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# On the combined role of strong and electroweak interactions in understanding nuclear binding energy scheme

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**Abstract:** With reference to proposed 4G model of final unification and strong interaction, recently we have developed a unified nuclear binding energy scheme with four simple terms, one energy coefficient of 10.1 MeV and two small numbers 0.0016 and 0.0019. In this paper, by eliminating the number 0.0019, we try to fine tune the estimation procedure of number of free or unbound nucleons pertaining to the second term with an energy coefficient of 11.9 MeV. It seems that, some kind of electroweak interaction is playing a strange role in maintaining free or unbound nucleons within the nucleus. It is possible to say that, strong interaction plays a vital role in increasing nuclear binding energy and electroweak interaction plays a vital role in reducing nuclear binding energy. Interesting observation is that, Z can be considered as a characteristic representation of range of number of bound isotopes of Z. For medium, heavy and super heavy atoms, beginning and ending mass numbers pertaining to bound states can be understood with 2Z+0.004Z^2 and 3Z+0.004Z^2 respectively. With further study, neutron drip lines can be understood. Based on this kind of data fitting procedure, existence of our 4G model of electroweak fermion of rest energy 584.725 GeV can be confirmed indirectly.

**Keywords:** 4G model of final unification; Four gravitational constants; Unified nuclear binding energy scheme; Free or unbound nucleons; Strong interaction; Electroweak interaction;

## 1. Introduction

We would like to emphasize the fact that, physics and mathematics associated with fixing of the energy coefficients of semi empirical mass formulae (SEMF) [1,2,3,4,5] are neither connected with residual strong nuclear force nor connected with strong coupling constant $\alpha_s$. Since nuclear force is mediated via quarks and gluons, it is necessary and compulsory to study the nuclear binding energy scheme in terms of nuclear coupling constants. In this direction, N. Ghahramany and team members have taken a great initiative in exploring the secrets of nuclear binding energy and magic numbers [6,7] with reference to quarks. Very interesting point of their study is that - nuclear binding energy can be understood with two or three terms having single variable energy coefficient. In this direction, based on three unified assumptions connected with gravity and atomic interactions, in a semi empirical approach, recently we have developed a very simple formula for nuclear binding energy with single energy coefficient having four simple terms [8-15]. Corresponding relations can be expressed in the following way. Starting from Z=3 to 118,

$$A_s \cong 2Z + 0.0016(2Z)^2 \cong 2Z + 0.0064Z^2 \tag{1}$$

$\cong$ Estimated mass number close to proton-neutron mean stability line.

$$BE \cong \left\{ A - A_{fg} - A^{1/3} - \frac{(A_s - A)^2}{A_s} \right\} (B_0 \cong 10.1 \text{ MeV}) \tag{2}$$

$\cong$ Estimated nuclear binding energy

Here, we would like to appeal that,

1) $A_{fg} \cong \left(1 + 0.0019A\sqrt{ZN}\right)$ can be called as the geometric number of free or unbound nucleons.

2) $A^{1/3}$ can be called as radial factor associated with nucleons.

3) $\frac{(A_s - A)^2}{A_s}$ can be called as isotopic asymmetric term associated with mean stable mass number.

4) Binding energy coefficient, $B_0 \cong \frac{1}{\alpha_s}\left(\frac{e^2}{4\pi\varepsilon_0 R_0}\right) \cong 10.1$ MeV seems to be associated with nuclear radius, strong coupling constant and fine structure ratio.

## 2. List of symbols

Newtonian gravitational constant = $G_N$
Electromagnetic gravitational constant= $G_e$
Nuclear gravitational constant = $G_s$
Weak gravitational constant = $G_W$
Fermi's weak coupling constant = $G_F$
Strong coupling constant = $\alpha_s$
Fine structure ratio = $\alpha$
Electroweak fermion = $M_w$
Reduced Planck's constant = $\hbar$
Speed of light = $c$
Elementary charge = $e$
Strong nuclear charge = $e_s$
Mass of proton = $m_p$
Mass of neutron = $m_n$
Mass of electron = $m_e$
Charge radius of nucleus= $R_0$
Proton number = $Z$
Neutron number = $N$
Mass number = $A$
Estimated mass number close to stability = $A_s$
Nuclear binding energy coefficient = $B_0$

## 3. Basic assumptions

1) There exists a characteristic electroweak fermion of rest energy, $M_w c^2 \cong 584.725$ GeV. It can be considered as the zygote of all elementary particles.
2) There exists a strong interaction elementary charge $(e_s)$ in such a way that, it's squared ratio with normal elementary charge is close to reciprocal of the strong coupling constant.
3) Each atomic interaction is associated with a characteristic gravitational coupling constant.

