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HUBBLE VOLUME AND THE FUNDAMENTAL INTERACTIONS

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ABSTRACT

If we do not yet know whether the universe is spatially closed or open, then the idea of Hubble volume can be used as a tool in cosmology and unification. In the universe, if the critical density is $\rho_c \cong \left(3H_0^2 / 8\pi G\right)$ and the characteristic Hubble radius is $R_0 \cong (c / H_0)$, mass of the cosmic Hubble volume is $M_0 \cong c^3 / 2GH_0$. There exists a charged heavy massive elementary particle M_X in such a way that, inverse of the fine structure ratio is equal to the natural logarithm of the sum of number of positively and negatively charged M_X in the Hubble volume. Surprisingly it is noticed that, M_X mass is close to Avogadro number times the rest mass of electron. Interesting observation is that, ratio of M_X and $\sqrt{e^2 / 4\pi\varepsilon_0 G}$ is 295.0606338. For any observable charged particle, there exist two kinds of masses and their mass ratio is 295.0606339. This idea can be applied to electron and proton and thus their corresponding interaction ranges can be fitted. If $\hbar$ is the quanta of the observed angular momentum, then its electromagnetic quanta can be expressed as $(\hbar / X_E)$.

KEYWORDS: Hubble radius, Hubble volume, Hubble mass, Mach's principle, Planck mass, Coulomb mass, Fine structure ratio, cosmological strong interaction range and CMBR temperature

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INTRODUCTION

Please note that, when it was proposed in 1948, the CMBR idea was never accepted by the science community. In 1965, this fantastic concept was realized serendipitously. The very surprising thing was that the experimentalists were not aware of what they discovered! Up to 1998, people believed in cosmic deceleration. By 2000, it was a shocking news to many cosmologists that, the universe is accelerating.

Please note that, still some scientists argue that, the only indication for the existence of dark energy is observations of distance measurements and associated redshifts. Cosmic microwave background anisotropies and baryon acoustic oscillations are only observations that redshifts are larger than expected from a "dusty" Friedmann-Lemaitre universe and the local measured Hubble constant.

In 1998, published observations of Type Ia supernovae by the High-z Supernova Search Team followed in 1999 by the Supernova Cosmology Project suggested that the expansion of the universe is accelerating. 2011 Nobel Prize in Physics was awarded for this work. According to the WMAP seven-year analysis, universe constitutes 72.8% dark energy, 22.7% dark matter and 4.6% ordinary matter. Authors would like to ask the following questions:

What are the important applications of the 72.8% dark energy or 22.7% matter in the other important fundamental areas of physics (like unification of the fundamental interactions)? What is the role of dark matter or dark energy in the construction of Hydrogen atom or the atomic nucleus? In this new direction authors noticed that, there exists strange relation in between the "Hubble volume" and the "fundamental interactions". In a simple picture, the characteristic Hubble length (c/H_0) can be considered as the infinite range of the electromagnetic and gravitational interactions. Please note that the subject of cosmology is still open. With the emerging technology, anything may happen in the coming future.

With reference to the Mach's principle and the Hubble volume, if "Hubble mass" is the product of cosmic critical density and the Hubble volume, then

1 In the Hubble volume, each and every point in the free space is influenced by the Hubble mass.

2 Within the Hubble volume, the Hubble mass plays a vital role in understanding the properties of electromagnetic and nuclear interactions.

3 Hubble mass plays a key role in understanding the geometry of the universe.

Current Status of Mach's Principle and the Hubble Volume

In theoretical physics, particularly in discussions of gravitation theories, Mach's principle [1-6] 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.

