An Insight into Planck's Units: Explaining the Experimental–Observations of Lack of Quantum Structure of Space-Time

Hasmukh K. Tank

Indian Space Research Organization 22/693 Krishna Dham-2, Vejalpur, Ahmedabad-380015 India.
E-mail: tank.hasmukh@rediffmail.com

This letter presents an insight into Planck's natural-units, that they are geometric-mean-values of astronomical-quantities, like total-mass of the universe M_0 and mass corresponding to Hubble's-constant $\left(hH_0/c^2\right)$, providing a theoretical support to the observational findings of Ragazzoni, R., Turatto, M. & Gaessler [Astrophysical Journal,587, L1–L4], Lieu, R. & Hillman, L.W [Astrophysical Journal, 585, L77–L80] and a news item published in Nature [Published on line on 31 March 2003 Nature DOI 10.1038/news030324-13] that there is no observational evidence for the quantum structure of space-time. Physicists have been expecting unification of gravitational and electric forces at Planck's energy; so they wanted to experimentally create a pair of particles whose gravitational-radius is equal to their Compton-wavelength. Whereas this paper shows that in nature there exists a "pair of unequal masses" which satisfies the condition of equality of gravitational and electrostatic potential-energies of the pair. If the universe with its total-mass M_0 and a particle of mass hH_0/c^2 both are electrically charged bodies, then the strengths of electric force and gravitational-force experienced by them will be equal. It is also pointed-out here that P.A.M. Dirac's observation of recurrences of the large-number 10^{40} and its explanation proposed by Tank [Proceedings of Indian National Sci. Acad. A, Vol. 63, No. 6, 469–474 (1997)] in 1997, by Sidharth [arXiv:gen-ph/0509026] in 2005, and by Funkhouser [arXiv:gen-ph/0611115] in 2006, should be viewed as attempts in search of natural system of units; and the recurrences $R_0/r_e = e^2/Gm_e$, $m_p = \left[M_0/m_p\right]^{1/2}$ should be taken more seriously than a mere coincidence, because its explanation by Tank also helped explaining the recurrences of the critical-acceleration of MOND noticed by Sivaram [Astrophys. and Space Sci. 215, (1994), 185–189].

1 Introduction

It has been realized by physicists since long that the conventional system of units, like meter, kilogram and second are arbitrarily chosen units; they do not correspond with any fundamental physical quantities; so we find it difficult to observe any regular pattern. Max Plank proposed a set of natural-units. Physicists have been expecting unification of gravitational and electric forces at the energies where protons attain the masses close to Planck's-mass. Large Hadrons Collider [LHC] was expected to yield some interesting results, because protons were to attain Planck's mass. It was believed that space and time are quantized; Planck-length is the "least-count" for "space" and Planck's unit of "time" is the "least-count" for "time". Whereas this letter shows that Planck's units are statistical-quantities, they are geometric-mean-values of the astronomical-quantities like total-mass of the universe M_0 and mass corresponding to Hubble's constant (hH_0/c^2).

(i) Planck's length L^* is a geometric-mean of: Gravitational-Radius corresponding to total mass of the universe M_0 and Compton-wavelength corresponding to the total-mass M_0 of the universe, i.e.

$$L^* = \left[\left(GM_0/c^2\right)(h/M_0c)\right]^{1/2}.$$

Also, L^* is a geometric-mean of: gravitational-radius of the universe and that of the lightest-particle of mass $\left(hH_0/c^2\right)$. L^* is also a geometric-mean of Compton-wavelengths of M_0 and $\left(hH_0/c^2\right)$.

(ii) Planck's unit of time T^* is a geometric-mean of age-of-the-universe T_0 and the period corresponding the total mass of the universe h/M_0c^2.

(iii) Planck's unit of mass M^* is a geometric-mean of total-mass-of the-universe M_0 and mass-of-the-lightest-particle. So, this letter provides a theoretical explanation for the experimental observations by Ragazzoni et al [1] and Lieu et. al. [2] that there is no evidence for quantum structure of space-time.