It may be noted that, when mass of any elementary particle is extremely small/negligible compared to macroscopic bodies, highly curved microscopic space-time can be addressed with large gravitational constants and magnitude of elementary gravitational constant seems to increase with decreasing mass and increasing interaction range. Based on this logic, we consider the possibility of existence of three large gravitational constants assumed to be associated with the electromagnetic, strong and weak interactions. Approximate background relation is, $G_x m_x^2 \approx \hbar c$. Based on these assumptions, in our recently published paper [15], we have a developed a semi empirical scheme for deriving the important results. Readers are encouraged to refer it for further analysis. Quantitatively,

$$\left.\begin{array}{l} G_e \cong 2.374335\times10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_s \cong 3.329561\times10^{28}\text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_w \cong 2.909745\times10^{22}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_N \cong 6.679855\times10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \\ G_F \cong 1.4402105\times10^{-62}\ \text{J.m}^3 \\ \alpha_s \cong 0.1151937 \text{ and } e_s \cong 2.9463591e \end{array}\right\}$$

our model is associated with 3 atomic gravitational constants and one celestial gravitational constant, we call our model as 4G model of Final Unification. Important results pertaining to nuclear physics are [15,16,17,18],

$$\alpha_s \cong \left(\frac{e}{e_s}\right)^2 \cong \left(\frac{\hbar c}{G_s m_p^2}\right)^2 \cong 0.1151937 \tag{6}$$

$$R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.23929 \text{ fm} \tag{7}$$

$$\hbar c \cong G_w M_w^2 \tag{8}$$

$$\left(\frac{e_s}{m_p}\right) \div \left(\frac{e}{m_e}\right) \cong \frac{G_s m_p m_e}{G_w M_w^2} \cong \frac{G_w M_w^2}{G_e m_e^2} \cong \frac{m_p}{M_w} \cong 0.001605 \tag{9}$$

$$\begin{gathered} G_F \cong G_w M_w^2 R_w^2 \\ \text{where, } R_w \cong \left(2G_w M_w / c^2\right) \end{gathered} \tag{10}$$

## 4. A review on the second term and fine tuning of number of free or unbound nucleons

In our recent paper [14], we proposed that, starting from Z=3 to 118,

1) All the nucleons are not involved in the nuclear binding energy scheme.
2) Nucleons that are not involved in the nuclear binding energy scheme can be called 'free nucleons'.
3) Number of free nucleons increases with increasing $A\sqrt{ZN}$ .
4) Nucleons that involve in nuclear binding energy scheme can be called 'active nucleons'.
5) In finding the free nucleon number, with trial–error solutions, a number close to 0.0019 could be arrived at.
6) Z=3 to 118, minimum number of free or unbound nucleons is 1.
7) For Z=2, minimum number of free or unbound nucleons is 'Zero'.
8) Number of free or unbound protons can be expressed with a relation of the form,

$$A_{fp} \cong 0.0019AZ \tag{11}$$

9) Number of free or unbound neutrons can be expressed with a relation of the form,

$$A_{fn} \cong 0.0019AN \tag{12}$$

10) Geometric number of free nucleons can be expressed with a relation of the form,

$$A_{fg} \cong 0.0019A\sqrt{ZN} \tag{13}$$

11) Active nucleon number can be expressed with a relation of the form,

$$A_a \cong A - A_{fg} \tag{14}$$

As the number 0.0019 is very close to 0.0016, in this paper, we try to eliminate 0.0019 with $\left(\frac{m_p}{M_w}\right)$. Starting from Z=3 to 118,

1) Number of free or unbound protons can be re-expressed with a relation of the form,

$$A_{fp} \approx \left(\frac{x_p m_p}{M_w}\right) \tag{15}$$

where, $x_p$ is a characteristic number associated with mass number and proton number.

2) Number of free or unbound neutrons can be re-expressed with a relation of the form,

$$A_{fn} \approx \left(\frac{x_n m_n}{M_w}\right) \tag{16}$$

where, $x_n$ is a characteristic number associated with mass number and neutron number.

3) Geometric number of free nucleons can be re-expressed with a relation of the form,

$$A_{fg} \approx \sqrt{\left(\frac{x_p m_p}{M_w}\right)\left(\frac{x_n m_n}{M_w}\right)} \approx \left(\frac{\sqrt{m_p m_n}}{M_w}\right)\sqrt{x_p x_n} \tag{17}$$

$(x_p, x_n)$ have been chosen in such a way that,

$$\left.\begin{array}{l}\sqrt{x_p + x_n} \cong A \\ \rightarrow x_p = AZ \text{ and } x_n = AN\end{array}\right\} \tag{18}$$

Hence, $$A_{fg} \approx \left(\frac{\sqrt{m_p m_n}}{M_w}\right)\sqrt{x_p x_n} \approx \left(\frac{\sqrt{m_p m_n}}{M_w}\right)A\sqrt{ZN} \approx 0.001606A\sqrt{ZN} \tag{19}$$

