.71	7.73

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58	0.09309	510.64	8.80	233	0.373965	1799.79	7.72
59	0.094695	519.12	8.80	234	0.37557	1805.86	7.72
60	0.0963	527.60	8.79	235	0.377175	1811.91	7.71
61	0.097905	536.07	8.79	236	0.37878	1817.94	7.70
62	0.09951	544.52	8.78	237	0.380385	1823.96	7.70
63	0.101115	552.97	8.78	238	0.38199	1829.96	7.69
64	0.10272	561.40	8.77	239	0.383595	1835.94	7.68
65	0.104325	569.82	8.77	240	0.3852	1841.91	7.67
66	0.10593	578.23	8.76	241	0.386805	1847.86	7.67
67	0.107535	586.63	8.76	242	0.38841	1853.79	7.66
68	0.10914	595.01	8.75	243	0.390015	1859.70	7.65
69	0.110745	603.39	8.74	244	0.39162	1865.60	7.65
70	0.11235	611.75	8.74	245	0.393225	1871.48	7.64
71	0.113955	620.10	8.73	246	0.39483	1877.34	7.63
72	0.11556	628.45	8.73	247	0.396435	1883.19	7.62
73	0.117165	636.77	8.72	248	0.39804	1889.01	7.62
74	0.11877	645.09	8.72	249	0.399645	1894.82	7.61
75	0.120375	653.40	8.71	250	0.40125	1900.62	7.60
76	0.12198	661.69	8.71	251	0.402855	1906.39	7.60
77	0.123585	669.98	8.70	252	0.40446	1912.15	7.59
78	0.12519	678.25	8.70	253	0.406065	1917.89	7.58
79	0.126795	686.51	8.69	254	0.40767	1923.62	7.57
80	0.1284	694.75	8.68	255	0.409275	1929.32	7.57
81	0.130005	702.99	8.68	256	0.41088	1935.01	7.56
82	0.13161	711.21	8.67	257	0.412485	1940.68	7.55
83	0.133215	719.42	8.67	258	0.41409	1946.33	7.54
84	0.13482	727.62	8.66	259	0.415695	1951.97	7.54
85	0.136425	735.81	8.66	260	0.4173	1957.58	7.53
86	0.13803	743.99	8.65	261	0.418905	1963.18	7.52
87	0.139635	752.15	8.65	262	0.42051	1968.76	7.51
88	0.14124	760.31	8.64	263	0.422115	1974.33	7.51
89	0.142845	768.45	8.63	264	0.42372	1979.87	7.50
90	0.14445	776.57	8.63	265	0.425325	1985.40	7.49
91	0.146055	784.69	8.62	266	0.42693	1990.91	7.48
92	0.14766	792.80	8.62	267	0.428535	1996.40	7.48
93	0.149265	800.89	8.61	268	0.43014	2001.87	7.47
94	0.15087	808.97	8.61	269	0.431745	2007.33	7.46
95	0.152475	817.04	8.60	270	0.43335	2012.76	7.45
96	0.15408	825.09	8.59	271	0.434955	2018.18	7.45
97	0.155685	833.13	8.59	272	0.43656	2023.58	7.44
98	0.15729	841.17	8.58	273	0.438165	2028.96	7.43
99	0.158895	849.18	8.58	274	0.43977	2034.32	7.42
100	0.1605	857.19	8.57	275	0.441375	2039.67	7.42
101	0.162105	865.18	8.57	276	0.44298	2044.99	7.41
102	0.16371	873.17	8.56	277	0.444585	2050.30	7.40
103	0.165315	881.14	8.55	278	0.44619	2055.59	7.39
104	0.16692	889.09	8.55	279	0.447795	2060.86	7.39
105	0.168525	897.04	8.54	280	0.4494	2066.11	7.38
106	0.17013	904.97	8.54	281	0.451005	2071.35	7.37
107	0.171735	912.89	8.53	282	0.45261	2076.56	7.36
108	0.17334	920.80	8.53	283	0.454215	2081.76	7.36

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109	0.174945	928.69	8.52
110	0.17655	936.57	8.51
111	0.178155	944.44	8.51
112	0.17976	952.30	8.50
113	0.181365	960.14	8.50
114	0.18297	967.97	8.49
115	0.184575	975.79	8.49
116	0.18618	983.59	8.48
117	0.187785	991.39	8.47
118	0.18939	999.17	8.47
119	0.190995	1006.93	8.46
120	0.1926	1014.69	8.46
121	0.194205	1022.43	8.45
122	0.19581	1030.16	8.44
123	0.197415	1037.87	8.44
124	0.19902	1045.57	8.43
125	0.200625	1053.26	8.43
126	0.20223	1060.94	8.42
127	0.203835	1068.60	8.41
128	0.20544	1076.25	8.41
129	0.207045	1083.89	8.40
130	0.20865	1091.51	8.40
131	0.210255	1099.12	8.39
132	0.21186	1106.72	8.38
133	0.213465	1114.30	8.38
134	0.21507	1121.87	8.37
135	0.216675	1129.43	8.37
136	0.21828	1136.97	8.36
137	0.219885	1144.50	8.35
138	0.22149	1152.01	8.35
139	0.223095	1159.52	8.34
140	0.2247	1167.01	8.34
141	0.226305	1174.48	8.33
142	0.22791	1181.94	8.32
143	0.229515	1189.39	8.32
144	0.23112	1196.83	8.31
145	0.232725	1204.25	8.31
146	0.23433	1211.66	8.30
147	0.235935	1219.05	8.29
148	0.23754	1226.43	8.29
149	0.239145	1233.80	8.28
150	0.24075	1241.15	8.27
151	0.242355	1248.49	8.27
152	0.24396	1255.81	8.26
153	0.245565	1263.12	8.26
154	0.24717	1270.42	8.25
155	0.248775	1277.70	8.24
156	0.25038	1284.97	8.24
157	0.251985	1292.22	8.23
158	0.25359	1299.46	8.22
159	0.255195	1306.69	8.22

