Limitation of Planck's Units and a New Fundamental Unit of Mass

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Abstract:

Max Planck derived fundamental units purely from fundamental physical constants h, c and G . Tank showed that Planck's unit of length is a geometric-mean of two un-equal lengths; namely Compton-wavelength and Gravitational-radius of every particle; and his unit of mass is a geometric-mean of two un-equal masses, namely total mass of the universe and the smallest conceivable mass $h\,H_0 / c^2$; so the units, obtained by taking square-root of a set of fundamental physical constants, may not be truly fundamental units. Weinberg obtained a unit of mass by taking cube-root of a set of four fundamental-constants, (h , c , G and H_0 , where H_0 is Hubble's constant), so we are not sure whether the multiplication of three masses in Weinberg's formula are of the same masses or of different ones. Therefore, here we shall derive a unit of mass without taking any square-root or cube-root. There is a strong possibility of physical existence of a particle with this mass, $h\,H_0 / c^2$; and it seems that a photon decays into a lighter photon plus this new particle of mass : $h\,H_0 / c^2$.

Key Words: Planck's units of mass, length and time, Fundamental unit of mass, Large-Number-Coincidence (LNC).

1. Introduction:

Weyl, Eddington and P.A.M. Dirac independently worked on an idea, that: We measure physical quantities in arbitrarily chosen units like: meter, kilogram and seconds. We should use some standard physical length, like the 'classical radius of an electron' (r_e), to measure lengths. As soon as they expressed the 'radius of the universe' R_0 in terms of 'radius of an electron', to their pleasant surprise, the ratio: (R_0 / r_e) turned out to be equal to the ratio ($e^2 / G\, m_e\, m_p$) $= 10^{40}$. And the ratio (M_0 / m_p) = ($e^2 / G\, m_e\, m_p$)^2 $= 10^{80}$; here M_0 is 'total mass of the universe' and m_p is mass of a proton. Though Dirac's 'Large Number Hypothesis', predicting reduction of 'strength of gravity' with age of the universe, did not match with observations, the numerology of the above 'Large Number Coincidence' has been striking. Later in 1997 this writer, while explaining the 'large-number-coincidence' [8], showed that this coincidence implies that: Mass of the universe is equal to gravitational potential-energy of the universe; and electro-static potential-energy stored in an electron is equal to energy of mass of it.

Similarly Max Planck tried to derive natural units, of mass, length and time, purely from the fundamental physical constants; but Planck's unit of mass did not match with mass of any physically observed particle; and his unit of length did not match with Compton wavelength of any particle. Later this writer showed [7] that Planck's unit of mass is 'geometric mean value' of two different masses, namely 'total mass of the universe' M_0 and smallest conceivable mass ($h\, H_0 / c^2$); and similarly, Planck's length is geometric-mean of Compton-wavelength and Gravitational-radius of every particle. So the mass and length obtained by taking square-root of a set of fundamental-constants may not be truly fundamental. To remind the readers, Planck's units of mass and length are:

$m_{\mathrm{P}} = \sqrt{\frac{\hbar c}{G}}$, and $l_{\mathrm{P}} = \sqrt{\frac{\hbar G}{c^3}}$

Following the line of thinking of Planck, Steven Weinberg tried to derive a fundamental unit of mass by taking four different fundamental constants, including H_0 [6].

Weinberg's mass: $m_W^3 = h^2 H_0 / c G$ ……..(1)

Here H_0 is Hubble's constant. But, in the LHS of expression-1 we are not sure, whether the product of three masses is of the same masses, or of different ones.

2. New Derivation of the Fundamental Unit of Mass:

So let us divide both the sides of Weinberg's expression-1 by a well-known set of fundamental-constants, $h c / G$, so that we do not have to take square-root or cube-root:

i.e. $(m_W^3) / (h c / G) = (h^2 H_0 / c G) / (h c / G)$

i. e. $m_T = h H_0 / c^2$ ……....(2)

Where: m_T is a fundamental unit of 'mass' proposed by this writer.

It may be interesting to see that: just as the 'fine-structure-constant' $(e^2 / h c) = (m_e / m_{pion})$, so exactly the product: $(e^2 / h c) [(G m_e m_{proton}) / (e^2)] = [(h H_0 / c^2) / m_e)]$. So the mass $(h H_0 / c^2)$ seems to be of physical significance, not just a mathematical quantity.

The gravitational radius of this mass would be:

$[G (h H_0 / c^2) / c^2]$

The Compton wavelength of this particle would be:

Compton wavelength: $[h / (h H_0 / c^2) c]$.

And the product of its gravitational-radius and Compton wavelength:

$[G (h H_0 / c^2) / c^2] [h / (h H_0 / c^2) c] = [h G / c^3]$, which is the square of Planck's length. As was mentioned earlier, Planck's length has been the geometric-

mean of two un-equal lengths. Therefore we derived here the unit of mass without taking any square-root or cube-root.

