Nuclear mass density in strong gravity and grand unification

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Abstract: It is noticed that, when the black hole mass density reaches the nuclear mass density, mass of the black hole approaches to 1.81×10^{31} Kg $\cong$ $9.1 M_{\odot}$. This characteristic mass can be called as the Fermi black hole mass. This proposed mass unit plays an interesting role in grand unification and primordial black holes. Mass ratio of Fermi black hole mass and Chandrasekhar's mass limit is 2π. Mass ratio of Fermi black hole mass and neutron star mass limit is $\sqrt{2\pi}$. Considering strong nuclear gravity, Fermi black hole mass can be obtained in a grand unified approach.

Keywords: black hole density; nuclear mass density; Fermi black hole mass; planck mass; Avogadro number.

1 Nuclear astrophysics - the window for grand unification

'Mass' is the common property of nucleons, electrons, atoms and stars. It's origin is still a mystery [1]. Considering nuclear astrophysics [2 - 4], it is possible to see all the gravitational and non-gravitational constants in a unified picture. Till date no single empirical relation is available for analysing the gravitational and non-gravitational constants in a unified manner. If N is the Avogadro number, it is noticed that

$$\ln \sqrt{\frac{e^2}{4\pi\varepsilon_0 G m_P^2}} \cong \sqrt{\frac{m_p}{m_e} - \ln\left(N^2\right)} \tag{1}$$

where m_p is the proton rest mass and m_e is the electron rest mass. From this expression, $G \cong 6.666270179 \times 10^{-11}$ $\mathrm{m^3 Kg^{-1} sec^{-2}}$. This obtained value can be compared with the recommended value of the gravitational constant [5]. Another interesting observation is,

$$R_0 \cong \frac{1}{N^2} \cdot \left(\frac{\hbar c}{G m_e^2}\right)^2 \cdot \frac{2Gm_e}{c^2} \cong 1.21565 \times 10^{-15} \text{ m} \tag{2}$$

In electron scattering experiments, this can be compared with the minimum distance between the nucleus and the electron. Physicists say, if strength of strong interaction is unity, with reference to the strong interaction, strength of gravitation is 10^{-39}. If one wishes to unify electroweak, strong and gravitational interactions it is a must to implement the classical gravitational constant G in the sub atomic physics. Then a large 'arbitrary number' has to be considered as a proportionality constant. With this large arbitrary number it is be possible to understand the mystery of the strong interaction and strength of gravitation. The basic and important problem is: How to select the arbitrary number? For this purpose 'mole' concept can be considered as a fundamental tool [5].

2 Fermi black hole mass and its applications in grand unification

Electron scattering experiments reveals that characteristic nuclear size is close to $R_0 \cong 1.21 \times 10^{-15}$ m. Density of the nuclear matter is 2.256×10^{17} $\mathrm{Kg/m^3}$. When the black hole mass density approaches the nuclear mass density, black hole mass approaches to 1.81×10^{31} Kg $\cong 9.1 \mathrm{M}_{\odot}$. This characteristic black hole mass can be termed as the "Fermi black hole mass limit $= M_F$" . This mass limit can be considered as the characteristic mass limit of the primordial universe or primordial cosmic black holes. Its radius is $R_F \cong \frac{2GM_F}{c^2} \cong 26.882$ Km. It is noticed that ratio of Fermi black hole mass limit and Chandrasekhar's mass limit is 2π. Another interesting result is: ratio of Fermi black hole mass and neutron mass limit [4] is close to $\sqrt{2\pi}$. Equating nuclear mass density and black hole mass density,

$$M_F \cong \left(\frac{c^2 R_0}{2Gm_n}\right)^{\frac{3}{2}} m_n \cong 1.81 \times 10^{31} \text{ Kg} \tag{3}$$

If existence of Fermi black hole is real and its origin is primordial, characteristic nuclear size,

$$R_0 \cong \left(\frac{M_F}{m_n}\right)^{\frac{2}{3}} \frac{2Gm_n}{c^2} \cong 1.21 \text{ fm} \tag{4}$$

A very interesting observation is

$$\frac{1}{\alpha} \cong \ln\left(\frac{M_F}{\sqrt{2m_n m_e}}\right) \tag{5}$$

where α is the fine structure ratio, m_n is the average rest mass of nucleon and m_e is the electron rest mass. A surprising semi empirical fit is the strong interaction range. If M_P is the planck mass, it is noticed that

$$b \cong \left(\frac{M_F}{M_P}\right)\frac{2Gm_n}{c^2} \cong 2.06 \text{ fm} \tag{6}$$

If $\sin\theta_W$ is the weak coupling angle [6],

$$\frac{e^2}{4\pi\varepsilon_0 G m_n m_e} \cong \frac{1}{sin^2\theta_W}\left(\frac{M_F}{m_n}\right)^{\frac{2}{3}} \cong \frac{1}{sin^2\theta_W}\left(\frac{R_F}{R_0}\right)^2 \tag{7}$$

Combining equations (4) and (6) it is noticed that,

$$m_n^2 \cong \left(\frac{b}{R_0}\right)^3 \frac{M_P^3}{M_F} \tag{8}$$

With trial and error it is noticed that

$$\left(\frac{b}{R_0}\right)^3 \cong \ln\left(\frac{1}{\alpha}\right) \tag{9}$$

Thus it can be suggested that,

$$m_n^2 \cong \ln\left(\frac{1}{\alpha}\right)\frac{M_P^3}{M_F} \tag{10}$$

Thus M_F can be considered as a reference mass unit in astrophysics. Considering the geometric mean of planck mass and the fermi black hole mass in Hawking's black hole temperature formula, it is noticed that,

$$4\pi k_B T \cong \frac{\hbar c^3}{2G\sqrt{M_F M_P}} \cong 211.7 \text{ MeV} \tag{11}$$

This can be compared with the QCD energy scale. From this coincidence it can be suggested that, Fermi black hole mass can be considered as the characteristic mass limit of 'quark star'.

3 Strong nuclear gravity and the Fermi black hole mass

The idea of strong gravity originally referred specifically to mathematical approach of Abdus Salam of unification of gravity and quantum chromo-dynamics, but is now often used for any particle level gravity approach [7, 8]. Key conceptual link that connects the gravitational force and non-gravitational forces is [9] - the classical force limit $\left(\frac{c^4}{G}\right)$. For mole number of particles, if strength of gravity is $(N.G)$, any one particle's weak force magnitude is $F_W \cong \frac{1}{N} \cdot \left(\frac{c^4}{N.G}\right) \cong \frac{c^4}{N^2 G}$. Ratio of 'classical force limit' and 'weak force magnitude' is N^2. This can be considered as the beginning of 'strong nuclear gravity'. Assumed relation for strong force and weak force magnitudes is $\sqrt{\frac{F_S}{F_W}} \cong 2\pi \ln\left(N^2\right)$. With these advanced concepts starting from nuclear stability to charged leptons, quarks, electroweak bosons and charged Higgs boson's origin can be understood [10-13]. It is noticed that,

$$M_F \cong \left(\frac{\hbar c}{(N.G)\, m_e^2}\right)^3 \sqrt{\frac{m_e^3}{m_n}} \tag{12}$$

In this way, Fermi black hole mass can be fitted in a unified way.

4 Conclusion

There exists a black hole of mass 1.81×10^{31} Kg $\cong 9.1\mathrm{M}_{\odot}$. It can be considered as a reference mass unit in astrophysics. It plays an interesting role in primordial cosmic evolution and grand unification. Proposed empirical relations can be given a chance in understanding the mystery of grand unification.

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