284	0.45582	2086.93	7.35
285	0.457425	2092.09	7.34
286	0.45903	2097.23	7.33
287	0.460635	2102.35	7.33
288	0.46224	2107.45	7.32
289	0.463845	2112.53	7.31
290	0.46545	2117.59	7.30
291	0.467055	2122.64	7.29
292	0.46866	2127.66	7.29
293	0.470265	2132.67	7.28
294	0.47187	2137.65	7.27
295	0.473475	2142.62	7.26
296	0.47508	2147.57	7.26
297	0.476685	2152.50	7.25
298	0.47829	2157.41	7.24
299	0.479895	2162.29	7.23
300	0.4815	2167.16	7.22
301	0.483105	2172.01	7.22
302	0.48471	2176.85	7.21
303	0.486315	2181.66	7.20
304	0.48792	2186.45	7.19
305	0.489525	2191.22	7.18
306	0.49113	2195.97	7.18
307	0.492735	2200.70	7.17
308	0.49434	2205.42	7.16
309	0.495945	2210.11	7.15
310	0.49755	2214.78	7.14
311	0.499155	2219.43	7.14
312	0.50076	2224.06	7.13
313	0.502365	2228.68	7.12
314	0.50397	2233.27	7.11
315	0.505575	2237.84	7.10
316	0.50718	2242.39	7.10
317	0.508785	2246.92	7.09
318	0.51039	2251.43	7.08
319	0.511995	2255.92	7.07
320	0.5136	2260.39	7.06
321	0.515205	2264.84	7.06
322	0.51681	2269.27	7.05
323	0.518415	2273.68	7.04
324	0.52002	2278.07	7.03
325	0.521625	2282.44	7.02
326	0.52323	2286.78	7.01
327	0.524835	2291.11	7.01
328	0.52644	2295.42	7.00
329	0.528045	2299.70	6.99
330	0.52965	2303.96	6.98
331	0.531255	2308.21	6.97
332	0.53286	2312.43	6.97
333	0.534465	2316.63	6.96
334	0.53607	2320.81	6.95

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160	0.2568	1313.90	8.21	335	0.537675	2324.97	6.94
161	0.258405	1321.10	8.21	336	0.53928	2329.10	6.93
162	0.26001	1328.28	8.20	337	0.540885	2333.22	6.92
163	0.261615	1335.45	8.19	338	0.54249	2337.32	6.92
164	0.26322	1342.61	8.19	339	0.544095	2341.39	6.91
165	0.264825	1349.75	8.18	340	0.5457	2345.44	6.90
166	0.26643	1356.87	8.17	341	0.547305	2349.47	6.89
167	0.268035	1363.99	8.17	342	0.54891	2353.48	6.88
168	0.26964	1371.08	8.16	343	0.550515	2357.47	6.87
169	0.271245	1378.17	8.15	344	0.55212	2361.44	6.86
170	0.27285	1385.23	8.15	345	0.553725	2365.38	6.86
171	0.274455	1392.29	8.14	346	0.55533	2369.30	6.85
172	0.27606	1399.33	8.14	347	0.556935	2373.21	6.84
173	0.277665	1406.35	8.13	348	0.55854	2377.09	6.83
174	0.27927	1413.36	8.12	349	0.560145	2380.94	6.82
175	0.280875	1420.36	8.12	350	0.56175	2384.78	6.81
176	0.28248	1427.34	8.11	351	0.563355	2388.59	6.81
177	0.284085	1434.30	8.10	352	0.56496	2392.39	6.80
178	0.28569	1441.25	8.10	353	0.566565	2396.16	6.79

It may also be noted that, based on 4G model of final unification, for light, medium, heavy and super heavy atomic nuclides, close to stable mass numbers, maximum binding energy can also be approximated with [3],

$$\langle BE\rangle_{\max} \cong \left[A_s - \left(\frac{1}{2} + 0.000935A_s^2\right) - A_s^{1/3}\right] \times 10.1\,\text{MeV}$$

$$\text{where, } Z \cong \frac{A_s}{1+\sqrt{1+0.00642A_s}} \cong \frac{A_s}{2+0.015A_s^{2/3}},\ A_s > 4$$

$$\sqrt{\frac{G_w}{G_n}} \cong \sqrt{\frac{m_e c^2}{M_{wf}c^2}} \cong \sqrt{\frac{0.511\,\text{MeV}}{584725\,\text{MeV}}} \cong \sqrt{\frac{e}{e_n}}(\beta) \cong \sqrt{\frac{e}{e_n}} \times 0.001605 \cong 0.000935$$

$G_w \cong$ Proposed weak gravitational constant (32)

$G_n \cong$ Proposed nuclear gravitational constant

$m_e \cong$ Rest mass of electron

$M_{wf} \cong$ Rest mass of the proposed electroweak fermion

See the following figure 3 and table 6 prepared with relation (32) and the experimental data [3].

