To correlate nuclear and Newtonian gravitational constants

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Introduction

Most desirable cases of any unified description [1] are: To simplify the complicated issues of known physics and to predict new effects, arising from a combination of the fields inherent in the unified description. In this context, for a better understanding, we would like suggest that: "By replacing $\left(\hbar c / G_N m_p^2\right)$ with a large gravitational constant, $G_s \cong (3.30 \pm 0.03) \times 10^{28}$ m^{3}kg^{-1}sec^{-2} assumed to be associated with nuclear structure, a basic model of 'nuclear quantum gravity' can be developed". For calculation purpose, we consider $G_s \cong 3.32956 \times 10^{28}$ m^{3}kg^{-1}sec^{-2}. Qualitatively, this idea is in agreement with "Strong gravity" concept [2] proposed by Abdus Salam and C.Sivaram. Recently, O. F. Akinto and Farida Tahir elaborated their work on 'modified strong gravity concepts' pertaining to QCD and general relativity in arXiv preprint [3]. In this context, we have shown various practical applications of G_s pertaining to micro physics as well as macro physics [4]. Interesting points to be noted are: 1) $\sqrt{G_s / G_N}$ plays a crucial role in understanding neutron star mass and radius. 2) $(G_s / G_N)^{\frac{1}{10}}$ plays a heuristic role in understanding proton-electron mass ratio.

To fit the nuclear charge radius

Nuclear charge radius can be fitted with,

$$R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.239 \text{ fm} \tag{1}$$

To fit Fermi's weak coupling constant

Fermi's weak coupling constant [5] can be fitted with the following empirical relation.

$$G_F \cong \left(\frac{m_e}{m_p}\right)^2 \hbar c R_0^2 \cong \frac{4G_s^2 m_e^2 \hbar}{c^3} \cong 1.44021 \times 10^{-62} \text{ J.m}^3 \tag{2}$$

Two new characteristic energy units

Based on the proposed G_s, one can construct two practical energy units in the following way.

$$E_\hbar \cong \left(\frac{e^2}{4\pi\varepsilon_0 \hbar c}\right)\left(\frac{G_s m_p^2}{\hbar c}\right)\left(m_p c^2\right) \cong \left(\frac{e^2 G_s m_p^3}{4\pi\varepsilon_0 \hbar^2}\right) \cong 20.174 \text{ MeV} \tag{3}$$

Using this energy unit, nuclear binding energy can be understood. Replacing $(\hbar)$ with $(\hbar/2)$, it is possible to construct another energy unit.

$$E_{(\hbar/2)} \cong \left(\frac{e^2 G_s m_p^3}{4\pi\varepsilon_0 (\hbar/2)^2}\right) \cong 80.696 \text{ MeV} \tag{4}$$

Using this energy unit, neutron-proton mass difference, neutron life time, line of beta stability can be understood.

To fit neutron-proton mass difference

Neutron-proton mass difference [5] can be understood with:

$$\left(\frac{m_n c^2 - m_p c^2}{m_e c^2}\right) \cong \ln \sqrt{\frac{E_{(\hbar/2)}}{m_e c^2}} \cong \ln \sqrt{\frac{4e^2 G_s m_p^3}{4\pi\varepsilon_0 \hbar^2 m_e c^2}} \cong \ln \sqrt{\frac{80.696 \text{ MeV}}{0.511 \text{ MeV}}} \tag{5}$$

To fit neutron life time

Neutron life time t_n can be understood with the following relation:

$$t_n \cong \exp\left(\frac{E_{(\hbar/2)}}{\left(m_n - m_p\right)c^2}\right)\times\left(\frac{\hbar}{m_n c^2}\right)$$
$$\cong \exp\left(\frac{80.696\text{ MeV}}{1.2933\text{ MeV}}\right)\times\left(\frac{\hbar}{m_n c^2}\right)\cong 877.9\,\text{sec} \quad (6)$$

This value can be compared with material bottle experimental result: (878.5 ± 0.8) sec [6].

Understanding beta stability line

Stable mass number corresponding to Z can be estimated with the following relation.

$$\left(A_s - 2Z\right) \approx \left(\frac{m_e c^2}{E_{(\hbar/2)}}\right)Z^2 \cong \left(\frac{0.511\text{ MeV}}{80.696\text{ MeV}}\right)Z^2$$
$$\approx \left(\frac{4\pi\varepsilon_0 \hbar^2 m_e c^2}{4e^2 G_s m_p^3}\right)Z^2 \approx 0.00633(Z)^2 \quad (7)$$

To understand nuclear binding energy close to beta stability line

For $Z \geq 3$, close to stable atomic nuclides, nuclear binding energy can be approximately fitted with the following relation.

$$(BE)_{As} \approx -\left(Z - \frac{3}{2}\right)E_\hbar \cong \left(Z - \frac{3}{2}\right)\left(\frac{e^2 G_s m_p^3}{4\pi\varepsilon_0 \hbar^2}\right)$$
$$\approx -\left(Z - \frac{3}{2}\right)\times 20.174\text{ MeV}. \quad (8)$$

Factor $(3/2)$ needs further study at fundamental level.

To understand neutron star mass and radius

A) If (M_{NS}, m_n) represent the masses of neutron star [7] and neutron, then,

$$\frac{G_N M_{NS} m_n}{\hbar c} \approx \sqrt{\frac{G_s}{G_N}} \rightarrow M_{NS} \approx 3.175 M_\odot \quad (9)$$

B) If R_{NS} represents the neutron star radius, then,

$$\frac{R_{NS}}{\left(\sqrt{G_s \hbar/c^3}\right)} \approx \sqrt{\frac{G_s}{G_N}} \rightarrow R_{NS} \approx 8.06\text{ km} \quad (10)$$

To fit proton-electron mass ratio

Proton-electron mass ratio can be fitted with,

$$\frac{m_p}{m_e} \cong \left\{\left(\frac{G_s}{G_N}\right)\left(\frac{G_s m_e^2}{\hbar c}\right)\right\}^{\frac{1}{10}} \cong \left(\frac{G_s^2 m_e^2}{G_N \hbar c}\right)^{\frac{1}{10}} \cong 1836.3 \quad (11)$$

To fit the Newtonian gravitational constant

From above relations, G_N can be fitted with:

$$G_N \cong \left(\frac{G_s m_e^2}{\hbar c}\right)\left(\frac{G_F}{\hbar c R_0^2}\right)^5 G_s \cong \left(\frac{G_s m_e^2}{\hbar c}\right)\left(\frac{m_e}{m_p}\right)^{10} G_s$$
$$\cong 6.679854 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2} \quad (12)$$

It needs further study at fundamental level.

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