The Viscous Universe and the Viscous Electron

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ABSTRACT – A modification of the Dirac extensible model of electron is applied to study both the universe and the electron. Frequencies of small oscillations of the nucleon and of the electron coupled to this universe are estimated. Two bold hypotheses combined with the models results permit us to estimate the nucleon-electron mass ratio. The mass and radius of the observable universe are also determined.

1 – Introduction

Dirac has proposed "an extensible model of electron" [1], where an electron of finite radius was supposed to be a charged spherical shell stabilized by a surface tension contribution. Dirac believed that the first excited state of his model could be interpreted as being the muon, but his idea did not work quite well. [1,2]. However inspired in [1], Chodos et al constructed the MIT bag model [3,4]as a means of modeling the structure of hadrons. These ideas motivated the present author to develop a bag model of the universe [5], taking in account the interplay between the gravitational interaction and the vacuum pressure at the boundary of the universe.

In this work we partially turn to the Dirac model but in a modified way, in order to treat both the universe and the electron. However instead to take a surface tension to stabilize the models, we will work with a viscous medium representing the vacuum at the boundaries of the spherical shells. The quantum vacuum represented by this viscous medium [6,7] leads to a logarithmic contribution for the potential describing these models.

2 – The viscous universe

We will construct a model of the universe as a spherical shell of mass expanding in a vacuum represented by a viscous fluid. We write

$$V = G\,M^2/(2r) + (h/\tau)\ln(r/r^*). \qquad (1)$$

In the potential given by (1), M is the mass content of the universe, G is the gravitational constant, h the Planck constant, τ is a characteristic time tied to the viscous fluid, and r^* a reference radius. We choose the reference radius such that at the equilibrium, the radius R is given by

$$R/r^* = e \cong 2.72. \qquad (2)$$

Besides this we take

$$G\,M^2/(2R) = ½\,Mc^2. \qquad (3)$$

Solving eq. (3) for R we find

$$R = G\,M/c^2. \qquad (4)$$

From the equilibrium condition, namely by putting $dV/dr|_R = 0$, we get

$$h/\tau = G\,M^2/(2R) = ½\,Mc^2. \qquad (5)$$

Taking in account equations (2), (3) and (5), we verify that at the equilibrium the two terms of the potential (1) contribute at equal footing for the mass energy of this model of universe.

It is worth to point out that the total mass of this universe is obtained by summing up over all the particles which compose it. If we pick up an electron of mass m_e, we can suppose that it performs harmonic oscillations due to small perturbations close to its equilibrium position. The spring constant k of these oscillations reads

$$k = d^2V/dr^2|_R = ½\, c^6/(G^2\, M). \qquad (6)$$

Then, the frequency of the small oscillations of the electron is

$$\omega_{e,u} = (k/m_e)^{1/2} = [c^3/(\sqrt{2}\, G)](m_e\, M)^{-1/2}. \qquad (7)$$

2.1- A bold hypothesis I

In reference [5], the separation in energy between the centroid of the odd parity levels and the ground state of the nucleon was evaluated. It can be written as

$$\hbar\, \omega_n = 2\, m_n\, c^2/\pi, \qquad (8)$$

where m_n is the mass of the nucleon.

Now we propose a bold hypothesis:

- The separation in energy levels of the electron gravitationally coupled to the universe matches the separation in energy levels of the nucleon, as given by (8).

Let us take the equality between these two distinct energy levels separation

$$\hbar\, \omega_{e,u} = \hbar\, \omega_n. \tag{9}$$

Putting (7) and (8) into (9)and solving for M we find

$$M = (\hbar^2\, \pi^2\, c^2)/(8\, G^2\, m_e\, m_n^{\ 2}). \tag{10}$$

The radius of the universe can also be estimated by inserting (10) into (4). We get

$$R = (\hbar^2\, \pi^2)/(8\, G\, m_e\, m_n^{\ 2}). \tag{11}$$

Evaluating numerically (10) and (11), we obtain

$$M \cong 1.1\text{x } 10^{53}\ \text{Kg}, \tag{12}$$

and

$$R \cong 0.8 \text{ x } 10^{26}\ \text{m}. \tag{13}$$

These values agree in order of magnitude with the mass and radius of the universe quoted in references [8,9].

3 – The viscous electron

We will treat the "viscous electron" in an analogous way we have treated the viscous universe. We write

$$V_e = G_e\, m_e{}^2 / (2r) + (h / \tau_e) \ln(r / r^*). \qquad (14)$$

The first term of (14) represents a repulsive spherical shell, being the energy associated to it proportional to $m_e{}^2$. In order to determine the coupling G_e we adopt the following reasoning. Paul Wesson [10] considers that the equivalence principle can be understood, if we look at the particle metric in a five-dimensional space-time.