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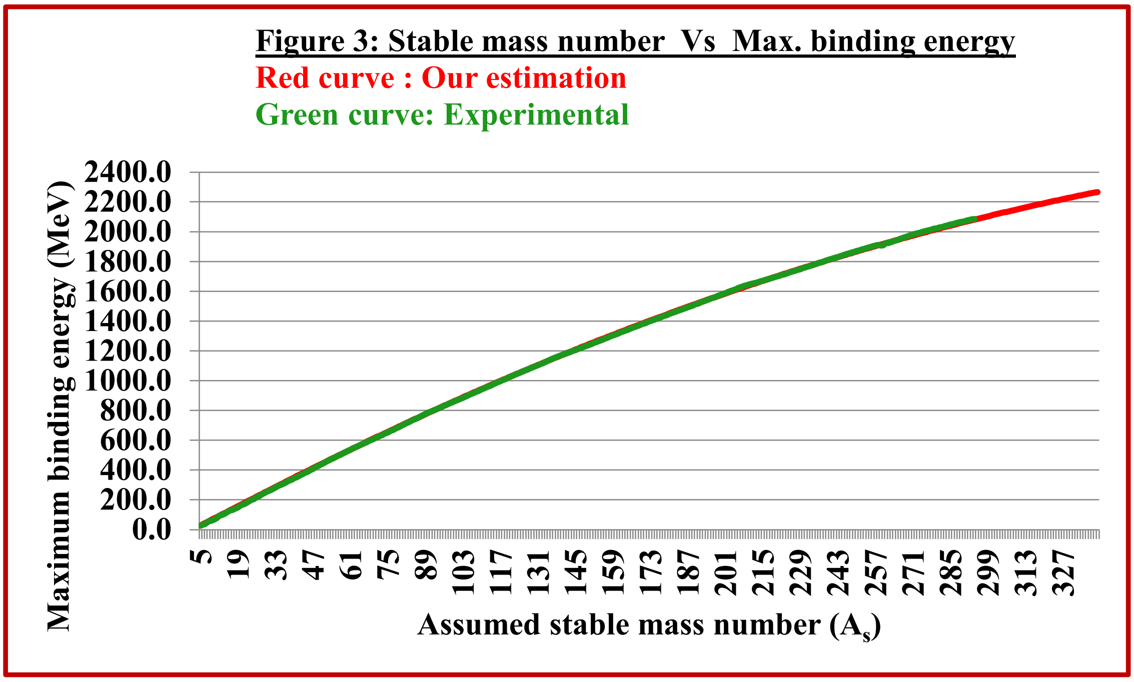

Table 6. Assumed stable mass number and its corresponding maximum binding energy.

Assumed stable mass number A_s	Estimated Max. Binding energy of A_s (MeV) Relation (32)	Experimental Max. Binding energy of A_s (MeV)	(Exp.-Est.) Binding energy (MeV)	Estimated Binding energy per nucleon (MeV)	Experimental Binding energy per nucleon (MeV)
5	27.94	27.56	-0.38	5.59	5.51
6	36.86	31.99	-4.86	6.14	5.33
7	45.87	39.25	-6.62	6.55	5.61
8	54.95	56.50	1.55	6.87	7.06
9	64.08	58.16	-5.91	7.12	6.46
10	73.25	64.98	-8.27	7.32	6.50
11	82.45	76.20	-6.24	7.50	6.93
12	91.67	92.16	0.49	7.64	7.68
13	100.91	97.11	-3.80	7.76	7.47
14	110.16	105.28	-4.87	7.87	7.52
15	119.42	115.49	-3.92	7.96	7.70
16	128.68	127.62	-1.06	8.04	7.98
17	137.95	131.76	-6.19	8.11	7.75
18	147.22	139.81	-7.41	8.18	7.77
19	156.49	147.80	-8.69	8.24	7.78
20	165.76	160.64	-5.11	8.29	8.03
21	175.02	167.41	-7.61	8.33	7.97
22	184.28	177.77	-6.51	8.38	8.08
23	193.53	186.56	-6.97	8.41	8.11
24	202.78	198.26	-4.52	8.45	8.26
25	212.02	205.59	-6.43	8.48	8.22