By considering minimum number of free nucleons as 1, starting from Z= 3 to 118,

$$A_{fg} \cong 1 + \left\{\left(\frac{\sqrt{m_p m_n}}{M_w}\right)A\sqrt{ZN}\right\} \tag{20}$$

Mass number close to mean stability can be expressed in the following way.

$$A_s \cong 2Z + \left(\frac{\sqrt{m_p m_n}}{M_w}\right)(2Z)^2 \cong 2Z + \left(\frac{\sqrt{m_p m_n}}{M_w}\right)(2Z)^2 \cong 2Z + 0.006423Z^2 \tag{21}$$

Important points to be noted are,

a) Number of free protons are $A_{fp} \approx \left(\frac{AZm_p}{M_w}\right)$ and number of free neutrons are $A_{fn} \approx \left(\frac{AZm_n}{M_w}\right)$.

b) Characteristic electroweak fermion of rest energy, $M_w c^2 \cong 584.725$ GeV seems to play a key role in estimating the number of free protons and free neutrons. This is the essence of this review. With reference to the data presented in Table 1, it can be confirmed. With this, indirectly existence of 584.725 GeV can be confirmed. We would like to appeal that, some kind of electroweak interaction is playing a strange role in maintaining free or unbound nucleons within the nucleus. It needs further study.

c) The ratio $\left(\frac{\sqrt{m_p m_n}}{M_w}\right)$ seems to play an interesting role in estimating the geometric number of free nucleons and proton-neutron mean stability.

d) When $(A-2Z) \to A_{fP}$, bound states of $(A,Z)$ seem to have a possible stability on lower side of $A$. This peculiar condition seems to be satisfied at $A_{low} \cong 2Z + 0.004Z^2$ where $\left(\frac{m_n - m_p}{m_e}\right) \times 0.001606 = 2.531 \times 0.001606 = 0.004$. For medium, heavy and super heavy atomic nuclides, this type of condition can be considered as a clue [19, 20]. See Table 2.

e) Similarly, when, $A_{up} \cong 3Z + 0.004Z^2$, binding energy seems to start reducing. If one is willing to consider $A_{up}$ as an upper limit of bound state of $(A,Z)$, then $Z$ can be considered as a characteristic representation of range of number of bound states of $Z$. These isotopes may or may not be stable. Clearly speaking, $(A_{\text{low}}, A_{\text{up}})$ seems to represent the starting and ending points of probability of forming of bound states of $Z$. Proceeding further, neutron drip lines can be understood.

f) Energy coefficient for the second term becomes, $\left(\frac{0.0019}{0.001606}\right) 10.1 \cong 1.1831 \times 10.1 \cong 11.95$ MeV. For data fitting purpose, we consider it as 11.90 MeV. Now, binding energy can be estimated with the following relation having two energy coefficients.

$$BE \cong \left(A - A^{1/3} - \frac{(A_s - A)^2}{A_s}\right) 10.1 \text{ MeV} - \left[1 + \left(0.001606 A\sqrt{ZN}\right)\right] 11.9 \text{ MeV} \tag{22}$$

g) Based on relation (22), it is possible to say that, strong interaction plays a vital role in increasing nuclear binding energy and electroweak interaction plays a vital role in reducing nuclear binding energy.

## 5. Discussion

1) Binding energy coefficient can be understood with the following relations.

$$B_0 \cong \frac{1}{\alpha_s}\left(\frac{e^2}{4\pi\varepsilon_0 R_0}\right) \cong \left(\frac{e_s^2}{4\pi\varepsilon_0 R_0}\right) \cong 10.08 \text{ MeV} \tag{23}$$

where, $\alpha_s \cong 0.1152$ and $R_0 \cong 1.24$ fermi

Based on relations (6) and (7),

$$B_0 \cong \frac{1}{2}\left(\frac{ee_s}{4\pi\varepsilon_0 \text{hc}}\right)\left(m_p c^2\right) \cong \frac{1}{2}\sqrt{\left(\frac{e^2}{4\pi\varepsilon_0 \text{hc}}\right)\left(\frac{e_s^2}{4\pi\varepsilon_0 \text{hc}}\right)}\left(m_p c^2\right) \cong 10.09 \text{ MeV} \tag{24}$$

where, $\left(\frac{e_s^2}{4\pi\varepsilon_0 \text{hc}}\right) \cong 0.06334854$ can be called as 'nuclear fine structure ratio'.

$\left(\frac{e^2}{4\pi\varepsilon_0 \text{hc}}\right) \cong \alpha$ is the 'fine structure ratio'.

