

Hubble volume, Cosmic variable proton mass and the CMB radiation energy density

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Abstract

It is noticed that, in the accelerating universe, proton mass, proton size and the strong coupling constant are cosmic variable constants. Independent of the cosmic red shift and CMBR observations, cosmic acceleration can be verified by measuring the ‘rate of decrease’ in the proton mass. Cosmic initial conditions can be addressed with the Planck mass $M_P \cong \sqrt{\hbar c/G}$ and the coulomb mass $M_C \cong \sqrt{e^2/4\pi\epsilon_0 G}$. Based on the Mach’s principle and the characteristic Hubble mass of the present universe, $M_0 \cong \frac{c^3}{2GH_0}$, it is noticed that, in the Hubble volume, critical density, observed matter density and the thermal energy density are in geometric series and the geometric ratio is $1 + \ln(M_0/M_C)$. In this connection, it can be suggested that - in understanding the basics of grand unification and cosmology, cosmic Hubble volume can be given a chance.

Keywords: Hubble mass, Planck mass, Coulomb mass, variable proton mass, variable proton size, variable strong coupling constant, CMB radiation, cosmic critical density, cosmic matter density, CMB thermal energy density and Cosmic age.

1 Introduction

This is an extension of our work published in JGSFR [1]. The central idea is - in the accelerating universe, proton mass and size are variable physical quantities. Even though this idea is not in-line with the present physics concepts, it makes an attempt to unify the fundamental interactions. In study of our theoretical cosmology we

generally consider galaxy as a point. Only the space between any two galaxies is increasing with time. It is generally accepted that, the expansion of the universe is on the average - i.e., when all matter is smeared uniformly, bound objects (as in Kinetic Energy \ll Potential Energy) do not participate in the expansion of the universe (negligible). Even gravitationally bound system like our solar system, or galaxies and even cluster of galaxies do not expand with the universe. Electromagnetism (EM) is forty orders of magnitude stronger, hence atoms which are EM bound systems are not affected by the expansion of the universe. There are cosmological scenarios called Big Rip where the the expansion of the universe is so rapid in the finite future (in fact, approaches infinite in finite time) that it would eventually tear apart atoms. However, current observations do not indicate that possibility. Considering the unification program [2], in this paper an attempt is made to understand the origin of the proton mass, proton size, the strong coupling constant and the CMB radiation.

Based on the big bang concepts- in the expanding universe, rate of decrease in CMBR temperature is a measure of the cosmic rate of expansion. Modern standard cosmology is based on two contradictory statements. They are - present CMBR temperature is isotropic and the present universe is accelerating. In particle physics also, till today laboratory evidence for the existence of dark matter and dark energy is very poor. Recent observations and thoughts supports the existence of the cosmic axis of evil. Independent of the cosmic red shift and CMBR observations, cosmic acceleration can be verified by measuring the ‘rate of decrease’ in the proton mass.

Large dimensionless constants and compound physical constants reflects an intrinsic property of nature [2].

Whether to consider them or discard them depends on the physical interpretations, logics, experiments, observations and our choice of scientific interest. In most of the critical cases, ‘time’ only will decide the issue. The mystery can be resolved only with further research, analysis, discussions and encouragement. If m_e and m_p are the rest masses of electron and proton respectively, it is noticed that,

$$\frac{\hbar c}{Gm_p\sqrt{M_0m_e}} \cong 0.99753 \quad (1)$$

where $M_0 \cong \frac{c^3}{2GH_0}$ and the best value [4,5] of H_0 is $70.4_{-1.4}^{+1.3}$ Km/sec/Mpc. Surprisingly this ratio is close to unity! How to interpret this ratio? This relation can be obtained semi empirically from the characteristic nuclear charge radius and the characteristic Hubble size! But it needs the knowledge of coupling ‘gravity’, ‘Avogadro number’ and the ‘non-gravitational’ atomic forces which is right now not in the main stream research. Interested readers may please refer [1,6]. Please note that, in the above relation along with the variable Hubble constant, there exists one variable atomic physical constant. Based on the above coincidence, magnitude of the present Hubble’s constant [7] can be expressed as

$$H_0 \cong \frac{Gm_p^2m_e c}{2\hbar^2} \cong 70.75 \text{ Km/sec/Mpc} \quad (2)$$