26	221.24	216.68	-4.56	8.51	8.33
27	230.47	224.95	-5.51	8.54	8.33
28	239.68	236.54	-3.14	8.56	8.45
29	248.88	245.01	-3.87	8.58	8.45
30	258.07	255.62	-2.45	8.60	8.52
31	267.25	262.92	-4.33	8.62	8.48
32	276.41	271.78	-4.63	8.64	8.49
33	285.57	280.96	-4.61	8.65	8.51
34	294.71	291.84	-2.87	8.67	8.58
35	303.84	298.82	-5.02	8.68	8.54
36	312.96	308.71	-4.25	8.69	8.58
37	322.07	317.10	-4.97	8.70	8.57
38	331.16	327.34	-3.81	8.71	8.61
39	340.24	333.94	-6.29	8.72	8.56
40	349.30	343.81	-5.49	8.73	8.60
41	358.35	351.62	-6.73	8.74	8.58
42	367.38	361.90	-5.49	8.75	8.62
43	376.40	369.83	-6.58	8.75	8.60
44	385.41	380.96	-4.45	8.76	8.66
45	394.40	388.37	-6.03	8.76	8.63
46	403.38	398.77	-4.61	8.77	8.67
47	412.34	407.26	-5.08	8.77	8.67
48	421.29	418.70	-2.58	8.78	8.72
49	430.22	426.85	-3.37	8.78	8.71
50	439.13	437.78	-1.35	8.78	8.76
51	448.03	445.85	-2.19	8.78	8.74
52	456.92	456.35	-0.57	8.79	8.78
53	465.78	464.29	-1.50	8.79	8.76
54	474.64	474.01	-0.63	8.79	8.78
55	483.47	482.08	-1.40	8.79	8.77
56	492.29	492.26	-0.03	8.79	8.79
57	501.10	499.91	-1.19	8.79	8.77
58	509.89	509.95	0.06	8.79	8.79
59	518.66	517.31	-1.34	8.79	8.77
60	527.41	526.85	-0.57	8.79	8.78
61	536.15	534.67	-1.49	8.79	8.77
62	544.87	545.26	0.39	8.79	8.79
63	553.58	552.10	-1.48	8.79	8.76
64	562.27	561.76	-0.51	8.79	8.78
65	570.94	569.21	-1.73	8.78	8.76
66	579.60	578.14	-1.46	8.78	8.76
67	588.24	585.41	-2.83	8.78	8.74
68	596.86	595.39	-1.47	8.78	8.76
69	605.46	602.00	-3.47	8.77	8.72
70	614.05	611.09	-2.97	8.77	8.73
71	622.62	618.95	-3.67	8.77	8.72
72	631.18	628.69	-2.49	8.77	8.73
73	639.71	635.47	-4.25	8.76	8.71
74	648.23	645.66	-2.57	8.76	8.73
75	656.74	652.57	-4.17	8.76	8.70
76	665.22	662.07	-3.15	8.75	8.71

77	673.69	669.59	-4.10	8.75	8.70
78	682.14	679.99	-2.15	8.75	8.72
79	690.58	686.95	-3.62	8.74	8.70
80	698.99	696.87	-2.13	8.74	8.71
81	707.39	704.37	-3.02	8.73	8.70
82	715.77	714.27	-1.50	8.73	8.71
83	724.14	721.74	-2.39	8.72	8.70
84	732.48	732.27	-0.22	8.72	8.72
85	740.81	739.38	-1.43	8.72	8.70
86	749.12	749.23	0.11	8.71	8.71
87	757.42	757.86	0.44	8.71	8.71
88	765.70	768.47	2.77	8.70	8.73
89	773.95	775.54	1.59	8.70	8.71
90	782.20	783.90	1.70	8.69	8.71
91	790.42	791.09	0.67	8.69	8.69
92	798.63	799.73	1.10	8.68	8.69
93	806.81	806.46	-0.35	8.68	8.67
94	814.98	814.68	-0.30	8.67	8.67
95	823.14	821.63	-1.51	8.66	8.65
96	831.27	830.78	-0.49	8.66	8.65
97	839.39	837.60	-1.79	8.65	8.64
98	847.49	846.25	-1.24	8.65	8.64
99	855.57	852.75	-2.82	8.64	8.61
100	863.63	861.93	-1.70	8.64	8.62
101	871.68	868.73	-2.95	8.63	8.60
102	879.71	877.95	-1.76	8.62	8.61
103	887.72	884.19	-3.53	8.62	8.58
104	895.71	893.09	-2.62	8.61	8.59
105	903.69	900.13	-3.55	8.61	8.57
106	911.64	909.48	-2.16	8.60	8.58
107	919.58	916.02	-3.57	8.59	8.56
108	927.50	925.24	-2.26	8.59	8.57
109	935.41	931.72	-3.68	8.58	8.55
110	943.29	940.64	-2.65	8.58	8.55
111	951.16	947.62	-3.54	8.57	8.54
112	959.01	957.01	-2.00	8.56	8.54
113	966.84	963.55	-3.29	8.56	8.53
114	974.65	972.59	-2.06	8.55	8.53
115	982.44	979.40	-3.04	8.54	8.52
116	990.22	988.68	-1.54	8.54	8.52
117	997.98	995.62	-2.35	8.53	8.51
118	1005.72	1004.95	-0.77	8.52	8.52
119	1013.44	1011.43	-2.01	8.52	8.50
120	1021.15	1020.54	-0.61	8.51	8.50
121	1028.83	1026.71	-2.12	8.50	8.49
122	1036.50	1035.52	-0.98	8.50	8.49
123	1044.15	1042.10	-2.05	8.49	8.47
124	1051.78	1050.69	-1.10	8.48	8.47
125	1059.40	1057.27	-2.12	8.48	8.46
126	1066.99	1066.37	-0.62	8.47	8.46
127	1074.57	1072.66	-1.91	8.46	8.45

