Cosmic mass and the electromagnetic & strong interactions

U. V. S. Seshavatharam, *Honorary faculty*
I-SERVE, Alakapuri, Hyderabad-35, AP, India.
E-mail: seshavatharam.uvs@gmail.com

Prof. S. Lakshminarayana
Dept. of Nuclear Physics, Andhra University
Visakhapatnam-03, India
e-mail: lnsrirama@yahoo.com

Abstract: It seems that- quanta of the angular momentum and the strong interaction range - both are connected with the large scale structure of the universe. In the expanding universe 'quanta' increases with increasing mass of the universe. By any chance if the noticed empirical relation is found to be true and valid, 'rate of decrease in fine structure ratio' is a measure of cosmic rate of expansion. Considering the integral nature of number of protons (of any nucleus), integral nature of 'hbar' can be understood.

Keywords: Hubble's constant; present universe mass, electron rest mass; proton rest mass; reduced planck's constant; classical force limit; strong interaction range;

1 Introduction

Considering and comparing the ratio of characteristic size of the universe and classical radius of electron with the electromagnetic and gravitational force ratio of electron and proton, Dirac in his large number hypothesis [1,2] suggested that, magnitude of the gravitational constant G inversely varies with the cosmic time. In supporting of this till today no such data is reported [3]. Considering the characteristic mass of the universe, in this paper an attempt is made to understand the mystery of the origin of the integral quantum constant and the strong interaction range.

1.1 Hubble's law

Hubble's law is the name for the astronomical observation in physical cosmology that:

1. All objects observed in deep space (interstellar space) are found to have a doppler shift observable relative velocity to Earth, and to each other; and
2. That this doppler-shift-measured velocity, of various galaxies receding from the Earth, is proportional to their distance from the Earth and all other interstellar bodies.

In effect, the space-time volume of the observable universe is expanding and Hubble's law is the direct physical observation of this process [4,5]. It is considered the first observational basis for the expanding space paradigm and today serves as one of the pieces of evidence most often cited in support of the Big Bang model [6,7].

Although widely attributed to Edwin Hubble, the law was first derived from the General Relativity equations by Georges Lemaitre in a 1927 article [8] where he proposed that the Universe is expanding and suggested an estimated value of the rate of expansion, now called the Hubble constant. Two years later Edwin Hubble confirmed the existence of that law and determined a more accurate value for the constant that now bears his name. The law is often expressed by the equation

$$v = H_0 D, \tag{1}$$

with H_0 the constant of proportionality (the Hubble constant), D is the galaxy distance and v is the recession velocity of the galaxy. The SI unit of H_0 is sec^{-1} but it is most frequently quoted in $Km/s/Mpc$.

1.2 Magnitude of the Hubble's constant

The value of the Hubble constant H_0 is estimated by measuring the redshift of distant galaxies [9] and then determining the distances to the same galaxies (by some other method than Hubble's law). Uncertainties in the physical assumptions used to determine these distances have caused varying estimates of the Hubble constant. For most of the second half of the 20th century the value of H_0 was estimated to be between 50 and 90 Km/s/Mpc. The Hubble Key Project [10] used the Hubble space telescope to establish the most precise optical determination in May 2001 of 72 ± 8 Km/s/Mpc, consistent with a measurement of H_0 based upon Sunyaev-Zel'dovich effect observations of many galaxy clusters having a similar accuracy. The most precise cosmic microwave background radiation determinations were 71 ± 4 Km/s/Mpc, by WMAP in 2003, and $70.4^{+1.5}_{-1.6}$ Km/s/Mpc, for measurements up to 2006. The five year release from WMAP in 2008 found $71.9^{+2.6}_{-2.7}$ Km/s/Mpc using WMAP-only data and 70.1 ± 1.3 Km/s/Mpc when data from other studies were incorporated, while the seven year release in 2010 found 71.0 ± 2.5 Km/s/Mpc using WMAP-only data and $70.4^{+1.3}_{-1.4}$ Km/s/Mpc when data from other studies were incorporated [11]. Thus in this paper it is taken as $H_0 \cong 70.4$ Km/s/Mpc.