(iv) The total mass of the universe M_0 and mass corresponding to Hubble's constant $\left(hH_0/c^2\right)$ form an interesting pair, that: Gravitational-Radius corresponding to total-mass of the universe is equal to Compton-wavelength of the lightest particle, of mass hH_0/c^2.

(v) Gravitational-radius of the lightest particle is equal to the Compton-wavelength of the total-mass of the universe, M_0. Physicists have been trying to generate a pair of particles of equal masses whose gravitational-radius is equal to their Compton-wavelength. But in nature, there exists a pair of unequal masses which satisfies the condition for unification of forces, that their gravitational-potential-energy should be equal to the electrostatic-potential-energy. So this pair is expected to provide some clue to a deeper understanding needed for unification of gravitational and electric forces.

It is also pointed-out here that P. A. M. Dirac's observation of recurrences of the large-number 10^{40} and its explanation proposed by Tank [4] in 1997, by Sidharth [5] in 2005, and by Funkhouser [6] in 2006, should be viewed as attempts in search of natural system of units; and the recurrences $R_0/r_e = e^2/Gm_e$, $m_p = \left[M_0/m_p\right]^{1/2}$ should be taken more seriously than a mere coincidence, because their explanation by Tank also helped explaining the recurrences of the critical-acceleration of MOND noticed by Sivaram [7] and led to further conclusions discussed in the references [8–10].

2 The Derivations

(i) Gravitational-Radius of the universe is equal to Compton-wavelength of the lightest particle, of mass hH_0/c^2:

The gravitational-radius-of-the-universe $R_0 = GM_0/c^2$; Here M_0 is total-mass of the universe. And Compton-wavelength of the lightest-particle of mass hH_0/c^2 ; where H_0 is Hubble's constant, is:

$$\begin{aligned} & h/\left(hH_0/c^2\right)c \\ \text{i.e.} \quad &= c/H_0, \\ \text{i.e.} \quad &= R_0, \\ \text{i.e.} \quad &= GM_0/c^2. \end{aligned}$$

(ii) Gravitational-radius of the lightest particle is equal to Compton-wavelength of the total-mass of the universe, M_0.

$$\begin{aligned} \text{i.e.} \quad &= G\left(hH_0/c^2\right)/c^2, \\ \text{i.e} \quad &= GhH_0/c^4, \\ \text{i.e.} \quad &= GhH_0/GH_0M_0c \end{aligned}$$

(Because $GH_0M_0 = c^3$, based on this author's previous work [4]), i.e.= h/M_0c which is the Compton-wavelength corresponding to the total-mass-of-the-universe.

(iii-a) Planck's length L^* is a geometric-mean of: Gravitational-Radius of the universe and Compton-wavelength corresponding to the total-mass of the universe:

$$\begin{aligned} \text{i.e. } L^* &= \left[\left(GM_0/c^2\right)(h/M_0c)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[hG/c^3\right]^{1/2}. \end{aligned}$$

Similarly, Planck's length is a geometric-mean of gravitational-radius and Compton-wavelengths of every particle of any mass.

(iii-b) Planck's length L^* is also a geometric-mean of: gravitational-radius of the universe and that of the lightest-particle of mass hH_0/c^2:

That is:

$$\begin{aligned} & \left[\left(GM_0/c^2\right)\left(GhH_0/c^4\right)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[G^2M_0hH_0/GM_0H_0c^3\right]^{1/2} \end{aligned}$$

(Because $GH_0M_0 = c^3$, based on this author's previous work [4]),

$$\begin{aligned} \text{i.e.} \quad &= \left[hG/c^3\right]^{1/2}, \\ \text{i.e.} \quad &= L^*. \end{aligned}$$

(iii-c) L^* is also a geometric-mean of Compton-wavelengths of M_0 and $\left(hH_0/c^2\right)$:

That is:

$$\begin{aligned} & \left[(h/M_0c)\left\{h/\left(hH_0/c^2\right)c\right\}\right]^{1/2}, \\ \text{i.e.} \quad &= \left[(h/M_0c)\,(c/H_0)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[(h/M_0c)\,(R_0)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[(h/M_0c)\left(GM_0/c^2\right)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[hG/c^3\right]^{1/2}, \\ \text{i.e.} \quad &= L^*. \end{aligned}$$

The references [1–3] also lead to a conclusion that nothing very special is observed at Planck length; there is no evidence for any quantum structure of space-time. This paper has shown that Planck-length is a statistical-quantity, a geometric-mean-value, not a length of any fundamental-entity.