2) With reference to the following reference semi empirical mass formula (SEMF) [5,14], we have prepared Table 1 and Figure 1. Readers are encouraged to refer other SEMF having different sets of energy coefficients.

$$BE_{\text{Ref}} \cong \left\{ \begin{array}{c} \left[\left(A\times 15.36\right)\right]-\left[\left(A^{2/3}\times 16.32\right)\right]-\left[\left(\frac{Z^2}{A^{1/3}}\right)0.6929\right] \\ -\left[\frac{\left((A/2)-Z\right)^2}{A}\times 90.46\right]\pm\left(\frac{11.32}{\sqrt{A}}\right) \end{array} \right\} \text{MeV} \quad (25)$$

By correlating the relations (19 to 25) and with a systematic study, in a microscopic approach, hidden physics can be explored in a unified approach. In Fig. 1 blue curve indicates our estimated binding energy and green curve indicates reference binding energy. Estimated binding energy needs a review for mass numbers close to A=2Z. Point to be noted is that, error in binding energy for the estimated range of lower (218) and upper (310) mass limits of Z=92 is on minimum side.

**Figure 1: Estimated binding energy of isotopes of Z=92**

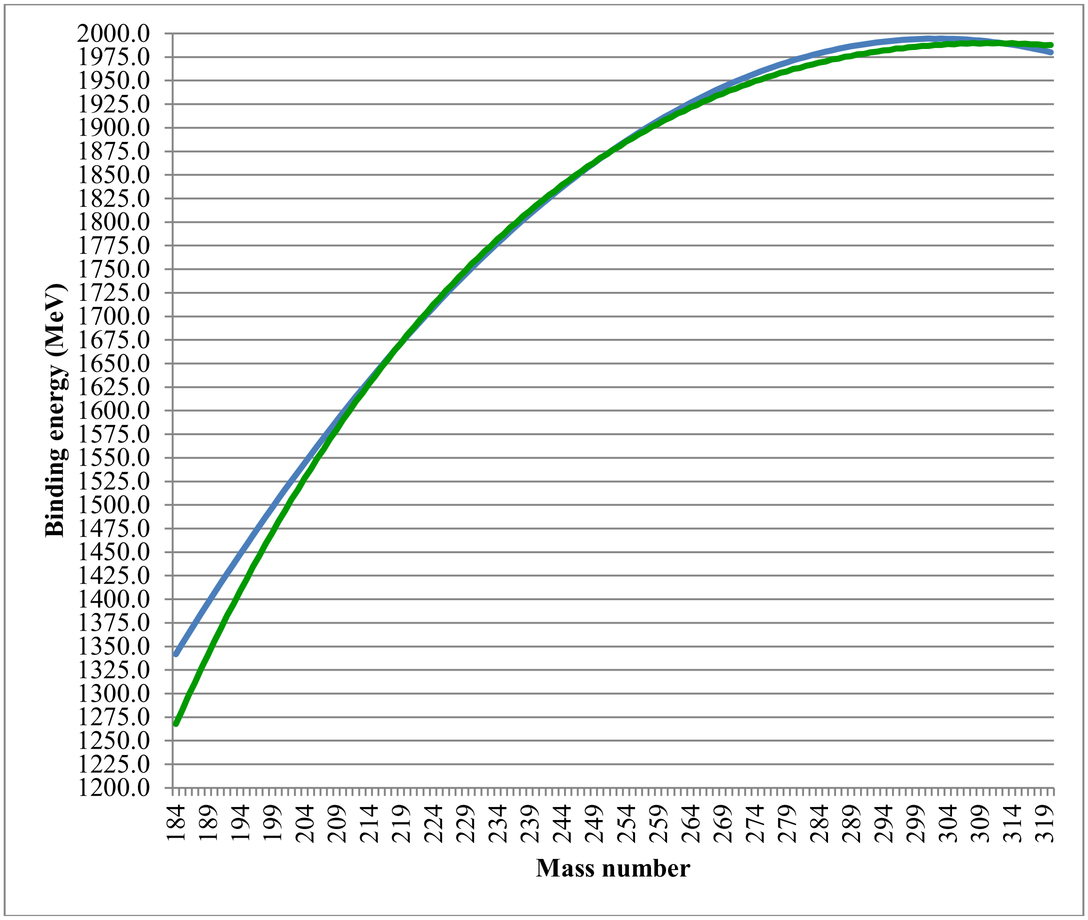

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**Table 1: Estimated nuclear binding energy of isotopes of Z=92**