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128	1082.13	1081.44	-0.69	8.45	8.45
129	1089.67	1088.24	-1.42	8.45	8.44
130	1097.19	1096.91	-0.29	8.44	8.44
131	1104.69	1103.51	-1.19	8.43	8.42
132	1112.18	1112.45	0.27	8.43	8.43
133	1119.65	1118.88	-0.77	8.42	8.41
134	1127.10	1127.43	0.34	8.41	8.41
135	1134.53	1134.18	-0.35	8.40	8.40
136	1141.94	1142.77	0.83	8.40	8.40
137	1149.34	1149.68	0.34	8.39	8.39
138	1156.71	1158.29	1.58	8.38	8.39
139	1164.07	1164.55	0.47	8.37	8.38
140	1171.41	1172.69	1.27	8.37	8.38
141	1178.74	1178.12	-0.62	8.36	8.36
142	1186.04	1185.28	-0.75	8.35	8.35
143	1193.32	1191.26	-2.06	8.34	8.33
144	1200.59	1199.08	-1.51	8.34	8.33
145	1207.84	1204.83	-3.01	8.33	8.31
146	1215.07	1212.40	-2.67	8.32	8.30
147	1222.28	1217.80	-4.48	8.31	8.28
148	1229.47	1225.39	-4.09	8.31	8.28
149	1236.65	1231.26	-5.39	8.30	8.26
150	1243.81	1239.24	-4.56	8.29	8.26
151	1250.95	1244.84	-6.11	8.28	8.24
152	1258.07	1253.10	-4.97	8.28	8.24
153	1265.17	1258.99	-6.18	8.27	8.23
154	1272.25	1266.93	-5.32	8.26	8.23
155	1279.32	1273.58	-5.73	8.25	8.22
156	1286.36	1281.59	-4.77	8.25	8.22
157	1293.39	1287.95	-5.44	8.24	8.20
158	1300.40	1295.89	-4.51	8.23	8.20
159	1307.39	1302.02	-5.37	8.22	8.19
160	1314.37	1309.45	-4.92	8.21	8.18
161	1321.32	1316.09	-5.23	8.21	8.17
162	1328.26	1324.10	-4.16	8.20	8.17
163	1335.17	1330.37	-4.80	8.19	8.16
164	1342.07	1338.03	-4.05	8.18	8.16
165	1348.95	1344.25	-4.71	8.18	8.15
166	1355.82	1351.56	-4.25	8.17	8.14
167	1362.66	1358.00	-4.66	8.16	8.13
168	1369.49	1365.77	-3.71	8.15	8.13
169	1376.29	1371.78	-4.52	8.14	8.12
170	1383.08	1379.03	-4.05	8.14	8.11
171	1389.85	1385.42	-4.43	8.13	8.10
172	1396.60	1392.76	-3.85	8.12	8.10
173	1403.34	1399.13	-4.21	8.11	8.09
174	1410.05	1406.59	-3.46	8.10	8.08
175	1416.75	1412.41	-4.34	8.10	8.07
176	1423.43	1419.28	-4.15	8.09	8.06
177	1430.09	1425.46	-4.62	8.08	8.05
178	1436.73	1432.80	-3.92	8.07	8.05

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179	1443.35	1438.90	-4.45	8.06	8.04
180	1449.95	1446.29	-3.66	8.06	8.03
181	1456.54	1452.24	-4.30	8.05	8.02
182	1463.11	1459.33	-3.77	8.04	8.02
183	1469.65	1465.52	-4.13	8.03	8.01
184	1476.18	1472.94	-3.25	8.02	8.01
185	1482.70	1478.69	-4.01	8.01	7.99
186	1489.19	1485.88	-3.31	8.01	7.99
187	1495.66	1491.88	-3.78	8.00	7.98
188	1502.12	1499.09	-3.03	7.99	7.97
189	1508.56	1505.01	-3.55	7.98	7.96
190	1514.98	1512.80	-2.17	7.97	7.96
191	1521.38	1518.56	-2.82	7.97	7.95
192	1527.76	1526.12	-1.64	7.96	7.95
193	1534.12	1532.06	-2.06	7.95	7.94
194	1540.47	1539.58	-0.89	7.94	7.94
195	1546.79	1545.68	-1.11	7.93	7.93
196	1553.10	1553.60	0.50	7.92	7.93
197	1559.39	1559.45	0.06	7.92	7.92
198	1565.66	1567.00	1.34	7.91	7.91
199	1571.91	1573.48	1.57	7.90	7.91
200	1578.14	1581.18	3.03	7.89	7.91
201	1584.36	1587.41	3.05	7.88	7.90
202	1590.56	1595.16	4.61	7.87	7.90
203	1596.73	1601.16	4.42	7.87	7.89
204	1602.89	1608.65	5.76	7.86	7.89
205	1609.03	1615.07	6.04	7.85	7.88
206	1615.16	1622.32	7.17	7.84	7.88
207	1621.26	1629.06	7.80	7.83	7.87
208	1627.34	1636.43	9.09	7.82	7.87
209	1633.41	1640.37	6.96	7.82	7.85
210	1639.46	1645.55	6.09	7.81	7.84
211	1645.49	1649.97	4.48	7.80	7.82
212	1651.50	1655.77	4.27	7.79	7.81
213	1657.49	1660.13	2.64	7.78	7.79
214	1663.46	1666.01	2.55	7.77	7.79
215	1669.42	1670.16	0.74	7.76	7.77
216	1675.35	1675.90	0.55	7.76	7.76
217	1681.27	1680.58	-0.69	7.75	7.74
218	1687.17	1687.05	-0.12	7.74	7.74
219	1693.05	1691.51	-1.55	7.73	7.72
220	1698.91	1697.79	-1.12	7.72	7.72
221	1704.76	1702.42	-2.34	7.71	7.70
222	1710.58	1708.66	-1.92	7.71	7.70
223	1716.39	1713.82	-2.56	7.70	7.69
224	1722.17	1720.30	-1.87	7.69	7.68
225	1727.94	1725.21	-2.74	7.68	7.67
226	1733.69	1731.60	-2.09	7.67	7.66
227	1739.42	1736.71	-2.72	7.66	7.65
228	1745.14	1743.08	-2.06	7.65	7.65
229	1750.83	1748.33	-2.50	7.65	7.63

