On the role of large nuclear gravity in understanding strong coupling constant, nuclear stability range, binding energy of isotopes and magic proton numbers – A critical review

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Abstract: With reference to our earlier published views on large nuclear gravitational constant G_s, nuclear elementary charge e_s and strong coupling constant $\alpha_s \cong (e/e_s)^2$, in this paper, we present simple relations for nuclear stability range, binding energy of isotopes and magic proton numbers.

Summary: Probable range of stable mass numbers can be estimated with $A_s \cong \left[Z + \sqrt{(1/\alpha_s)} \pm 1\right]^x$ where $x \cong 1.2$ for $\mathrm{Z} \approx (3 \text{ to } 100)$ and $x \cong 1.19$ for $\mathrm{Z} \geq 100$. A_s can also be expressed as, $A_s \cong 2Z + kZ^2$ where $k \cong \left[4\pi\varepsilon_0 (\hbar/2)^2 m_e c^2 / e^2 G_s m_p^3\right] \cong 0.006333$. Energy coefficient being $\left[e_s^2 / 8\pi\varepsilon_0 \left(G_s m_p / c^2\right)\right] \approx 10.06$ MeV, for $Z \approx (5 \text{ to } 118)$, nuclear binding energy can be understood/fitted with two terms as, $B_{A_s} \cong \left\{A_s - \left[(kA_s Z/2.531) + 3.531\right]\right\} \times 10.06$ MeV wh ere $\ln\left(1/\sqrt{k}\right) \cong \left(m_n - m_p / m_e\right) \cong 2.531$. By considering a third term of the form $\left[(A_s - A)^2 / A_s\right]$, binding energy of isotopes of Z can be fitted approximately. It needs further investigation.

Discussion

1) So far no model could succeed in understanding nuclear binding energy with gravity.
2) So far no model could address or succeed in implementing strong coupling constant in low energy nuclear physics.
3) So far no model could attempt to understand nuclear stability and binding energy with the combined effects of strong nuclear gravity and strong nuclear charge.
4) Understanding nuclear binding energy with a single energy coefficient of magnitude $\dfrac{e_s^2}{8\pi\varepsilon_0\left(G_s m_p/c^2\right)} \cong 10.09$ MeV is a challenging task and so far, except Ghahramany et al, no one could attempt to do that. It may also be noted that, in Ghahramany's model, energy constant is a variable [32] and in our model energy constant remains same for any nuclide.
5) Estimation of nucleon stability range is simple in our model compared to SEMF and Ghahramany's model. Interesting point to be noted is that, in our model, nucleon stability range or stable mass numbers can be estimated without considering the binding energy formula. We have provided different relations for understanding nucleon stability.
6) Proposed new and result oriented number $k \cong \left(\dfrac{4\pi\varepsilon_0 \hbar^2 m_e c^2}{4e^2 G_s m_p^3}\right) \cong \dfrac{4\pi\varepsilon_0 G_s m_p m_e}{4e_s^2} \cong 0.0063326$ seems to play a key role in understanding nuclear stability and binding energy vide relations (6), (7), (8), (9), (10), (16) and (20).
7) Proposed first tem is not new and proposed second term $\left[(kA_s Z/2.531) + 3.531\right] \times 10.06$ MeV seems to play an excellent role in fitting and understanding the binding energy of medium and heavy stable nuclides. It can be evidenced form table-3. Correction seems to be required for light atomic nuclides. It needs further study.
8) Proposed third term $\left[(A_s - A)^2 / A_s\right] \times 10.06$ MeV seems to be approximate in fitting and understanding the binding energy of isotopes. We are working on it for its validity and better alternative with respect correct stable mass number of Z.

9) In deuteron, binding energy seems to be proportional to e^2 and in other atomic nuclides, binding energy seems to be proportional to e_s^2.
10) Considering the average of $\left(e^2,\, e_s^2\right)$ and without considering 0.71 MeV (as there exists only one proton), based on relation (22), binding energies of $1H2$ and $1H3$ nuclides can be estimated as, $\left[2-2^{\frac{1}{3}}\right]5.6 \cong 4.15$ MeV and $\left[3-3^{\frac{1}{3}}\right]5.6 \cong 8.72$ MeV respectively.
11) Considering the average of $\left(e^2,\, e_s^2\right)$ and considering 0.71 MeV (since there exists two protons), based on relation (22), binding energy of $2He3$ can be estimated as, $\left[3-3^{\frac{1}{3}}\right]4.9 \cong 7.63$ MeV.
12) Coulombic energy coefficient being 0.7 MeV, with reference to $\ln\left(\frac{e^2}{4\pi\varepsilon_0 G_s m_p m_e}\right) \cong 1.515$, volume or surface energy coefficient can be expressed as 1.515*10.09 = 15.3 MeV and asymmetric energy coefficient can be expressed as, 1.515*15.3 = 23.0 MeV. For $\left(Z \geq 10\right)$, binding energy can also be estimated with,

$$B_A \cong \left(A - A^{2/3} - 1\right) * 15.3\text{MeV} - \frac{Z^2}{A^{1/3}} * 0.7\text{MeV} - \frac{\left(A-2Z\right)^2}{A} * 23.0\text{MeV} \tag{26}$$