In the physics history, it was suggested that, gravitational constant and the speed of light were cosmic variables. In our earlier paper it was assumed that, reduced Planck’s constant was a cosmic variable[6]. In no way these ideas were fitting into the existing concepts of physics. Another alternative idea is - to assume that, proton mass is a cosmic variable. If so one must explain the origin of proton size and the strong coupling constant. In this paper an attempt is made to fit these strong interaction properties.

1.1 Hubble volume - a compromise between closed and and flat universe

In modern cosmology, the shape of the universe is flat. In between the closed space and flat space, there is one compromise. That is ‘Hubble volume’. Note that Hubble volume is only a theoretical and spherical expanding volume and is virtual. From Hubble volume one can estimate the Hubble mass. By coupling the Hubble mass with the Mach’s principle, one can understand the origin of cosmic physical parameters.

1.2 Mach’s principle - Hubble volume - Hubble mass

In theoretical physics, particularly in discussions of gravitation theories, Mach’s principle [8-12] is the name given by Einstein to an interesting hypothesis often credited to the physicist and philosopher Ernst Mach. The idea is that the local motion of a rotating reference frame is determined by the large scale distribution of matter. There are a number of rival formulations of the principle. A very general statement of Mach’s principle is ‘local physical laws are determined by the large-scale structure of the universe’. This concept was a guiding factor in Einstein’s development of the general theory of relativity. Einstein realized that the overall distribution of matter would determine the metric tensor, which tells the observer which frame is rotationally stationary. Note that till today quantitatively Mach’s principle was not implemented successfully in cosmic and nuclear physics. With reference to the Hubble radius $R_0 \cong \frac{c}{H_0}$, Hubble mass can be expressed as $M_0 \cong \frac{c^3}{2GH_0}$. Considering the Mach’s principle and the Hubble mass, in this paper an attempt is made to understand the origin of the cosmic and strong interaction physical parameters.

1.3 Hubble’s law

Hubble’s law is the name for the astronomical observation in physical cosmology that the space-time volume of the observable universe is expanding [7]. 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. The law is often expressed by the equation

$$v = H_0 D, \quad (3)$$

with H_0 the constant of proportionality (the Hubble constant), D is the galaxy distance and v the recession velocity of the galaxy. The SI unit of H_0 is sec^{-1} but it is most frequently quoted in Km/sec/Mpc. The Hubble Key Project used the Hubble space telescope to establish the most precise optical determination [3-5]. The most precise CMB radiation determinations by WMAP for the seven year release in 2010 found 71.0 ± 2.5 Km/s/Mpc. The most accurate value is $70.4_{-1.4}^{+1.3}$ Km/s/Mpc [5].

1.4 Hubble mass - The characteristic mass of the present universe

The characteristic radius of the present universe is

$$R_0 \cong \frac{c}{H_0} \cong 1.307646 \times 10^{26} \text{ m} \quad (4)$$

where $H_0 \cong 70.75$ Km/sec/Mpc. Let the cosmic closure density is,

$$\rho_0 \cong \frac{3H_0^2}{8\pi G} \cong 9.40 \times 10^{-27} \text{ Kg/m}^3 \quad (5)$$

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

$$v_0 \cong \frac{4\pi}{3} \left(\frac{c}{H_0}\right)^3 \cong 9.36611 \times 10^{78} \text{ m}^3 \quad (6)$$

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

$$M_0 \cong \rho_0 \cdot v_0 \cong \frac{c^3}{2GH_0} \cong 8.80434 \times 10^{52} \text{ Kg} \quad (7)$$

This may be called as the Hubble mass of the present universe. Here one may ask the question: what is the physical meaning of characteristic radius or characteristic volume or characteristic density or characteristic mass? Particle horizon, event horizon etc are connected with the Hubble radius $\left(\frac{c}{H_0}\right)$ and are well known. Its corresponding Hubble volume is $\frac{4\pi}{3} \left(\frac{c}{H_0}\right)^3$. The critical density $\frac{3H_0^2}{8\pi G}$ plays a key role in cosmic expansion. When all these physical expressions play a critical or crucial role in the cosmic structure, the mass unit $\frac{c^3}{2GH_0}$ will also play some crucial or interesting role in the observable universe. In this paper, an attempt is made to understand the applications of the Hubble mass in the existing physical laws of atom and the universe.