| Proton number | Estimated Mean mass number | Mass number | Neutron number | Excess neutron number | Free proton number | Free neutron number | Estimated BE (MeV) | Reference BE ( MeV) | Difference in Binding energy (MeV)1 |
|---|---|---|---|---|---|---|---|---|---|
| 92 | 238 | 184 | 92 | 0 | 27 | 27 | 1341.8 | 1268.0 | -73.8 |
| 92 | 238 | 185 | 93 | 1 | 27 | 28 | 1352.8 | 1282.4 | -70.4 |
| 92 | 238 | 186 | 94 | 2 | 27 | 28 | 1363.7 | 1298.1 | -65.6 |
| 92 | 238 | 187 | 95 | 3 | 28 | 29 | 1374.6 | 1312.0 | -62.6 |
| 92 | 238 | 188 | 96 | 4 | 28 | 29 | 1385.3 | 1327.3 | -58.0 |
| 92 | 238 | 189 | 97 | 5 | 28 | 29 | 1395.9 | 1340.6 | -55.3 |
| 92 | 238 | 190 | 98 | 6 | 28 | 30 | 1406.5 | 1355.4 | -51.1 |
| 92 | 238 | 191 | 99 | 7 | 28 | 30 | 1416.9 | 1368.3 | -48.6 |
| 92 | 238 | 192 | 100 | 8 | 28 | 31 | 1427.3 | 1382.7 | -44.6 |
| 92 | 238 | 193 | 101 | 9 | 29 | 31 | 1437.5 | 1395.1 | -42.4 |
| 92 | 238 | 194 | 102 | 10 | 29 | 32 | 1447.7 | 1409.0 | -38.7 |
| 92 | 238 | 195 | 103 | 11 | 29 | 32 | 1457.8 | 1421.0 | -36.8 |
| 92 | 238 | 196 | 104 | 12 | 29 | 33 | 1467.8 | 1434.5 | -33.3 |
| 92 | 238 | 197 | 105 | 13 | 29 | 33 | 1477.7 | 1446.1 | -31.6 |
| 92 | 238 | 198 | 106 | 14 | 29 | 34 | 1487.4 | 1459.1 | -28.4 |
| 92 | 238 | 199 | 107 | 15 | 29 | 34 | 1497.1 | 1470.3 | -26.9 |
| 92 | 238 | 200 | 108 | 16 | 30 | 35 | 1506.8 | 1482.9 | -23.9 |
| 92 | 238 | 201 | 109 | 17 | 30 | 35 | 1516.3 | 1493.7 | -22.6 |
| 92 | 238 | 202 | 110 | 18 | 30 | 36 | 1525.7 | 1505.9 | -19.8 |
| 92 | 238 | 203 | 111 | 19 | 30 | 36 | 1535.0 | 1516.3 | -18.7 |
| 92 | 238 | 204 | 112 | 20 | 30 | 37 | 1544.2 | 1528.1 | -16.1 |
| 92 | 238 | 205 | 113 | 21 | 30 | 37 | 1553.4 | 1538.1 | -15.2 |
| 92 | 238 | 206 | 114 | 22 | 30 | 38 | 1562.4 | 1549.6 | -12.9 |
| 92 | 238 | 207 | 115 | 23 | 31 | 38 | 1571.4 | 1559.2 | -12.1 |
| 92 | 238 | 208 | 116 | 24 | 31 | 39 | 1580.2 | 1570.3 | -9.9 |
| 92 | 238 | 209 | 117 | 25 | 31 | 39 | 1589.0 | 1579.6 | -9.4 |
| 92 | 238 | 210 | 118 | 26 | 31 | 40 | 1597.6 | 1590.3 | -7.3 |
| 92 | 238 | 211 | 119 | 27 | 31 | 40 | 1606.2 | 1599.3 | -6.9 |
| 92 | 238 | 212 | 120 | 28 | 31 | 41 | 1614.7 | 1609.7 | -5.0 |
| 92 | 238 | 213 | 121 | 29 | 31 | 41 | 1623.1 | 1618.3 | -4.8 |
| 92 | 238 | 214 | 122 | 30 | 32 | 42 | 1631.4 | 1628.3 | -3.0 |
| 92 | 238 | 215 | 123 | 31 | 32 | 42 | 1639.5 | 1636.6 | -2.9 |
| 92 | 238 | 216 | 124 | 32 | 32 | 43 | 1647.6 | 1646.3 | -1.3 |
| 92 | 238 | 217 | 125 | 33 | 32 | 44 | 1655.7 | 1654.3 | -1.3 |
| 92 | 238 | 218 | 126 | 34 | 32 | 44 | 1663.6 | 1663.7 | 0.2 |
| 92 | 238 | 219 | 127 | 35 | 32 | 45 | 1671.4 | 1671.4 | 0.0 |
| 92 | 238 | 220 | 128 | 36 | 33 | 45 | 1679.1 | 1680.5 | 1.4 |
| 92 | 238 | 221 | 129 | 37 | 33 | 46 | 1686.7 | 1687.9 | 1.1 |
| 92 | 238 | 222 | 130 | 38 | 33 | 46 | 1694.3 | 1696.7 | 2.4 |
| 92 | 238 | 223 | 131 | 39 | 33 | 47 | 1701.7 | 1703.8 | 2.0 |
| 92 | 238 | 224 | 132 | 40 | 33 | 47 | 1709.1 | 1712.2 | 3.2 |
| 92 | 238 | 225 | 133 | 41 | 33 | 48 | 1716.3 | 1719.1 | 2.7 |
| 92 | 238 | 226 | 134 | 42 | 33 | 49 | 1723.5 | 1727.3 | 3.8 |
| 92 | 238 | 227 | 135 | 43 | 34 | 49 | 1730.6 | 1733.8 | 3.2 |
| 92 | 238 | 228 | 136 | 44 | 34 | 50 | 1737.5 | 1741.7 | 4.2 |
| 92 | 238 | 229 | 137 | 45 | 34 | 50 | 1744.4 | 1748.0 | 3.6 |
| 92 | 238 | 230 | 138 | 46 | 34 | 51 | 1751.2 | 1755.6 | 4.4 |
| 92 | 238 | 231 | 139 | 47 | 34 | 52 | 1757.9 | 1761.7 | 3.8 |
| 92 | 238 | 232 | 140 | 48 | 34 | 52 | 1764.5 | 1769.0 | 4.5 |
| 92 | 238 | 233 | 141 | 49 | 34 | 53 | 1771.0 | 1774.8 | 3.8 |
| 92 | 238 | 234 | 142 | 50 | 35 | 53 | 1777.4 | 1781.9 | 4.5 |
| 92 | 238 | 235 | 143 | 51 | 35 | 54 | 1783.8 | 1787.4 | 3.7 |
| 92 | 238 | 236 | 144 | 52 | 35 | 55 | 1790.0 | 1794.3 | 4.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 92 | 238 | 237 | 145 | 53 | 35 | 55 | 1796.1 | 1799.6 | 3.5 |