1.3 Physical constants and their fundamental ratios

Characteristic size of the universe is

$$R_0 \cong \frac{c}{H_0} \cong 1.314147 \times 10^{26} \text{ m} \tag{2}$$

Classical radius of electron of mass m_e is

$$R_e \cong \frac{e^2}{4\pi\varepsilon_0 G m_e c^2} \cong 2.8794 \times 10^{-15} \text{ m} \tag{3}$$

Ratio of R_0 and R_e is

$$X_1 \cong \frac{R_0}{R_e} \cong \frac{4\pi\varepsilon_0 G m_e c^3}{e^2 H_0} \cong 4.6635 \times 10^{40} \tag{4}$$

Electromagnetic and gravitational force ratio of electron of mass m_e and proton of mass m_p is

$$X_2 \cong \frac{e^2}{4\pi\varepsilon_0 G m_p m_e} \cong 2.26867 \times 10^{39} \tag{5}$$

Ratio of X_1 and X_2 is

$$\frac{X_1}{X_2} \cong \frac{4.6635 \times 10^{40}}{2.26867 \times 10^{39}} \cong 20.5561 \tag{6}$$

1.4 Characteristic mass of the present universe

Let the cosmic closure density is,

$$\rho_0 \cong \frac{3H_0^2}{8\pi G} \tag{7}$$

Volume of the universe in a Euclidean sphere of radius $\left(\frac{c}{H_0}\right)$ is equal to

$$v_0 \cong \frac{4\pi}{3}\left(\frac{c}{H_0}\right)^3 \tag{8}$$

Mass of the universe in a Euclidean sphere is

$$M_0 \cong \rho_0 \cdot v_0 \cong \frac{c^3}{2GH_0} \cong 8.84811 \times 10^{52} \text{ Kg} \tag{9}$$

If m_n is the mass of nucleon, number of nucleons in a Euclidean volume of size $\frac{c}{H_0}$ is

$$X_3 \cong \frac{M_0}{m_n} \cong \frac{c^3}{2GH_0 m_n} \cong 5.286322 \times 10^{79} \tag{10}$$

From these ratios it is noticed that,

$$X_1 \approx \sqrt{X_3} \approx X_2 \tag{11}$$

J. V. Narlikar says [12]:*Reactions among physicists have varied as to the significance of all these numbers. Some dismiss it as a coincidence with the rejoinder 'So what' ? Others have read deep significance into these relations. The later class includes such distinguished physicists as A. S. Eddington and P. A. M. Dirac.*

Dirac pointed out in 1937 that the relationships (3) to (11) contain the Hubble constant H_0 and therefore the magnitudes computed in these formulae vary with the epoch in the standard Friedmann model. Finally Dirac made a distinction between e, m_e, and m_p on one side and G on the other in the sense that the former are atomic quantities where as G has macroscopic significance. In the Machian cosmologies, G is in fact related to the large scale structure of the universe. Dirac therefore assumed that, if we use 'atomic units' that always maintain fixed values for atomic quantities, then G varies with cosmic time t as $G \,\alpha\, t^{-1}$.

2 The reduced Planck's constant - strange coincidence

David Gross [13] says: *After sometime in the late 1920s Einstein became more and more isolated from the mainstream of fundamental physics. To a large extent this was due to his attitude towards quantum mechanics, the field to which he had made so many revolutionary contributions. Einstein, who understood better than most the implications of the emerging interpretations of quantum mechanics, could never accept it as a final theory of physics. He had no doubt that it worked, that it was a successful interim theory of physics, but he was convinced that it would be eventually replaced by a deeper, deterministic theory. His main hope in this regard seems to have been the hope that by demanding singularity free solutions of the nonlinear equations of general relativity one would get an overdetermined system of equations that would lead to quantization conditions.* These words clearly suggests that, at fundamental level there exists some interconnection in between quantum mechanics and gravity [14]. Empirically it is noticed that