2 The Coulomb mass in the the Planck scale

In the Planck scale, similar to the Planck mass, with reference to the elementary charge, a new mass unit can be constructed in the following way.

$$M_C \cong \sqrt{\frac{e^2}{4\pi\epsilon_0 G}} \cong 1.859211 \times 10^{-9} \text{ Kg} \quad (8)$$

$$M_C c^2 \cong \sqrt{\frac{e^2 c^4}{4\pi\epsilon_0 G}} \cong 1.042941 \times 10^{18} \text{ GeV} \quad (9)$$

Here 'e' is the elementary charge and (c^4/G) is the classical limit of force. How to interpret this mass unit? Is it a primordial massive charged particle? If 2 such oppositely charged particles annihilates, a large amount of energy can be released. Considering so many such pairs annihilation hot big bang or inflation can be understood.

This may be the root cause of cosmic energy reservoir. Such pairs may be the chief constituents of black holes. In certain time interval with a well defined quantum rules they annihilate and release a large amount of energy in the form of γ photons. In the expanding universe, with its pair annihilation, origin of the CMBR can be understood.

It is widely accepted that charged leptons, quarks, and baryons all these comes under matter or mass carriers and photons and mesons comes under force carriers. If so what about this new mass unit? is it a fermion? or is it a boson? or else is it represents a large potential well in the primordial matter or mass generation program? Is it the mother of magnetic monopoles? Is it the mother of all charged particles? By any suitable proportionality ratio or with a suitable scale factor if one is able to bring down its mass to the observed particles mass scale, very easily a grand unified model can be developed. 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. Characteristic 'Coulomb radius' can be expressed as

$$R_C \cong \frac{2GM_C}{c^2} \cong 2.716354 \times 10^{-36} \text{ m} \quad (10)$$

2.1 To understand the Proton rest mass

Giving a primary and fundamental significance [13] to the existence of m_e, \hbar, G & c , and considering the Machian concept of the distance cosmic back ground in the form of 'cosmic Hubble mass', m_p can be considered as the characteristic cosmic variable physical quantity.

$$(m_p)_0 \cong \frac{\hbar c}{G\sqrt{M_0 m_e}} \cong \sqrt{\frac{m_e}{M_0}} \cdot \frac{M_P^2}{m_e} \quad (11)$$

where $M_P \cong \sqrt{\hbar c/G}$ and $(m_p)_0$ is the present mass of the nucleon. Present proton-electron mass ratio is

$$\frac{(m_p)_0}{m_e} \cong \sqrt{\frac{m_e}{M_0}} \cdot \left(\frac{M_P}{m_e}\right)^2 \quad (12)$$

At the Planck scale, i.e. when $M_0 \cong M_C \cong \sqrt{\frac{e^2}{4\pi\epsilon_0 G}}$, mass of proton is

$$(m_p)_P \cong \frac{\hbar c}{G\sqrt{M_C m_e}} \cong \frac{M_P^2}{\sqrt{M_C m_e}} \cong 11510.2075 \text{ Kg} \quad (13)$$

This may be an imaginary mass of proton at the Planck scale. Grand unified models assumes the existence of heavy massive particles and magnetic monopoles in the early universe. Based on this point, the proposed idea

can be given a chance. This mass unit plays an interesting role in particle physics. Authors are working in this new direction.

If this idea is true, this new Planck scale nucleon rest mass must play a critical role in understanding the characteristics of the present proton-like present proton size and the present strong coupling constant. In this connection, an attempt is made in the following subsections. At any time t , it can be suggested that,

$$\left[\frac{(m_p)_P}{(m_p)_t} \right] \cong \sqrt{\frac{M_t}{M_C}} \quad (14)$$

where M_t is the cosmic Hubble at time t and $(m_p)_t$ is the mass of proton at time t .