| 92 | 238 | 238 | 146 | 54 | 35 | 56 | 1802.2 | 1806.2 | 4.1 |
| 92 | 238 | 239 | 147 | 55 | 35 | 56 | 1808.1 | 1811.3 | 3.2 |
| 92 | 238 | 240 | 148 | 56 | 35 | 57 | 1813.9 | 1817.6 | 3.7 |
| 92 | 238 | 241 | 149 | 57 | 36 | 58 | 1819.7 | 1822.4 | 2.7 |
| 92 | 238 | 242 | 150 | 58 | 36 | 58 | 1825.4 | 1828.6 | 3.2 |
| 92 | 238 | 243 | 151 | 59 | 36 | 59 | 1830.9 | 1833.2 | 2.2 |
| 92 | 238 | 244 | 152 | 60 | 36 | 60 | 1836.4 | 1839.1 | 2.7 |
| 92 | 238 | 245 | 153 | 61 | 36 | 60 | 1841.8 | 1843.5 | 1.7 |
| 92 | 238 | 246 | 154 | 62 | 36 | 61 | 1847.1 | 1849.2 | 2.1 |
| 92 | 238 | 247 | 155 | 63 | 36 | 61 | 1852.3 | 1853.3 | 1.0 |
| 92 | 238 | 248 | 156 | 64 | 37 | 62 | 1857.4 | 1858.8 | 1.4 |
| 92 | 238 | 249 | 157 | 65 | 37 | 63 | 1862.4 | 1862.8 | 0.4 |
| 92 | 238 | 250 | 158 | 66 | 37 | 63 | 1867.3 | 1868.0 | 0.7 |
| 92 | 238 | 251 | 159 | 67 | 37 | 64 | 1872.1 | 1871.8 | -0.4 |
| 92 | 238 | 252 | 160 | 68 | 37 | 65 | 1876.9 | 1876.9 | 0.0 |
| 92 | 238 | 253 | 161 | 69 | 37 | 65 | 1881.5 | 1880.4 | -1.1 |
| 92 | 238 | 254 | 162 | 70 | 38 | 66 | 1886.1 | 1885.3 | -0.8 |
| 92 | 238 | 255 | 163 | 71 | 38 | 67 | 1890.5 | 1888.6 | -1.9 |
| 92 | 238 | 256 | 164 | 72 | 38 | 67 | 1894.9 | 1893.3 | -1.6 |
| 92 | 238 | 257 | 165 | 73 | 38 | 68 | 1899.1 | 1896.5 | -2.7 |
| 92 | 238 | 258 | 166 | 74 | 38 | 69 | 1903.3 | 1900.9 | -2.3 |
| 92 | 238 | 259 | 167 | 75 | 38 | 69 | 1907.4 | 1903.9 | -3.4 |
| 92 | 238 | 260 | 168 | 76 | 38 | 70 | 1911.3 | 1908.2 | -3.1 |
| 92 | 238 | 261 | 169 | 77 | 39 | 71 | 1915.2 | 1911.0 | -4.2 |
| 92 | 238 | 262 | 170 | 78 | 39 | 72 | 1919.0 | 1915.1 | -3.9 |
| 92 | 238 | 263 | 171 | 79 | 39 | 72 | 1922.7 | 1917.7 | -5.0 |
| 92 | 238 | 264 | 172 | 80 | 39 | 73 | 1926.3 | 1921.7 | -4.7 |
| 92 | 238 | 265 | 173 | 81 | 39 | 74 | 1929.9 | 1924.1 | -5.7 |
| 92 | 238 | 266 | 174 | 82 | 39 | 74 | 1933.3 | 1927.9 | -5.4 |
| 92 | 238 | 267 | 175 | 83 | 39 | 75 | 1936.6 | 1930.2 | -6.5 |
| 92 | 238 | 268 | 176 | 84 | 40 | 76 | 1939.8 | 1933.7 | -6.1 |
| 92 | 238 | 269 | 177 | 85 | 40 | 76 | 1943.0 | 1935.8 | -7.1 |
| 92 | 238 | 270 | 178 | 86 | 40 | 77 | 1946.0 | 1939.3 | -6.8 |
| 92 | 238 | 271 | 179 | 87 | 40 | 78 | 1949.0 | 1941.2 | -7.8 |
| 92 | 238 | 272 | 180 | 88 | 40 | 79 | 1951.9 | 1944.5 | -7.4 |
| 92 | 238 | 273 | 181 | 89 | 40 | 79 | 1954.6 | 1946.3 | -8.4 |
| 92 | 238 | 274 | 182 | 90 | 40 | 80 | 1957.3 | 1949.4 | -7.9 |
| 92 | 238 | 275 | 183 | 91 | 41 | 81 | 1959.9 | 1951.0 | -8.9 |
| 92 | 238 | 276 | 184 | 92 | 41 | 82 | 1962.4 | 1953.9 | -8.4 |
| 92 | 238 | 277 | 185 | 93 | 41 | 82 | 1964.8 | 1955.4 | -9.3 |
| 92 | 238 | 278 | 186 | 94 | 41 | 83 | 1967.1 | 1958.2 | -8.9 |
| 92 | 238 | 279 | 187 | 95 | 41 | 84 | 1969.3 | 1959.6 | -9.7 |
| 92 | 238 | 280 | 188 | 96 | 41 | 85 | 1971.4 | 1962.2 | -9.2 |
| 92 | 238 | 281 | 189 | 97 | 42 | 85 | 1973.4 | 1963.4 | -10.0 |
| 92 | 238 | 282 | 190 | 98 | 42 | 86 | 1975.4 | 1965.9 | -9.5 |
| 92 | 238 | 283 | 191 | 99 | 42 | 87 | 1977.2 | 1966.9 | -10.3 |
| 92 | 238 | 284 | 192 | 100 | 42 | 88 | 1978.9 | 1969.3 | -9.7 |
| 92 | 238 | 285 | 193 | 101 | 42 | 88 | 1980.6 | 1970.2 | -10.4 |
| 92 | 238 | 286 | 194 | 102 | 42 | 89 | 1982.2 | 1972.4 | -9.8 |
| 92 | 238 | 287 | 195 | 103 | 42 | 90 | 1983.6 | 1973.2 | -10.5 |
| 92 | 238 | 288 | 196 | 104 | 43 | 91 | 1985.0 | 1975.2 | -9.8 |
| 92 | 238 | 289 | 197 | 105 | 43 | 91 | 1986.3 | 1975.9 | -10.4 |
| 92 | 238 | 290 | 198 | 106 | 43 | 92 | 1987.5 | 1977.8 | -9.7 |
| 92 | 238 | 291 | 199 | 107 | 43 | 93 | 1988.6 | 1978.3 | -10.2 |
| 92 | 238 | 292 | 200 | 108 | 43 | 94 | 1989.6 | 1980.1 | -9.5 |
| 92 | 238 | 293 | 201 | 109 | 43 | 95 | 1990.5 | 1980.5 | -10.0 |
| 92 | 238 | 294 | 202 | 110 | 43 | 95 | 1991.3 | 1982.2 | -9.1 |
| 92 | 238 | 295 | 203 | 111 | 44 | 96 | 1992.0 | 1982.5 | -9.6 |