$$\hbar \cong \frac{Gm_p\sqrt{M_0 m_e}}{c} \cong 1.057185 \times 10^{-34} \text{ joule.sec} \quad (12)$$

where M_0 is the characteristic mass of the present universe. This is a striking, astounding and accurate coincidence ! This is a multi-purpose expression also. Any value of the atomic constant can be estimated with this expression. Writing this in a ratio form,

$$X_4 \cong \frac{\hbar c}{Gm_p\sqrt{M_0 m_e}} \cong 1 \quad (13)$$

How to interpret this ratio? Compared to the above ratios X_1, X_2, and X_3 this ratio is close to unity. Giving a primary significance to the existence of m_e, m_p & c, and considering the Machian concept of the distance cosmic back ground [15,16], $\hbar$ can be considered as the compound physical constant. From the atomic structure point of view also this idea can be strengthened. If electron is revolving round the nucleus, naturally m_p and m_e both are the characteristic physical inputs. If so: in the expanding universe 'quanta' increases with increasing mass of the universe. Any how this is a very sensitive problem.

Considering the 'integral nature' of number of protons (of any nucleus), integral nature of $n \cdot \hbar$ can be understood. Considering any two successive integers n and $n+1$, their geometric state can be expressed as $\sqrt{n\,(n+1)} \cdot \hbar$. If this logic is true, it can be suggested that $\hbar$ is a compound physical constant and is connected with the large scale structure of the universe. The cosmological fine structure ratio can be given as

$$\alpha \cong \frac{e^2}{4\pi\varepsilon_0 Gm_p\sqrt{m_e M_0}} \quad (14)$$

It is the strength of electromagnetic interaction and is an intrinsic property of nature. Several different types of astrophysical observations [17,18], have established the evidence that the expansion of the universe entered a phase of acceleration. Cosmic acceleration and dark energy constitute one of the most important and challenging of current problems in cosmology and other areas of physics. By any chance if the noticed empirical relation (12) is found to be true and valid, and if universe is really accelerating and its mass is increasing, then 'rate of increase in $\hbar$' or 'rate of decrease in α' will be a measure of cosmic rate of expansion[19,20]. With reference to relation (12), magnitude of the Hubble's constant can be fitted as

$$H_0 \cong \frac{Gm_p^2 m_e c}{2\hbar^2} \cong 70.74955 \text{ Km/sec/Mpc} \quad (15)$$

In hydrogen atom, potential energy of electron in Bohr radius [21,22] can be expressed as

$$E_P \cong -\frac{e^2}{4\pi\varepsilon_0 Gm_p M_0} \times \frac{e^2 c^2}{4\pi\varepsilon_0 Gm_p} \quad (16)$$

Total energy of electron in Bohr radius can be expressed as

$$E_P \cong -\frac{e^2}{4\pi\varepsilon_0 Gm_p M_0} \times \frac{e^2 c^2}{8\pi\varepsilon_0 Gm_p} \quad (17)$$

Considering the integral nature of number of protons (of any nucleus), above relation can be expressed as

$$E_T \cong -\frac{e^2}{4\pi\varepsilon_0 G\,(n \cdot m_p)\,M_0} \times \frac{e^2 c^2}{8\pi\varepsilon_0 G\,(n \cdot m_p)} \quad (18)$$

where $n = 1, 2, 3, ..$ Thus in a discrete form this relation can be expressed as

$$E_T \cong -\frac{1}{n^2} \times \frac{e^2}{4\pi\varepsilon_0 Gm_p M_0} \times \frac{e^2 c^2}{8\pi\varepsilon_0 Gm_p} \quad (19)$$

To move further and to know the mystery of origin of $\hbar$, in this paper an attempt is made to search for the other such coincidences.