Inspired in Wesson's work [10], we consider in the five-dimensional momentum space, the five contributions taken at equal footing and write

$$p_x = p_y = p_z = p_t = p_w, \qquad (15)$$

$$\alpha\hbar c / r = p_x \alpha c, \qquad (16)$$

$$G_e\, m_e{}^2 / (2r) = (5/2)\, p_x \alpha c = 5\, \alpha\hbar c / (2r). \qquad (17)$$

We notice that (17) defines the coupling constant G_e, while α is the fine-structure constant. Next we proceed in an analogous way we have done before for the viscous universe. Doing this we get

$$k_e = d^2V_e / dr^2|_R = ½\, c^6 / (G_e{}^2\, m_e). \qquad (18)$$

In (18) k_e is the spring constant relative to the small oscillations of the electron around its equilibrium position R. the frequency of these oscillations is given by

$$\omega_e = (k_e / \mu)^{1/2} = [c^3/(\sqrt{2}\, G_e)](\mu\, m_e)^{-1/2}. \tag{19}$$

In (19) μ is the reduced mass of the electron (the electron interacting with itself), namely

$$\mu = m_e/2. \tag{20}$$

Inserting (20) and G_e (defined by (17)) into (19) we obtain

$$\hbar\, \omega_e = m_e\, c^2/(5\alpha). \tag{21}$$

4 – A bold hypothesis II

As was done with respect to the electron, it is also possible to look at the frequency of the small oscillations of the nucleon coupled to the universe. We have

$$\omega_{n,u} = (k/m_n)^{1/2} = [c^3/(\sqrt{2}\, G)](m_n\, M)^{-1/2}. \tag{22}$$

Now we propose a new bold hypothesis which is somewhat symmetric to the first one, namely: -

The separation in energy levels of the nucleon, gravitationally coupled to the universe, matches the separation in energy levels of the electron self-interaction. Therefore by considering equations (21) and (22) we get

$$\hbar\, \omega_{n,u} = \hbar\, \omega_e, \tag{23}$$

$$[\hbar\, c^3/(\sqrt{2}\, G)](m_n\, M)^{-1/2} = m_e\, c^2/(5\alpha). \qquad (24)$$

Solving (24) for M, the mass of the viscous universe, we find

$$M = (25\, \hbar^2\, c^2\, \alpha^2)/(2\, G^2\, m_e^2\, m_n). \qquad (25)$$

As can be verified in equations (10) and (25) by using the two symmetric bold hypothesis, we was able to obtain two equivalent relations for the mass of the universe in terms of some physical constants and of the nucleon and electron masses. Making the requirement of the equality between these two different forms of evaluating M, we obtain the for the nucleon-electron mass ratio the relation

$$m_n/m_e = \pi^2/(100\alpha^2). \qquad (26)$$

Inserting $1/\alpha$ =137in (26) we get

$$m_n/m_e \cong 1852. \qquad (27)$$

Relation (27) must be compared with the approximate values of 1838.7 and 1836 for the neutron-electron and proton-electron mass-ratios respectively.

Meanwhile in a recent paper Manley [11] has advanced the idea that the radius of the observable universe could be inferred from the following hypothesis: -

“A compromise between the quantity of information stored in the observable universe of radius R can be computed as the number of square unit cells of length equal to twice the Planck length L_P covering the spherical surface of radius R (according to the holographic principle [12]), but also as the number of cubic unit cells of edge equal to twice the proton length contained in the sphere of the same radius R".

Here we will go to modify slightly the Manley [11] assumption, considering the edge of the cubic unit cell as being twice the nucleon radius. Taking in account these considerations we can write

$$R_{Manley} = (128\,\pi^3\,\hbar^2\,)/(\sqrt{3}G\,m_n^3). \tag{28}$$

In writing (28) we have considered the nucleon radius $\Re_n$ as that obtained in [13], namely

$$\Re_n = (2\pi/\sqrt{3})\,\hbar/(m_n\,c). \tag{29}$$

Now making the equality of R_{Manley}, given by (28), with the radius of the viscous universe as obtained in (10), we have for the nucleon-electron mass ratio:

$$(\,m_n\ /m_e)|_{Manley} = 1024\,\pi/\sqrt{3}. \tag{30}$$

Relation (30) gives for the nucleon-electron mass ratio the approximate value of 1857.

In the hypothetical situation that the value of α was unknown, we could make the equality between the two different ways of estimate m_n/m_e, equaling (26) and (30). Doing this we obtain

$$1/\alpha^2 = 102400/(\pi\sqrt{3}), \tag{31}$$

which implies

$$1/\alpha \cong 137.2 \quad (32)$$

5 – Very brief remarks

To close this paper we would like to get inspiration in Wheeler [14] and Joos [15] ideas about the gravitational interaction. In a succinct summary of Einstein theory of general relativity, Wheeler [14] states that: “Spacetime tells matter how to move; matter tells spacetime how to curve”. Meanwhile Joos [15] in a paper dealing with the decoherence of the gravitational field has completed Wheeler’s statement:- “Thus, matter does not only tell space to curve but also to behave classically ”.

Taking in account equation (9) of this work, we can say:-The electron looks at the universe as the nucleon (proton in particular) looks at itself. And by considering equation (23):- The nucleon looks at the universe as the electron looks at itself.

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