2.2 The present size of the proton

Let the Planck scale proton radius is

$$(R_p)_P \cong \frac{2G(m_p)_P}{c^2} \cong 1.70953 \times 10^{-23} \text{ m} \quad (15)$$

It is noticed that, at present proton radius is close to

$$(R_p)_0 \cong \left[\frac{(m_p)_P}{(m_p)_0} \right]^{1/4} \cdot \frac{2G(m_p)_P}{c^2} \cong 8.755843 \times 10^{-16} \text{ m} \quad (16)$$

where $(m_p)_P$ is the assumed proton mass at the Planck scale and $(m_p)_0$ is the present proton mass. This obtained value can be compared with the experimental rms charge radius of the present proton, $8.768(69) \times 10^{-16} \text{ m}$ [13]. Volume ratio is $\left[\frac{(m_p)_P}{(m_p)_0} \right]^{3/4} \cong 1.343583 \times 10^{23}$ and is close to the Avogadro number $6.022141793 \times 10^{23}$.

2.3 The present strong coupling constant

The strong coupling constant α_s is a fundamental parameter of the Standard Model. It plays a more central role in the QCD analysis of parton densities in the moment space. It is noticed that,

$$\frac{1}{\alpha_s} \cong \sqrt{1 + \ln \left[\frac{(m_p)_P}{(m_p)_0} \right]} \cong 8.4856582 \quad (17)$$

and $\alpha_s \cong 0.1178459$. This can be compared with the experimental value [13].

3 To understand the CMBR temperature

Pair particles creation and annihilation in 'free space' is an interesting idea. In the expanding universe, by considering the proposed charged M_C and its pair annihilation as a characteristic cosmic phenomena, origin of

the isotropic CMB radiation can be addressed. Where the free space is occupied by a large massive body, there the pair annihilation of M_C can not be seen and this may be a reason for the observed anisotropy of CMB. At any time t , it can be suggested that

$$k_B T_t \cong \sqrt{\frac{M_C}{M_t}} \cdot 2M_C c^2 \quad (18)$$

where M_t is the cosmic mass at time t and T_t is the cosmic temperature at time t . Please note that, at present

$$T_0 \cong \sqrt{\frac{M_C}{M_0}} \cdot \frac{2M_C c^2}{k_B} \cong 3.5175 \text{ } ^0\text{Kelvin} \quad (19)$$

Qualitatively and quantitatively this can be compared with the present CMBR temperature $2.725 \text{ } ^0\text{Kelvin}$. It seems to be a direct consequence of the Mach's principle. It means - at any time, the cosmic mass or cosmic size play a critical role in the pair annihilation energy of M_C . Initial temperature of the universe can be expressed as

$$T_C \cong \frac{2M_C c^2}{k_B} \cong 2.42 \times 10^{31} \text{ } ^0\text{Kelvin} \quad (20)$$

With reference to the present observed CMBR temperature, considering the 3 dimensional average thermal energy $\frac{3}{2}k_B T_t$, above relation can be expressed as

$$\frac{3}{2}k_B T_t \cong \sqrt{\frac{M_C}{M_t}} \cdot 2M_C c^2 \quad (21)$$

Thus,

$$T_0 \cong \left(\frac{2}{3} \right) \sqrt{\frac{M_C}{M_0}} \cdot \frac{2M_C c^2}{k_B} \cong 2.345 \text{ } ^0\text{Kelvin} \quad (22)$$

In this way, origin of the CMB radiation can be studied. But it has to be discussed in depth. Please see the following section. Now, initial temperature of the universe can be expressed as

$$T_C \cong \left(\frac{2}{3} \right) \frac{2M_C c^2}{k_B} \cong 1.61 \times 10^{31} \text{ } ^0\text{Kelvin} \quad (23)$$