2.1 Alternative to the Planck scale

If $\hbar$ is a cosmic variable, then what about the validity of 'Planck mass' and 'Planck scale'? Answer is very simple. $\sqrt{\frac{\hbar c}{G}}$ can be replaced with $\sqrt{\frac{e^2}{4\pi\varepsilon_0 G}}$. It can be called as the 'Coulomb mass'. Its corresponding rest energy is $\sqrt{\frac{e^2c^4}{4\pi\varepsilon_0 G}}$. It can be called as the 'Coulomb energy'. Planck energy can be replaced with the 'Coulomb energy'.

$$M_C \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} \cong 1.859211 \times 10^{-9} \text{ Kg} \tag{20}$$

$$M_C c^2 \cong \sqrt{\frac{e^2c^4}{4\pi\varepsilon_0 G}} \cong 1.042941 \times 10^{18} \text{ GeV} \tag{21}$$

Coulomb size can be expressed as

$$R_C \cong \sqrt{\frac{e^2 G}{4\pi\varepsilon_0 c^4}} \cong 1.38068 \times 10^{-36} \text{ m} \tag{22}$$

Clearly speaking e, c and G play a vital role in fundamental physics. With these 3 constants space-time curvature concepts at a charged particle surface can be studied.

3 Classical limits of force and power

Special theory of relativity says that light speed is the maximum speed that a material particle can move with. It is the natural speed with which photon or electromagnetic signal travels in free space. Till today there is no explanation for this characteristic speed limit. Throughout the cosmic evolution whether the speed limit is constant or changing? is also an answer-less question. It is an accepted and universal idea that 'gravity' and 'gravitational radiation' also propagates with speed of light.

Here it is very important to note that physics works on physical constants and runs on mathematical equations. The combination of the observed and well believed physical constants play a vital role in understanding many physical phenomena. Their combination generates some special and strange constants which are natural, unbelievable and unmeasurable. The formation of black holes, coulomb mass etc can be understood with those fundamental and compound physical constants.

3.1 Expressions for the fundamental force and power

One such fundamental and unbelievable compound physical constant is $\frac{c^4}{G}$ where c is the speed of light and G is the gravitational constant. The more surprising and strange thing is that its dimensions are identical to the dimensions of 'force'. Its magnitude is 1.21×10^{44} newton. This is a very big magnitude and can not be measured in laboratory experiments. The most unfortunate thing is that it appears in general theory of relativity in inverse form as $\frac{8\pi G}{c^4}$. It connects the gravitational and non-gravitational forces. Whether to consider it or discard it - it depends only on our personal and scientific interest. It represents the maximum 'gravitational force of attraction' and maximum 'electromagnetic force'. It can be considered as the maximum 'string tension'.

Another fundamental and unbelievable compound physical constant is $\frac{c^5}{G}$. The more surprising and strange thing is that its dimensions are identical to the dimensions of 'power'. Its magnitude is 3.63×10^{52} joule/sec. This is also a very big magnitude and can not be measured in laboratory experiments. Whether to consider it or discard it - it depends only on our personal and scientific interest. Combining them with some of the classical and quantum laws of physics, some miracles can be done.

3.2 Deduction of the fundamental force $\frac{c^4}{G}$

In Sun-Planet system, from Newton's law of gravitation,

$$F_g = \frac{GM_S m_P}{r^2} \tag{23}$$

Here, M_S= mass of sun, m_P =mass of planet and r = distance between them. Centripetal force on planet is,

$$F_c = \frac{m_P v^2}{r} \tag{24}$$

where, v = orbiting velocity of planet. Eliminating r from equation (23), force of attraction between sun-planet can be given as,

$$F = \left(\frac{m_P}{M_S}\right)\left(\frac{v^4}{G}\right) \tag{25}$$

It is very clear that, since (m_P/M_S) is a ratio, (v^4/G) must have the dimensions of 'force'. Following the 'constancy of speed of light', a force of the form, $\left(c^4/G\right)$ can be constructed. This can be considered as the upper limit or magnitude of any force. Nature of the force may be mechanical or electromagnetic or gravitational. Note that in GTR this force appears in an inverse form [12] as

