Understanding nuclear stability and binding energy with nuclear and electromagnetic gravitational constants

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Introduction

Based on the old and ignored scientific assumption put forward by Nobel laureate Abdus Salam [1], we propose two large pseudo gravitational constants assumed to be associated with strong and electromagnetic interactions. With them, currently believed generalized physical constants like, proton-electron mass ratio, neutron life time, weak coupling constant, strong coupling constant, nuclear charge radius, root mean square radius of proton, Planck's constant, Bohr radius of hydrogen atom, molar mass constant, Avogadro number and Newtonian gravitational constant etc and concepts like nuclear binding energy, nuclear stability, nuclear charge radii and atomic radii. can be reviewed in a unified approach [2].

Two basic assumptions of final unification

Assumption-1: Magnitude of the gravitational constant associated with the electromagnetic interaction is,
$G_e \cong (2.375 \pm 0.002)\times 10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$.

Assumption-2: Magnitude of the gravitational constant associated with the strong interaction is,
$G_s \cong (3.328 \pm 0.002)\times 10^{28}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$.

To understand proton, electron rest masses and nuclear charge radius

Based on these two assumptions,

$$\frac{m_p}{m_e} \cong \left(\frac{G_s m_p^2}{\hbar c}\right)\left(\frac{G_e m_e^2}{\hbar c}\right) \quad (1)$$

$$\left(\frac{G_s m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_e m_e^2}\right) \quad (2)$$

If one is willing to define Planck mass as $M_{pl} \cong \sqrt{\hbar c/G_N}$ and Nuclear Planck mass as $m_{npl} \cong \sqrt{\hbar c/G_s} \approx 546.7\ \text{MeV}/c^2$,

$$m_p \cong \left(\frac{m_e^6 M_{pl}}{m_{npl}^2}\right)^{1/5} (\text{Or})\ m_e \cong \left(\frac{m_p^5 m_{npl}^2}{M_{pl}}\right)^{1/6} \quad (3)$$

$$R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.239\text{fm (and)}$$
$$R_p \cong \frac{\sqrt{2}G_s m_p}{c^2} \cong 0.876\text{fm} \quad (4)$$

where R_0 and R_p can be considered as nuclear charge radius and RMS radius of proton [3] respectively.

Nuclear stability and nuclear binding energy at stable mass numbers

It is noticed that,

$$\left.\begin{aligned} -\left(\frac{3}{5}\left[e^2/4\pi\varepsilon_0 R_p\right]\right) &\cong -0.986\ \text{MeV} \\ -\left(\frac{3}{5}\left[G_s m_p^2/R_p\right]\right) &\cong -398.0\ \text{MeV} \end{aligned}\right\} \quad (5)$$

seem to represent the respective self binding energies. Then for $(Z \geq 5)$, nuclear binding energy [4] close to stable mass numbers can be expressed with,

$$(BE)_{As} \cong -\left(Z-2+\sqrt{\frac{Z}{30}}\right)\sqrt{\left(\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 R_p}\right)\left(\frac{3}{5}\frac{G_s m_p^2}{R_p}\right)}$$
$$\cong -\left(Z-2+\sqrt{\frac{Z}{30}}\right)\times(19.75\text{ to }19.8)\ \text{MeV} \ldots\ldots\ldots\ldots(6)$$

See column-2 of table-1 prepared with 19.75 MeV. With this binding energy constant stable mass number A_s can be estimated with,

$$A_s \approx X + \left(Y^2 + Y\right) \quad (7)$$

$$\left.\begin{array}{l}\text{where, } X \approx \left(Z+\sqrt{\dfrac{Z}{30}}-2\right)\left(\dfrac{19.75\text{ MeV}}{8.8\text{ MeV}}\right) \\ \text{and } Y \approx \left[(X-2Z)^2/Z\right]\end{array}\right\}$$

Considering 8.8 MeV as the maximum binding energy per nucleon, X can be referred to the lowest possible imaginary stable mass number and $(A_s - X) \approx (Y^2 + Y)$.

Table-1: To estimate medium, heavy and super heavy atomic nuclides and their binding energy

Proton number	Estimated Binding energy (MeV)	Estimated stable mass number with even-odd correction	Actual (stable and long living) isotopes
21	391.8	45 ±2	45
25	472.3	53 ±2	55
31	592.8	69 ±2	69,71
35	673.1	79 ±2	79,81
41	793.3	93 ±2	93
47	913.5	109 ±2	107,109
51	993.5	119 ±2	121,123
55	1073.5	131 ±2	133
59	1153.4	141 ±2	141
60	1173.4	144 ±2	142,144, 146, 143,145, 148,150
65	1273.3	159 ±2	159
69	1353.2	169 ±2	169
75	1473.0	187 ±2	187,185
81	1592.7	205 ±2	205,203
86	1692.4	220 ±2	222
92	1812.1	238 ±2	238,235
100	1971.6	262 ±2	257
106	2091.1	282 ±2	272

Corrections in estimated A_s :

If Z is even and estimated A_s is even,.

$$\text{Corrected } A_s \text{ range} \cong \{\text{Estimated } A_s \pm 2\} \quad (8)$$

If Z is even and estimated A_s is odd,

$$\text{Corrected } A_s \text{ range} \cong \{(\text{Estimated } A_s - 1) \pm 2\} \quad (9)$$

If Z is odd and estimated A_s is odd,

$$\text{Corrected } A_s \text{ range} \cong \{\text{Estimated } A_s \pm 2\} \quad (10)$$

If Z is odd and estimated A_s is even,.

$$\text{Corrected } A_s \text{ range} \cong \{(\text{Estimated } A_s - 1) \pm 2\} \quad (11)$$

In this table, estimated stable mass numbers can be understood with the following relation.

$$A_s \approx 2Z + k(2Z)^2 \approx Z + 0.0064Z^2 \quad (12)$$

$$\text{where, } k \cong \left(\frac{G_s m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_e m_e^2}\right) \cong 1.605 \times 10^{-3},$$

Quantitatively this relation can be compared with the computationally proposed relation (8) of reference [4] which takes the following form.

$$N_s \cong 0.968051Z + 0.00658803Z^2 \quad (13)$$

where N_s is the neutron number of a nucleus with atomic number Z on the line of beta stability. Based on 'mass number', relation (13) can also be expressed in the following form.

$$Z \approx \frac{\sqrt{4kA+1}-1}{4k} \quad (14)$$

where A is any mass number .This relation (14) can be compared with existing stability relation,

$$Z \approx A/\left[2 + (a_c/2a_a) A^{2/3}\right] \quad (15)$$

where $(a_c/2a_a) \cong 0.0157$. 'Workability' point of view and 'final unification' point of view, proposed two assumptions, can be recommended for further research and analysis.

References

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