4 Cosmic critical density, matter density and thermal energy density

It is noticed that, there exists a very simple relation in between the cosmic critical density, matter density and the thermal energy density. It can be expressed in the following way. At any time t ,

$$\left(\frac{\rho_c}{\rho_m} \right)_t \cong \left(\frac{\rho_m}{\rho_T} \right)_t \cong 1 + \ln \left(\frac{M_t}{M_C} \right) \quad (24)$$

where $\rho_c \cong M_t \left[\frac{4\pi}{3} \left(\frac{c}{H_t} \right)^3 \right]^{-1} \cong \frac{3H_t^2}{8\pi G}$, ρ_m is the matter density and ρ_T is the thermal energy density expressed in gram/cm³ or Kg/m³. Considering the Planck - Coulomb scale, at the beginning if $M_t \cong M_C$

$$\left(\frac{\rho_c}{\rho_m} \right)_C \cong \left(\frac{\rho_m}{\rho_T} \right)_C \cong 1 \quad (25)$$

$$(\rho_c)_C \cong (\rho_m)_C \cong (\rho_T)_C \quad (26)$$

Thus at any time t ,

$$\rho_m \cong \sqrt{\rho_c \cdot \rho_T} \quad (27)$$

$$\rho_m \cong \left[1 + \ln \left(\frac{M_t}{M_C} \right) \right]^{-1} \rho_c \quad (28)$$

$$\rho_T \cong \left[1 + \ln \left(\frac{M_t}{M_C} \right) \right]^{-2} \rho_c \cong \left[1 + \ln \left(\frac{M_t}{M_C} \right) \right]^{-1} \rho_m \quad (29)$$

In this way, observed matter density and the thermal energy density can be studied in a unified manner. The observed CMB anisotropy can be related with the inter galactic matter density fluctuations.

4.1 Present matter density of the universe

At present if $H_0 \cong 70.75$ Km/sec/Mpc,

$$(\rho_m)_0 \cong \left[1 + \ln \left(\frac{M_0}{M_C} \right) \right]^{-1} (\rho_c)_0 \quad (30)$$

$\cong 6.573 \times 10^{-32}$ gram/cm³ where $(\rho_c)_0 \cong 9.4 \times 10^{-30}$ gram/cm³ and $\left[1 + \ln \left(\frac{M_0}{M_C} \right) \right] \cong 143.013$. Based on the average mass-to-light ratio for any galaxy [14]

$$(\rho_m)_0 \cong 1.5 \times 10^{-32} \eta h_0 \text{ gram/cm}^3 \quad (31)$$

where for any galaxy, $\left\langle \frac{M_G}{L_G} \right\rangle \cong \eta \left(\frac{M_\odot}{L_\odot} \right)$ and the number $h_0 \cong \frac{H_0}{100 \text{ Km/sec/Mpc}} \cong \frac{70.75}{100} \cong 0.7075$

Note that elliptical galaxies probably comprise about 60% of the galaxies in the universe and spiral galaxies thought to make up about 20% percent of the galaxies in the universe. Almost 80% of the galaxies are in the form of elliptical and spiral galaxies. For spiral galaxies, $\eta h_0^{-1} \cong 9 \pm 1$ and for elliptical galaxies, $\eta h_0^{-1} \cong 10 \pm 2$. For our galaxy inner part, $\eta h_0^{-1} \cong 6 \pm 2$. Thus the average ηh_0^{-1} is very close to 8 to 9 and its corresponding matter density is close to $(6.0 \text{ to } 6.76) \times 10^{-32}$ gram/cm³ and can be compared with the above proposed magnitude of 6.573×10^{-32} gram/cm³.