$$\frac{1}{F} = \frac{8\pi G}{c^4} \tag{26}$$

Considering this magnitude as the upper limit of gravitational force of attraction, minimum distance between any 2 massive bodies can be obtained as follows. Let,

$$\frac{Gm_1m_2}{r^2} \leq \frac{c^4}{G} \tag{27}$$

Here, m_1 and m_2 are any 2 massive bodies and r is distance between them. Then minimum distance between the 2 bodies can be obtained as

$$r_{\min} = \frac{G\sqrt{m_1 m_2}}{c^2} \tag{28}$$

This is a simple and very strange expression. By any chance if mass of the 2 bodies is equal then

$$r_{\min} = \frac{Gm}{c^2} \tag{29}$$

Without going deep into general theory of relativity and combining Newton's law of gravitation and Special theory of relativity, results of GTR can be obtained. This idea can be applied to elementary particles also. Magnitude of force of attraction or repulsion between any 2 elementary particles having charges e_1 and e_2 can be expressed as

$$F = \frac{e_1 e_2}{4\pi\varepsilon_o r^2} \leq \frac{c^4}{G} \tag{30}$$

Minimum distance between e_1 and e_2 can be obtained as

$$r_{\min} = \sqrt{\frac{e_1 e_2}{4\pi\varepsilon_o}\left(\frac{G}{c^4}\right)} = \sqrt{\frac{e^2}{4\pi\varepsilon_o}\left(\frac{G}{c^4}\right)} \tag{31}$$

where $e_1 = e_2 = e$.

Charged particle's space-time curvature can be understood from this expression. With this idea GTR can be applied to charged elementary particles easily. Not only that this method simply and directly leads to Coulomb scale and grand unification or TOE. With a suitable proportionality ratio or scaling factor quark confinement can be understood as a charged space-time curvature. Characteristic potential energy near to a charge e corresponding to r_{min} can be expressed as

$$E_p \cong \frac{e^2}{4\pi\varepsilon_o r_{min}} \cong \sqrt{\frac{e^2}{4\pi\varepsilon_o}\left(\frac{c^4}{G}\right)} \tag{32}$$

3.3 The strong interaction range

From equation (28), considering the electron and the universe as the two point particles, their minimum distance can be expressed as

$$d_e = \frac{G\sqrt{m_e M_0}}{c^2} \cong 0.2108 \text{ fm} \tag{33}$$

Considering the proton and the universe as the two point particles, their minimum distance can be expressed as

$$d_p = \frac{G\sqrt{m_p M_0}}{c^2} \cong 9.034 \text{ fm} \tag{34}$$

Surprisingly it is noticed that, geometric mean of d_e and d_p is close to the strong interaction range 1.4 fm [22,23,24].

$$R_s \cong \sqrt{d_e d_p} \cong \frac{G\sqrt{M_0\sqrt{m_p m_e}}}{c^2} \cong 1.38 \text{ fm} \tag{35}$$

where R_s is the strong interaction range. In a ratio form it can be expressed as

$$X_5 \cong \frac{\sqrt{d_e d_p}}{R_s} \cong \frac{G\sqrt{M_0\sqrt{m_p m_e}}}{c^2 R_s} \cong 1 \tag{36}$$

Qualitatively and quantitatively it is clear that $\frac{GM}{c^2}$ represents the characteristic radius of a black hole where gravity is very strong. Relation (36) is having a peculiar meaning and seems to connected with the large scale structure of the universe. This is another significance of the characteristic mass of the universe. This idea may be given a chance.