13) With advanced research in high energy nuclear physics, hadronic melting points can be understood and bare quarks can be made identifiable.
14) With further research in nuclear astrophysics, it is certainly possible to understand the combined effects of Newtonian gravitational constant and proposed nuclear gravitational constant. Considering the ratio of nuclear gravitational constant and Newtonian gravitational constant, estimated masses of white dwarfs, neutron stars and black holes [33,34], can be fitted approximately. For example,

$$\left.\begin{aligned}
M_X &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{e^2}{4\pi\varepsilon_0 G_N}} \approx 0.473 M_\odot \\
M_X &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{e_s^2}{4\pi\varepsilon_0 G_N}} \approx 1.373 M_\odot \\
M_X &\approx \left(\frac{G_s}{G_N}\right)\sqrt{\frac{\hbar c}{G_N}} \approx 5.456 M_\odot
\end{aligned}\right\} \tag{27}$$

$$\left.\begin{aligned}
M_X &\approx \sqrt{\frac{G_s}{G_N}}\,\frac{e^2}{4\pi\varepsilon_0 G_N m_p} \approx 0.023 M_\odot \\
M_X &\approx \sqrt{\frac{G_s}{G_N}}\,\frac{e_s^2}{4\pi\varepsilon_0 G_N m_p} \approx 0.2 M_\odot \\
M_X &\approx \sqrt{\frac{G_s}{G_N}}\left(\frac{\hbar c}{G_N m_n}\right) \approx 3.174 M_\odot
\end{aligned}\right\} \tag{28}$$

15) At the moment of a neutron star's birth, the nucleons that compose it have a temperature of around 10^{11} to 10^{12} K [35]. Considering M_X as a critical mass for neutron stars and black holes, corresponding critical temperature can be fitted with,

$$\left.\begin{aligned}
T_X &\approx \frac{\hbar c^3}{8\pi k_B G_N \sqrt{M_X M_{pl}}} \\
\text{where, } M_{pl} &\cong \sqrt{\frac{\hbar c}{G_N}} \cong 2.176\times 10^{-8}\text{kg}
\end{aligned}\right\} \tag{29}$$

16) Quantitatively, Fermi's weak coupling constant [36] and electron rest mass can be fitted with the following relations.

$$G_F \cong \left(\frac{m_e}{m_p}\right)^2 \hbar c R_0^2 \cong \frac{4 G_s^2 m_e^2 \hbar}{c^3} \cong 1.4402\times 10^{-62}\ \text{J.m}^3 \tag{30}$$

$$m_e \cong \sqrt{\frac{G_F c^3}{4 G_s^2 \hbar}} \quad \text{and} \quad \frac{2 G_s m_e}{c^2} \cong \sqrt{\frac{G_F}{\hbar c}} \tag{31}$$

17) In a theoretical and verifiable approach, magnitude of the Newtonian gravitational constant can be estimated with nuclear elementary physical constants. For example, with reference to Planck scale, we noticed that [14],

$$\frac{\pi R_0^2}{\pi R_{pl}^2} \cong \frac{G_s^2 m_p^2}{G_N \hbar c} \cong \left(\frac{m_p}{m_e}\right)^{12} \tag{32}$$

$$\text{where, } R_0 \cong \frac{2 G_s m_p}{c^2},\ R_{pl} \cong \frac{2 G_N M_{pl}}{c^2} \cong 2\sqrt{\frac{G_N \hbar}{c^3}}$$

$$G_N \cong \left(\frac{m_e}{m_p}\right)^{10}\left(\frac{G_F c^2}{4\hbar^2}\right) \cong \left(\frac{m_e}{m_p}\right)^{12}\left(\frac{G_s m_p^2}{\hbar c}\right) G_s \cong \left(6.66 \text{ to } 6.68\right)\times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \tag{33}$$

18) Our proposed assumptions seem to ease the way of understanding and refining the basic concepts of final unification.

Conclusion

Semi empirical mass formula and Fermi gas model, both, are lagging in implementing the strong coupling constant and gravity in nuclear structure. In this context, understanding and estimating nuclear binding energy with 'strong interaction' and 'unification' concepts seem to be quite interesting and needs a serious consideration at basic level. In this context, relations (6), (7), (9), (10), (11), (20), (21), and (24) can be considered as favorable or supporting tools for our proposed model. With further research, mystery of magic numbers can be understood and a unified model of nuclear binding energy and stability scheme pertaining to high and low energy nuclear physics can be developed.

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