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230	1756.51	1755.13	-1.38	7.64	7.63
231	1762.16	1760.25	-1.92	7.63	7.62
232	1767.80	1766.69	-1.12	7.62	7.62
233	1773.42	1771.93	-1.49	7.61	7.60
234	1779.02	1778.57	-0.46	7.60	7.60
235	1784.61	1783.86	-0.74	7.59	7.59
236	1790.17	1790.41	0.24	7.59	7.59
237	1795.71	1795.53	-0.18	7.58	7.58
238	1801.24	1801.69	0.45	7.57	7.57
239	1806.75	1806.97	0.23	7.56	7.56
240	1812.24	1813.45	1.21	7.55	7.56
241	1817.71	1818.69	0.98	7.54	7.55
242	1823.16	1825.00	1.84	7.53	7.54
243	1828.59	1830.03	1.44	7.53	7.53
244	1834.01	1836.05	2.04	7.52	7.52
245	1839.40	1841.36	1.96	7.51	7.52
246	1844.78	1847.82	3.04	7.50	7.51
247	1850.14	1852.98	2.83	7.49	7.50
248	1855.48	1859.19	3.71	7.48	7.50
249	1860.80	1864.02	3.22	7.47	7.49
250	1866.11	1869.99	3.88	7.46	7.48
251	1871.39	1875.09	3.70	7.46	7.47
252	1876.65	1881.27	4.61	7.45	7.47
253	1881.90	1886.07	4.17	7.44	7.45
254	1887.13	1892.10	4.97	7.43	7.45
255	1892.34	1896.64	4.30	7.42	7.44
256	1897.53	1902.54	5.01	7.41	7.43
257	1902.70	1907.50	4.80	7.40	7.42
258	1907.86	1911.69	3.84	7.39	7.41
259	1912.99	1906.33	-6.66	7.39	7.36
260	1918.11	1909.07	-9.04	7.38	7.34
261	1923.20	1923.93	0.72	7.37	7.37
262	1928.28	1923.39	-4.89	7.36	7.34
263	1933.34	1929.63	-3.71	7.35	7.34
264	1938.38	1937.23	-1.15	7.34	7.34
265	1943.41	1943.25	-0.16	7.33	7.33
266	1948.41	1950.31	1.90	7.32	7.33
267	1953.40	1956.31	2.91	7.32	7.33
268	1958.36	1963.37	5.01	7.31	7.33
269	1963.31	1968.54	5.23	7.30	7.32
270	1968.24	1974.78	6.54	7.29	7.31
271	1973.15	1979.66	6.50	7.28	7.31
272	1978.04	1985.87	7.83	7.27	7.30
273	1982.92	1990.44	7.53	7.26	7.29
274	1987.77	1994.17	6.40	7.25	7.28
275	1992.61	2000.08	7.47	7.25	7.27
276	1997.42	2004.86	7.44	7.24	7.26
277	2002.22	2009.64	7.41	7.23	7.26
278	2007.00	2013.00	6.00	7.22	7.24
279	2011.76	2019.40	7.64	7.21	7.24
280	2016.50	2023.56	7.06	7.20	7.23

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281	2021.23	2028.82	7.59	7.19	7.22
282	2025.93	2031.81	5.88	7.18	7.21
283	2030.62	2038.45	7.83	7.18	7.20
284	2035.29	2042.53	7.24	7.17	7.19
285	2039.94	2047.73	7.79	7.16	7.19
286	2044.57	2050.33	5.77	7.15	7.17
287	2049.18	2057.22	8.04	7.14	7.17
288	2053.77	2060.64	6.87	7.13	7.16
289	2058.34	2066.06	7.72	7.12	7.15
290	2062.90	2068.28	5.38	7.11	7.13
291	2067.44	2075.12	7.69	7.10	7.13
292	2071.95	2078.16	6.21	7.10	7.12
293	2076.45	2083.52	7.07	7.09	7.11
294	2080.93	2085.34	4.41	7.08	7.09
295	2085.39			7.07	
296	2089.84			7.06	
297	2094.26			7.05	
298	2098.67			7.04	
299	2103.05			7.03	
300	2107.42			7.02	
301	2111.77			7.02	
302	2116.10			7.01	
303	2120.41			7.00	
304	2124.71			6.99	
305	2128.98			6.98	
306	2133.24			6.97	
307	2137.48			6.96	
308	2141.69			6.95	
309	2145.89			6.94	
310	2150.07			6.94	
311	2154.24			6.93	
312	2158.38			6.92	
313	2162.50			6.91	
314	2166.61			6.90	
315	2170.70			6.89	
316	2174.77			6.88	
317	2178.82			6.87	
318	2182.85			6.86	
319	2186.86			6.86	
320	2190.85			6.85	
321	2194.83			6.84	
322	2198.78			6.83	
323	2202.72			6.82	
324	2206.64			6.81	
325	2210.54			6.80	
326	2214.42			6.79	
327	2218.28			6.78	
328	2222.13			6.77	
329	2225.95			6.77	
330	2229.76			6.76	
331	2233.54			6.75	