3. Interpretation of the Cosmological red-shift in terms of Decay of the Photon, and the newly proposed particle of the fundamental mass:

The linear part of the 'cosmological red-shift' is expressed as:

$(h f_0 - h f) / (h f) = H_0 D / c$

i.e. $(h f_0 - h f) = [(h f) H_0 D / c] = [(h H_0) (D / \lambda)]$ .....(3)

The expression-3 implies that the cosmologically red-shifting photon continuously splits into a lighter photon and the 'particle of fundamental mass $h H_0 / c$, while traveling every distance of its wavelength.

Similarly, there seems to be a fundamental unit of acceleration, a_0 :

Where: $a_0 = G (h H_0 / c^2) / (h G / c^3) = H c$ .....(4)

The cosmologically red-shifting photon can be viewed as decelerating at this rate, as follows:

$(h f_0 - h f) / (h f) = H_0 D / c$

i.e. $(h f_0 - h f) = [(h f / c^2) (H_0 c) D$ .....(5)

Even the four space-probes Pioneer-10, Pioneer-11, Galileo and Ulysses too are observed to decelerate at this rate, $H_0 c$, as reported by Anderson et. al. [9].

(i) For Pioneer-10, $a = (8.09 \pm 0.2) \times 10^{-10}$ m / s^2

(ii) For Pioneer-11, $a = (8.56 \pm 0.15) \times 10^{-10}$ m / s^2

(iii) For Ulysses, $a = (12 \pm 3) \times 10^{-10}$ m / s^2

(iv) For Galileo, $a = (8.0 \pm 3) \times 10^{-10}$ m / s^2

All these decelerations are of the same order of magnitude as $H_0 c = 6.87 \times 10^{-10}$ m/s^2; and match strikingly with the 'critical-acceleration' a_0 of MOND; an extremely rare-probability coincidence. Matching of four different decelerations, in spite of the differences in the space-probes' mass, velocities and directions, is

itself a striking coincidence; and its matching with the deceleration experienced by the ‘cosmologically red-shifting photon’ cannot be ignored by a scientific mind as a coincidence. Slight differences in their values can be attributed to mundane effects like thermal radiation. Moreover, the extra-galactic photon experiences some gravitational blue-shift when it enters the gravitational-field of our milky-way galaxy. If we can send Hubble-like telescope out-side our milky-way galaxy then the value of $H_0\ c$ may be found very close to the decelerations of the above space-probes.

4. Role of the Fundamental Acceleration in Cosmology

This value of acceleration ($H_0\ c$) also seems to play its role in the formations of structures of: nucleus-of-atom, globular-clusters, spiral-galaxies, galactic-clusters and the whole universe; as Sivaram C. has numerically-found the following interesting coincidences, [10] that:

(i) For a typical atomic nucleus of mass m_n , $(\ A = 150\ )$

$$a = G\ m_n / r_n^2 \ \sim\ 1.0 \text{ x } 10^{-10}\ \text{m / s}^2$$

(ii) For a globular cluster of mass 10^6 solar-masses and radius R_g = 100 pc,

$$a = G\ M_g / R_g^2 \ \sim 10^{-10}\ \text{m / s}^2$$

(iii) For a spiral galaxy of mass $M_{gal} = 10^{12}$ solar-masses and radius R_{gal} = 30 kpc,

$$a = \ G\ M_{\text{gal}}\ / R_{gal}^2 \sim\ 0.8 \text{ x } 10^{-10}\ \text{m / s}^2$$

(iv) For a typical cluster of galaxies, $M_c = 10^{16}$ solar-masses and radius R_c = 3 Mpc,

$$a = G\ M_c / R_c^2 \ \sim\ 10^{-10}\ \text{m / s}^2$$

(v) Also, for the observable-universe as a whole, with a density of 10^{-29} grams/ cm^3 and radius R= 10^{28} cm,

$$a = c\,H_0 = 6.87 \times 10^{-10}\ m/s^2$$

(vi) And, the value of 'critical acceleration of MOND, $a_0 \sim 10^{-10}\ m/s^2$

These coincidences can be explained as follows: For stability of a structure, the self-gravitational-acceleration of a structure should be equal and opposite of the acceleration of the un-manifest-energy in the universe; to establish equilibrium between the two accelerations.

Conclusion:

We found here that the currently used fundamental units of mass, length and time , as proposed by Max Planck, were obtained by taking square-root of a set of fundamental physical constants; so they were geometric mean of unequal masses and lengths. Whereas here we derived a fundamental unit of mass without taking any square-root or cube-root of a set of fundamental physical constants, and obtained a truly fundamental unit of mass; and considered a strong possibility of physical existence of a particle with this fundamental unit of mass. As a supportive evidence we interpreted the cosmological red-shift in terms of decay of photons into a lighter photon and the new particle of mass equal to one fundamental unit of mass. Then we considered a possibility of a fundamental unit of 'change of velocity', i.e. acceleration and presented five supportive evidences, that the photons and four space-probes Pioneer-10, Pioneer-11, Galileo and Ulysses, do show decelerations at this fundamental unit of deceleration.

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