(iv) Planck's unit of time T^* is a geometric-mean of age-of-the-universe and the period corresponding the total-mass of the universe h/M_0c^2

Age-of-the-universe $T_0 = 1/H_0$.

So the product of the two periods is:

$$\begin{aligned} & (1/H_0)\left(h/M_0c^2\right), \\ \text{i.e.} \quad &= h/H_0M_0c^2, \\ \text{i.e.} \quad &= hG/c^5 \end{aligned}$$

(Because $GH_0M_0 = c^3$, based on this author's previous work [4])

$$\begin{aligned} \text{i.e.} \quad &= T^{*2}, \\ \text{i.e. } T^* &= \left[(T_0)\left(h/M_0c^2\right)\right]^{1/2}. \end{aligned}$$

(v) Planck's unit of mass M^* is a geometric-mean of total-mass-of the-universe M_0 and mass-of-the-lightest--particle :

$$\begin{aligned} \text{i.e.} \quad &= \left[(M_0)\left(hH_0/c^2\right)\right]^{1/2}, \\ \text{i.e.} \quad &= \left[M_0hH_0c/c^3\right]^{1/2}, \\ \text{i.e.} \quad &= \left[M_0hH_0c/GM_0H_0\right]^{1/2} \end{aligned}$$

(Because $GH_0M_0 = c^3$, based on this author's previous work [4]),

$$\text{i.e.} \quad = \quad [hc/G]^{1/2},$$
$$\text{i.e.} \quad = \quad M^*.$$

(vi) P.A.M. Dirac took the classical-radius of the electron e^2/m_ec^2 as a natural unit of length; and found an interesting relation:

$$R_0/r_e = e^2/Gm_em_p = \left[M_0/m_p\right]^{1/2} = 10^{40}.$$

Tank [4] explained the above relation and reached a conclusion that the relation implies: (i) Gravitational potential-energy of the universe is equal to the energy-of-mass of the universe; (ii) Electrostatic potential-energy of the electron is equal to the energy-of-mass of it; and (iii) Strengths of electric-force, strong-force and gravitational-force are proportional to densities of matter within the electron, the pi-meson and the universe respectively. Sidharth [5] and Funkhouser [6] have given a similar explanation for the recurrences of the Large-Number, but they have not drawn any conclusions for further application.

From the above comparison of Planck's natural units and Dirac's natural units we are led to a conclusion that Dirac's choice of natural units leads to interesting new relations. These relations should not be ignored as mere coincidences, because these relations have emerged from right choice of natural-units.

Sivaram [7] noticed the recurrences of the same value of acceleration, equal to the "critical-acceleration" of MOND, at the radial-distance R in the case of the electron, the proton, the nucleus, the globular-clusters, the spiral-galaxies, the galactic-clusters and the universe. Tank [8–10] could explain these recurrences based on equality of potential-energy and energy-of-mass of these systems, the equality which helped him to explain Dirac's large-number-ratios in 1997. Thus, Dirac's attempt to choose natural-units has led to a conclusion, of equality of potential-energy and energy-of-mass of various systems of matter, which helped explaining another set of recurrences noticed by Sivaram, and to draw further conclusions discussed in the references [8–10]

Also, if we measure distances in the units of radius-of-the-universe R_0 and measure masses of bodies in the units of total-mass-of-the-universe M_0 then the gravitational-constant G becomes unity; as follows:

> Gravitational-potential-energy of a system of masses M and m at a distance r is
>
> $$= (M/M_0)\left(mc^2\right)/(r/R_0).$$

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