332	2237.31			6.74	
333	2241.06			6.73	
334	2244.79			6.72	
335	2248.51			6.71	
336	2252.20			6.70	
337	2255.88			6.69	
338	2259.53			6.69	
339	2263.17			6.68	
340	2266.79			6.67	

Relations (24) to (32) clearly establish the physical existence of the proposed nuclear elementary charge, $e_n \cong 2.9464e$ and the proposed electroweak coefficient, $\beta \cong 0.001605$. It needs further study.

5. Conclusions

Within the acceptable error bars, the revised formulae for the electroweak and asymmetry terms can be given a chance in exploring the mystery of nuclear binding energy associated with wide range of protons and very wide range of neutrons. With reference to Fermi gas model and unification point of view, we would like to emphasize the point that, strong and weak interactions play a vital role in understanding nuclear stability and binding energy. Considering relations (1) to (32) and corresponding data and figures, we argue and appeal the science community to recommend this unified subject for further research.

Data availability statement: The data that support the findings of this study are openly available.

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References

1. Seshavatharam U.V.S and Lakshminarayana S. Radius, surface area and volume dependent electroweak term and isospin dependent asymmetry term of the strong and electroweak mass formula. Int. J. Phys. Appl. 2025;7(1):122-134.
2. Seshavatharam U.V.S and Lakshminarayana S. Understanding the Origins of Quark Charges, Quantum of Magnetic Flux, Planck's Radiation Constant and Celestial Magnetic Moments with the 4G Model of Nuclear Charge. Current Physics. 1, e090524229812, 122-147, 2024.
3. Seshavatharam U.V.S and Lakshminarayana S. Exploring condensed matter physics with refined electroweak term of the strong and electroweak mass formula. World Scientific News.193(2) 105-13, 2024.
4. Seshavatharam U. V. S, Gunavardhana Naidu T and Lakshminarayana S. Nuclear evidences for confirming the physical existence of 585 GeV weak fermion and galactic observations of TeV radiation. International Journal of Advanced Astronomy. 13(1):1-17, 2025.
5. Seshavatharam U. V. S., Gunavardhana Naidu T and Lakshminarayana S. 2022. To confirm the existence of heavy weak fermion of rest energy 585 GeV. AIP Conf. Proc. 2451 p 020003
6. Seshavatharam U V S and Lakshminarayana S. 4G model of final unification – A brief report Journal of Physics: Conference Series 2197 p 012029, 2022.
7. Seshavatharam U. V. S and Lakshminarayana S., H. K. Cherop and K. M. Khanna, Three Unified Nuclear Binding Energy Formulae. World Scientific News, 163, 30-77, 2022.