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 92 | 238 | 296 | 204 | 112 | 44 | 97 | 1992.6 | 1984.0 | -8.7 |
| 92 | 238 | 297 | 205 | 113 | 44 | 98 | 1993.2 | 1984.1 | -9.0 |
| 92 | 238 | 298 | 206 | 114 | 44 | 99 | 1993.6 | 1985.5 | -8.1 |
| 92 | 238 | 299 | 207 | 115 | 44 | 99 | 1994.0 | 1985.6 | -8.4 |
| 92 | 238 | 300 | 208 | 116 | 44 | 100 | 1994.2 | 1986.9 | -7.4 |
| 92 | 238 | 301 | 209 | 117 | 44 | 101 | 1994.4 | 1986.8 | -7.6 |
| 92 | 238 | 302 | 210 | 118 | 45 | 102 | 1994.5 | 1987.9 | -6.5 |
| 92 | 238 | 303 | 211 | 119 | 45 | 103 | 1994.5 | 1987.7 | -6.7 |
| 92 | 238 | 304 | 212 | 120 | 45 | 104 | 1994.3 | 1988.8 | -5.6 |
| 92 | 238 | 305 | 213 | 121 | 45 | 104 | 1994.1 | 1988.5 | -5.7 |
| 92 | 238 | 306 | 214 | 122 | 45 | 105 | 1993.8 | 1989.4 | -4.4 |
| 92 | 238 | 307 | 215 | 123 | 45 | 106 | 1993.5 | 1989.0 | -4.5 |
| 92 | 238 | 308 | 216 | 124 | 46 | 107 | 1993.0 | 1989.8 | -3.2 |
| 92 | 238 | 309 | 217 | 125 | 46 | 108 | 1992.4 | 1989.3 | -3.1 |
| 92 | 238 | 310 | 218 | 126 | 46 | 109 | 1991.7 | 1990.0 | -1.7 |
| 92 | 238 | 311 | 219 | 127 | 46 | 109 | 1991.0 | 1989.4 | -1.6 |
| 92 | 238 | 312 | 220 | 128 | 46 | 110 | 1990.1 | 1990.0 | -0.2 |
| 92 | 238 | 313 | 221 | 129 | 46 | 111 | 1989.2 | 1989.2 | 0.1 |
| 92 | 238 | 314 | 222 | 130 | 46 | 112 | 1988.1 | 1989.7 | 1.6 |
| 92 | 238 | 315 | 223 | 131 | 47 | 113 | 1987.0 | 1988.9 | 1.9 |
| 92 | 238 | 316 | 224 | 132 | 47 | 114 | 1985.8 | 1989.3 | 3.5 |
| 92 | 238 | 317 | 225 | 133 | 47 | 115 | 1984.4 | 1988.3 | 3.9 |
| 92 | 238 | 318 | 226 | 134 | 47 | 115 | 1983.0 | 1988.6 | 5.6 |
| 92 | 238 | 319 | 227 | 135 | 47 | 116 | 1981.5 | 1987.6 | 6.0 |
| 92 | 238 | 320 | 228 | 136 | 47 | 117 | 1979.9 | 1987.7 | 7.8 |