4 Conclusion

Large dimensionless constants and compound physical constants reflects an intrinsic property of nature. Whether to consider them or discard them depends on physical interpretations, experiments and observations. By any chance if the noticed empirical relation (12) is found to be true and valid, and if universe is really accelerating and its mass is increasing, then 'rate of increase in $\hbar$' or 'rate of decrease in α' will be a measure of cosmic rate of expansion. The mystery can be resolved with further research and analysis.

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References

[1] P. A. M. Dirac. The cosmological constants. Nature, 139, 323, 1937.

[2] P. A. M. Dirac. A new basis for cosmology. Proc. Roy. Soc. A 165, 199, 1938.

[3] M. L. Gershteyn et al. Experimental evidence that the gravitational constant varies with orientation. http://arxiv.org/ftp/physics/papers/0202/0202058.pdf

[4] Hubble E. P. A relation between distance and radial velocity among extra-galactic nebulae. PNAS, 1929, v. 15, 168-173.

[5] Hubble, E.P. The 200-inch telescope and some problems it may solve, PASP, 59,153-167, 1947.

[6] J. A. Frieman et al. Dark energy and the accelerating universe. http://arxiv.org/abs/0803.0982v1.

[7] Robert P. Kirsnner. Hubble's diagram and Cosmic expansion. PNAS, Jan-2004 vol.101, no. 1 p8-13.

[8] Lematre, Georges. Expansion of the universe, A homogeneous universe of constant mass and increasing radius accounting for the radial velocity of extragalactic nebulae. Monthly Notices of the Royal Astronomical Society 91: 483-490.

[9] J. Huchara. Estimates of the Hubble Constant, 2009. Harvard-Smithsonian Center for Astrophysics. http://hubble.plot.dat

[10] W. L. Freedman et al. Final Results from the Hubble Space Telescope Key Project to Measure the Hubble Constant. The Astrophysical Journal 553 (1): 47-72.

[11] Seven-Year Wilson Microwave Anisotropy Probe (WMAP) Observations: Sky Maps, Systematic Errors, and Basic Results (PDF). nasa.gov. Retrieved 2010-12-02.

[12] J. V. Narlikar. An Introduction to Cosmology. 3rd edition, Cambridge University Press.(2002)

[13] David Gross, Einstein and the search for Unification. Current science, Vol. 89, No. 12, 25 Dec 2005.

[14] Hawking S.W. A Brief History of Time. Book. Bantam Dell Publishing Group. 1988.

[15] Raine, D. J. Mach's Principle in general relativity. Royal Astronomical Society 171: 507. 1975.

[16] CODATA recommended values of the fundamental physical constants:2006. Rev. Mod. Phys. 80 (2008) 633, Apr - Jun 2008.

[17] S. Perlmutter. Supernovae, Dark Energy, and the Accelerating Universe, Physics Today, April 2003, pp 53-60

[18] Mustapha Ishak. Remarks on the Formulation of the Cosmological Constant/Dark Energy Problems. Found Phys (2007) 37:1470-1498 .

[19] J.K.Webb et al. Evidence for spatial variation of the fine structure constant. Physical Review Letters. 23 August 2010. arXiv1008.3907W. doi:10.1103/PhysRevLett.107.191101.

[20] J.K.Webb et al. Indications of a spatial variation of the fine structure constant. http://arxiv.org/pdf/1008.3907v2.pdf

[21] N. Bohr. On the Constitution of Atoms and Molecules. (Part-1) Philos. Mag. 26, 1 1913

[22] N. Bohr. On the Constitution of Atoms and Molecules. (Part-2, Systems containing only a Single Nucleus). Philos. Mag. 26, 476, 1913

[23] Geiger H and Marsden E. On a diffuse reaction of the particles. Proc. Roy. Soc., Ser. A 82: 495-500, 1909.

[24] Hideki Yukawa. Meson theory in its developments. Nobel Lecture, December 12, 1949

[25] Recami E. Elementary Particles as Micro-Universes, and "Strong Black-holes": A Bi-Scale Approach to Gravitational and Strong Interactions. Preprint NSF-ITP-02-94.