8. Seshavatharam U.V.S and Lakshminarayana, S., On the Combined Role of Strong and Electroweak Interactions in Understanding Nuclear Binding Energy Scheme. Mapana Journal of Sciences, 20(1), 1-18, 2021.
9. Seshavatharam U.V.S and Lakshminarayana S., Strong and Weak Interactions in Ghahramany's Integrated Nuclear Binding Energy Formula. World Scientific News, 161, 111-129, 2021.
10. Seshavatharam U.V.S and Lakshminarayana S. Is reduced Planck's constant - an outcome of electroweak gravity? Mapana Journal of Sciences. 19(1), 1,-13, 2020.
11. Seshavatharam U.V.S and Lakshminarayana S. A very brief review on strong and electroweak mass formula pertaining to 4G model of final unification. Proceedings of the DAE Symp. on Nucl. Phys. 67,1173, 2023.
12. Seshavatharam U.V.S and Lakshminarayana S. Computing unified atomic mass unit and Avogadro number with various nuclear binding energy formulae coded in Python. Int. J. Chem. Stud. 2025;13(1):24-30.
13. Bethe H. A. Thomas-Fermi Theory of Nuclei. Phys. Rev., 167(4), 879-907, 1968.
14. Myers W. D. and Swiatecki W. J. Nuclear Properties According to the Thomas-Fermi Model.LBL-36557 Rev. UC-413, 1995.
15. Myers W. D. and Swiatecki W. J. Table of nuclear masses according to the 1994 Thomas-Fermi model. United States: N. p., 1994. Web.
16. P.R. Chowdhury, C. Samanta, D.N. Basu, Modified Bethe– Weizsacker mass formula with isotonic shift and new driplines. Mod. Phys. Lett. A 20, 1605–1618, 2005.
17. G. Royer, On the coefficients of the liquid drop model mass formulae and nuclear radii. Nuclear Physics A, 807, 3–4, 105-118, 2008.
18. Djelloul Benzaid, Salaheddine Bentridi, Abdelkader Kerraci, Naima Amrani. Bethe–Weizsa¨cker semiempirical mass formula coefficients 2019 update based on AME2016.NUCL. SCI. TECH. 31:9, 2020.
19. Gao, Z.P., Wang, YJ., Lü, HL. et al., Machine learning the nuclear mass. NUCL. SCI. TECH. 32, 109, 2021.
20. Peng Guo, et. al. (DRHBc Mass Table Collaboration), Nuclear mass table in deformed relativistic Hartree-Bogoliubov theory in continuum, II: Even-Z nuclei. Atomic Data and Nuclear Data Tables 158 (2024) 101661
21. Cht. Mavrodiev S, Deliyergiyev M.A. Modification of the nuclear landscape in the inverse problem framework using the generalized Bethe-Weizsäcker mass formula. Int. J. Mod. Phys. E 27: 1850015, 2018.
22. Ghahramany N, Gharaati, S., & Ghanaatian, M. New approach to nuclear binding energy in integrated nuclear model. Journal of Theoretical and Applied Physics, 6(1), 3, 2012.
23. Ghahramany N, Sh Gharaati, Ghanaatian M, Hora H. New scheme of nuclide and nuclear binding energy from quark-like model. Iranian Journal of Science & Technology A3, 201-208, 2011.
24. N. Ghahramany M. Ghanaatian and M. Hooshmand. Quark-Gluon Plasma Model and Origin of Magic Numbers. Iranian Physical Journal, 1-2, 35-38, 2007.
25. C. Grojean. Higgs Physics. Proceedings of the 2015 CERN–Latin-American School of High-Energy Physics, 143-157, 2016, CERN-2016-005 (CERN, Geneva, 2016)
26. Ahmed Abokhalil. The Higgs Mechanism and Higgs Boson: Unveiling the Symmetry of the Universe. arXiv:2306.01019v2 [hep-ph]
27. A. Einstein, B. Podolsky, and N. Rosen. Can quantum-mechanical description of physical reality be considered complete?. Phys. Rev. 47, 777, 1935.
28. N. Bohr. Can quantum mechanical description of physical reality be considered complete? Phys. Rev. 480, 696, 1935,
29. J.S. Bell. On the Einstein Podolsky Rosen paradox. Physics 1, 195, 1964.
30. J. Bell, On the problem of hidden variables in quantum mechanics. Reviews of Modern Physics. 38, 3, 447, 1966.
31. Seshavatharam U.V.S, Lakshminarayana S. EPR argument and mystery of the reduced Planck's constant. Algebras, Groups, and Geometries. 36(4), 801-822, 2020.
32. Sunil Mukhi. String theory: a perspective over the last 25 years. Class. Quantum Grav. 28 153001, 2011.
33. Sachdev, Subir. Strange and stringy. Scientific American. 308 (44): 44–51,2013.

34. Blumenhagen R., Lüst D., Theisen S. Basic Concepts of String Theory. Theoretical and Mathematical Physics Springer Heidelberg, Germany, 2013.
35. Arnab Priya Saha and Aninda Sinha Phys. Field Theory Expansions of String Theory Amplitudes.Rev. Lett. 132, 221601,2024.
36. Seshavatharam U.V.S. and Lakshminarayana S. On the compactification and reformation of string theory with three large atomic gravitational constants. International Journal of Physical Research, 9(1), 42-48, 2021.
37. D d'Enterria et al. The strong coupling constant: state of the art and the decade ahead. J. Phys. G: Nucl. Part. Phys. 51 090501, 2024.
38. S. Navas et al. Quarks. (Particle Data Group), Phys. Rev. D 110, 030001 (2024)
39. Seshavatharam U.V.S. and Lakshminarayana S. Understanding the Role of Nuclear Elementary Charge and Its Potential in Estimating Nuclear Binding Energy and Strong Coupling Constant. Preprints 2025, 2025042431. https://doi.org/10.20944/preprints202504.2431.v1
40. M. Ismail1, W. M. Seif, and A. Abdurrahman. Relative stability and magic numbers of nuclei deduced from behavior of cluster emission half-lives. Phys. Rev. C 94, 024316.
41. Maruhn, J.A., Reinhard, PG., Suraud, E. The Fermi-Gas Model. In: Simple Models of Many-Fermion Systems. Springer, Berlin, Heidelberg.2010.
42. Seshavatharam U.V.S. et al. On the Role of Fermi Gas Model in Understanding the Binding Energy of Stable Atomic Nuclides. Prespacetime Journal, 6 (12), 2015.
43. Seshavatharam U.V.S. and Lakshminarayana S. Super symmetry in strong and weak interactions. Int. J. Mod. Phys. E,19, 263--280, 2010.
44. Deur Alexandre, Brodsky Stanley J, De Téramond, Guy F. The QCD running coupling. Progress in Particle and Nuclear Physics. 90: 1–74, 2016.
45. Seshavatharam U.V.S. and Lakshminarayana S. Simplified & Unified Picture of Nuclear Binding Energy. Prespacetime journal, 6(11), 1261-1273, 2015.
46. H. Gao M. Vanderhaeghen, The proton charge radius. Rev. Mod. Phys. 94, 015002, 2022.