**Table-2: Lower and upper mass limits of heavy and super heavy atomic nuclides**

| Proton number | Estimated mean mass number | Estimated lower mass number | Estimated upper mass number |
|---|---|---|---|
| 118 | 325 | 292 | 410 |
| 117 | 322 | 289 | 406 |
| 116 | 318 | 286 | 402 |
| 115 | 315 | 283 | 398 |
| 114 | 311 | 280 | 394 |
| 113 | 308 | 277 | 390 |
| 112 | 304 | 274 | 386 |
| 111 | 301 | 271 | 382 |
| 110 | 297 | 268 | 378 |
| 109 | 294 | 266 | 375 |
| 108 | 291 | 263 | 371 |
| 107 | 287 | 260 | 367 |
| 106 | 284 | 257 | 363 |
| 105 | 281 | 254 | 359 |
| 104 | 277 | 251 | 355 |
| 103 | 274 | 248 | 351 |
| 102 | 271 | 246 | 348 |
| 101 | 267 | 243 | 344 |
| 100 | 264 | 240 | 340 |
| 99 | 261 | 237 | 336 |
| 98 | 257 | 234 | 332 |
| 97 | 254 | 232 | 329 |
| 96 | 251 | 229 | 325 |
| 95 | 248 | 226 | 321 |
| 94 | 245 | 223 | 317 |
| 93 | 241 | 221 | 314 |
| 92 | 238 | 218 | 310 |

| | | | |
|---|---|---|---|
| 91 | 235 | 215 | 306 |
| 90 | 232 | 212 | 302 |
| 89 | 229 | 210 | 299 |
| 88 | 226 | 207 | 295 |
| 87 | 222 | 204 | 291 |
| 86 | 219 | 202 | 288 |
| 85 | 216 | 199 | 284 |
| 84 | 213 | 196 | 280 |
| 83 | 210 | 194 | 277 |
| 82 | 207 | 191 | 273 |
| 81 | 204 | 188 | 269 |
| 80 | 201 | 186 | 266 |

## 6. Conclusion

Considering the proposed relations (1 to 25), our unified binding energy scheme assumed to be associated with free protons and free neutrons can be recommended for further research. We would like to appeal that, some kind of electroweak interaction is playing a strange role in maintaining free or unbound nucleons within the nucleus. With further study, lower and upper mass limits of bound states of medium and heavy atomic nuclides and corresponding neutron drip lines can be explored. Proceeding further, existence of our 4G model of electroweak fermion of rest energy 584.725 GeV can be confirmed indirectly.

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