Understanding nuclear structure with Schwarzschild interaction and Avogadro number

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Introduction

By considering the strength of the Schwarzschild interaction as 'unity' and by considering the squared Avogadro number as a suitable scaling factor, the authors made an attempt to understand the basics of nuclear physics with three assumptions and developed many useful semi-empirical relations in a constructive approach [1]. The key point to be noted is that both the electromagnetic interaction and the strong interaction both seem to be associated with two different gravitational constants.

Understanding the strength of any interaction

With reference to Black hole physics, it is reasonable to say that,

1) Black holes are the most compact form of matter.
2) Gravitational interaction taking place at black holes can be referred to 'Schwarzschild interaction'.
3) Strength of this 'Schwarzschild interaction' can be assumed to be unity.
4) Magnitude of the operating force at the black hole surface is of the order of $\left(c^4/G\right)$.
5) Strength of any other interaction can be defined as the ratio of operating force magnitude and the classical or astrophysical force magnitude $\left(c^4/G\right)$.
6) If one is willing to represent the magnitude of the operating force as a fraction of $\left(c^4/G\right)$ i.e. X times of $\left(c^4/G\right)$, where $X \ll 1$, then

$$\frac{X \text{ times of } \left(c^4/G\right)}{\left(c^4/G\right)} \cong X \rightarrow \text{Effective } G \Rightarrow \frac{G}{X} \quad (1)$$

If X is very small, $(1/X)$ becomes very large. In this way, X can be considered as the strength of interaction.

Basic assumptions of final unification

The following three assumptions can be considered in a final unification program.

1) Avogadro's number N_A can be considered as a scaling factor.
2) The gravitational constant associated with the electron can be expressed as:

$$G_E \cong N_A^2 G \quad (2)$$

$$\rightarrow G_E \cong N_A^2 G \cong 2.420350673\times10^{37} \text{ m}^3.\text{kg}^{-1}.\text{sec}^{-2}$$

The gravitational constant associated with the proton can be expressed with the following relation.

$$\left(\frac{G_S m_p m_e}{\hbar c}\right) \cong \left(\frac{\hbar c}{G_E m_e^2}\right) \quad (3)$$

$$\rightarrow G_S \cong 3.266260584\times10^{28} \text{ m}^3.\text{kg}^{-1}.\text{sec}^{-2}.$$

With reference to the Schwarzschild interaction, for electromagnetic interaction, $X \cong 2.7574\times10^{-46}$ and for strong interaction, $X \cong 2.04327\times10^{-39}$.

Understanding the strong coupling constant and the proton-electron mass ratio

From relation (3), it is possible to show that,

$$\left[\frac{\hbar c}{G_S m_p^2} \cong \sqrt{\alpha_s}\right] \rightarrow \alpha_s \cong 0.11970192 \quad (4)$$

$$\frac{m_p}{m_e} \cong \left[\left(\frac{G_S m_p^2}{\hbar c}\right)\left(\frac{G_E m_p^2}{\hbar c}\right)\right]^{\frac{1}{3}} \quad (5)$$

Based on these relations (4) and (5) and with further research, basics of final unification can be understood to some extent.

To fit the RMS radius of proton and nuclear unit charge radius

It is noticed that,

$$\left.\begin{aligned} R_p &\cong \left(\frac{\sqrt{2}G_S m_p}{c^2}\right) \cong 0.859651\times10^{-15}\text{ m} \\ R_c &\cong \left(\frac{2G_S m_p}{c^2}\right) \cong 1.21573\times10^{-15}\text{ m} \end{aligned}\right\} \quad (6)$$

From experiments, the root mean square radius of the proton is $R_p \cong 0.8418467$ fm and $R_p \cong 0.8775$ fm. The geometric mean of these two values is 0.8594885 fm. Based on these relations, if $R_p \cong 0.8594885$ fm,

$$G \cong \frac{\sqrt{2}\hbar^2}{N_A^2 m_e^3 R_p} \cong 6.675109\times10^{-11}\ \frac{\text{m}^3}{\text{kg.sec}^2}. \quad (7)$$

$R_c \cong 1.21573\times10^{-15}$ m can be considered as the nuclear unit charge radius.

Proton-neutron beta stability line:

The naturally occurring stable mass number connected with the proton number can be expressed as follows [2].

$$\begin{aligned} A_s &\cong 2Z + \left\{\left(\frac{G_S m_p m_e}{\hbar c}\right)(2Z)^2\right\} \\ &\cong 2Z + (0.006296521)Z^2 \end{aligned} \quad (8)$$

If $Z = 92$, obtained $A_s \cong 237.3$ and its actual stable mass number is 238.

To fit and understand the nuclear binding energy

By considering the geometric mean of gravitational and coulombic self energies, the characteristic binding energy potential B_0 can be expressed as follows. If $R_p \cong 0.8775$ fm,

$$B_0 \cong -\frac{3}{5}\sqrt{\left(\frac{G_S m_p^2}{R_p}\right)\left(\frac{e^2}{4\pi\varepsilon_0 R_p}\right)} \cong -19.6\text{ MeV} \quad (9)$$

For Z=30 onwards, at the stable mass number, nuclear binding energy can be approximately fitted with the following relation.

$$(B)_{A_s} \cong -Z * B_0 \cong -Z*19.6\text{ MeV} \quad (10)$$

With the semi-empirical mass formula, this proposal can be shown to be correct for the stable mass numbers of Z>=30. For Z=30 onwards, above and below the stable mass number,

$$(B)_A \cong -(A/A_s)^p * Z*19.6\text{ MeV} \quad (11)$$

where $p \cong 4/3$ if $(A < A_s)$; $p \cong 2/3$ if $(A > A_s)$;

For Z<30, above and below the stable mass number, nuclear binding energy can be approximately fitted with the following relation.

$$(B)_A \cong -k_z (A/A_s)^p\, Z*19.60\text{ MeV} \quad (12)$$

where $k_z \cong (Z/30)^{\frac{1}{6}}$ and

$\{p \cong 4/3$ if $(A<A_s)$; $p \cong 2/3$ if $(A > A_s)$;

Discrete potential energy of electron in the hydrogen atom

Discrete potential energy of electron in the hydrogen atom can be fitted with the following relation.

$$(E_{pot})_n \cong -\left(\frac{1}{2n^2}\right)\left(\frac{G_S m_p m_e}{\hbar c}\right)^2 \sqrt{m_p m_e}\,c^2 \quad (13)$$

where, $n = 1,2,3,\ldots$. Here, it may be noted that, $(1/2n^2)$ can be considered as the probability of finding one electron out of possible $(2n^2)$ electrons. Comparing this semi-empirical result with Bohr's theory of hydrogen atom, it is noticed that,

$$\sqrt{\frac{4\pi\varepsilon_0 G_S m_p m_e}{e^2}} \cong \left(2\sqrt{\frac{m_e}{m_p}}\right)^{1/4} \cong 0.464803 \quad (14)$$

$\rightarrow G_S \cong 3.2712467\times10^{28}\ \text{m}^3.\text{kg}^{-1}.\text{sec}^{-2}$.

References

[1] U. V. S. Seshavatharam, Lakshminarayana S. Understanding Nuclear Structure With Final unification Journal of Applied Physical Science International (In press). (http://www.ikpress.org/articles-press/33)

[2] U. V. S. Seshavatharam, Lakshminarayana S. Understanding Nuclear Stability, Binding Energy and Magic Numbers with Fermi Gas Model. Journal of Applied Physical Science International, 4 (2) pp.51-59 (2015)