4.2 Present thermal energy density of the universe

At present if $H_0 \cong 70.75$ Km/sec/Mpc,

$$(\rho_T)_0 \cong \left[1 + \ln \left(\frac{M_0}{M_C} \right) \right]^{-2} (\rho_c)_0 \cong 4.6 \times 10^{-34} \text{ gram/cm}^3 \quad (32)$$

and thus

$$(\rho_T c^2)_0 \cong \left[1 + \ln \left(\frac{M_0}{M_C} \right) \right]^{-2} (\rho_c c^2)_0 \cong 4.131 \times 10^{-14} \text{ J/m}^3 \quad (33)$$

At present if

$$(\rho_T c^2)_0 \cong a T_0^4 \quad (34)$$

where $a \cong 7.56576 \times 10^{-16}$ J/m³K⁴ is the radiation energy density constant, then the obtained temperature is, $T_0 \cong 2.718$ °Kelvin. This is accurately fitting with the observed CMBR temperature, $T_0 \cong 2.725$ °Kelvin. Thus in this way, the present value of the Hubble's constant and the present CMBR temperature can be correlated with the following trial-error relation.

$$\left[1 + \ln \left(\frac{c^3}{2GH_0 M_C} \right) \right]^{-1} H_0 \cong \sqrt{\frac{8\pi G a T_0^4}{3c^2}} \quad (35)$$

5 Present cosmic age

Cosmic age can be assumed as

$$t \cong \left(\frac{\rho_c c^2}{\rho_T c^2} \right)_t \left(\frac{1}{H_t} \right) \cong \left[1 + \ln \left(\frac{c^3}{2GH_t M_C} \right) \right]^2 \left(\frac{1}{H_t} \right) \quad (36)$$

Here note that, cosmic age is directly proportional to the ratio of critical energy density and the thermal energy density. In this way, this proposed method differs from the current or standard model of cosmology by the ratio $\left(\frac{\rho_c c^2}{\rho_T c^2} \right)_0$. Thus at any time t ,

$$t \cdot H_t \cong \left(\frac{\rho_c c^2}{\rho_T c^2} \right)_t \cong \left[1 + \ln \left(\frac{c^3}{2GH_t M_C} \right) \right]^2 \quad (37)$$

At present if $H_0 \cong 70.75$ Km/sec/Mpc, present cosmic age can be expressed as

$$t_0 \cong \left[1 + \ln \left(\frac{c^3}{2GH_0 M_C} \right) \right]^2 \left(\frac{1}{H_0} \right) \quad (38)$$

i.e The present cosmic age is 8.92×10^{21} sec $\cong 282.7$ trillion years. With this large time - smooth cosmic expansion, cosmic isotropy, super novae dimming and magnetic monopole vanishing etc can be understood. In Indian vedic cosmology, total age of the universe is 311

trillion years [15]. This is a striking and surprising coincidence. It can be suggested that, modern cosmology and Indian vedic cosmology can be studied in a unified manner.

5.1 Time concept in Indian vedic cosmology

According to the Indian vedic science, the life span of Lord Brahma, the creator of the universe, is 100 'Brahma-Years'. One day or one night in the life of Brahma is called a Kalpa or 4.32 billion years. Every Kalpa creates 14 Manus one after the other, who in turn manifest and regulate this world. Thus, there are fourteen generations of Manu in each Kalpa. Each Manus life (Manvantara) consists of 71 Chaturyugas (quartets of Yugas or eras). Each Chaturyuga is composed of four eras or Yugas: Satya, Treta, Dwapara and Kali. The span of the Satya Yuga is 1,728,000 human years, Treta Yuga is 1,296,000 human years long, the Dwapara Yuga 864,000 human years and the Kali Yuga 432,000 human years. When Manu perishes at the end of his life, Brahma creates the next Manu and the cycle continues until all fourteen Manus and the Universe perish by the end of Brahma's day. When 'night' falls, Brahma goes to sleep for a period of 4.32 billion years, which is a period of time equal one day (of Brahma) and the lives of fourteen Manus. The next 'morning', Brahma creates fourteen additional Manus in sequence just as he has done on the previous 'day'. The cycle goes on for 100 'divine years' at the end of which Brahma perishes and is regenerated. Brahma's entire life equals 311 trillion, 40 billion years. Once Brahma dies there is an equal period of unmanifestation for 311 trillion, 40 billion years, until the next Brahma is created.

Conclusions

The proposed relations are interesting and may be useful in understanding the basics of grand unification and cosmology. Further research, analysis, observations and experiments in this new direction may reveal the facts.

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