One of the main motivations behind formulating the general theory of relativity was to provide a mathematical description of the Mach's principle. However, soon after its formulation, it was realized that the theory does not follow Mach's principle. As the theoretical predictions were matching with the observations, Einstein believed that the theory was correct and did not make any farther attempt to reformulate the theory to explain Mach's principle. Later on, several attempts were made by different researchers to formulate the theory of gravity based on Mach's principle. However most of these theories remain unsuccessful to explain different physical phenomena. In the standard cosmology, "Hubble volume" or "Hubble sphere" is a spherical region of the Universe surrounding an observer beyond which objects recede from that observer at a rate greater than the speed of light due to the expansion of the Universe. The commoving radius of a Hubble sphere (known as the Hubble radius or the Hubble length) is, (c/H_0), where (c) is the speed of light and (H_0) is the Hubble constant. More generally, the term "Hubble volume" can be applied to any region of space with a volume of the order of $4\pi/3(c/H_0)^3$.

Proposed New Concepts on the Mach's Principle, Hubble Volume and Hubble Mass

Note that till today quantitatively Mach's principle was not implemented successfully in cosmic and nuclear physics. If we do not yet know whether the universe is spatially closed or open, then the idea of Hubble volume can be used as a tool in cosmology and unification. Where ever we go in the flat universe, for the observer, Hubble volume is the only observable/workable volume. Hence where ever we go in the universe, Hubble volume plays the same role. It seems to be a quantitative description to the Mach's principle. In the universe, if the critical density is $\rho_c \cong \left(3H_0^2/8\pi G\right)$ and the characteristic Hubble radius is $R_0 \cong (c/H_0)$, mass of the cosmic Hubble volume is $M_0 \cong \frac{c^3}{2GH_0}$. For the time being let us call this mass as "Hubble mass". With this definition, apart from cosmology, Mach's principle can be given a fundamental unified significance in atomic, nuclear and particle physics! Here, as a point of curiosity, if one is willing to consider this mass as a characteristic mass of the universe, very easily, planck scale, cosmology and particle physics can be studied in a unified manner. If m_p is the rest mass of proton and m_e is the rest mass of electron, it is noticed that,

$$R_s \cong \frac{G\sqrt{M_0\sqrt{m_p m_e}}}{c^2} \cong (1.37 \text{ to } 1.39)\times 10^{-15} \text{ m} \quad (1)$$

In reality, this length is nothing but the observed strong interaction range or the characteristic nuclear unit radius!

$$2R_s \cong \frac{2G\sqrt{M_0\sqrt{m_p m_e}}}{c^2} \cong (2.74 \text{ to } 2.78)\times 10^{-15} \text{ m} \quad (2)$$

This is close to the classical radius of electron! If M_p is the Planck mass and $R_0 \cong (c/H_0)$ is the gravitational and electromagnetic interaction range, it is noticed that,

$$\ln\left(\frac{m_e R_0^2}{M_P R_s^2}\right) \cong \frac{1}{137.2} \cong \frac{1}{\alpha}. \quad (3)$$

This is another interesting coincidence! How to interpret these relations? Here, the utmost fundamental observation is: all the believed atomic and nuclear constants are joining with the growing cosmic Hubble size or Hubble volume or the Hubble mass. In the accelerating universe, how is it possible? Including the CMB radiation energy density and the observed matter- energy density, in this connection, authors observed so many interesting relations. Whether this is the beginning of a controversy or the beginning of unification, for the time being authors propose the following (interesting) observations and concepts related to Mach's principle, Hubble volume and the fundamental interactions.

TO UNIFY THE ATOM AND THE UNIVERSE

The subject of unification is very interesting and very complicated [7-18]. By implementing the Avogadro number N as a scaling factor in unification program, one can probe the constructional secrets of elementary particles. The Planck's quantum theory of light, thermodynamics of stars, black holes and cosmology totally depends upon the famous Boltzmann constant k_B which in turn depend on the Avogadro number [19]. From this it can be suggested that, Avogadro number is more fundamental and characteristic than the Boltzmann constant and indirectly plays a crucial role in the formulation of the quantum theory of radiation. In this connection it is noticed that, 'molar electron mass' plays a very interesting role in nuclear and particle physics. Even if Avogadro number is a man-made number, authors' humble opinion is - first let us find the various applications of the Avogadro number in unification. At any one nice relation, its meaning can be understood. The ratio of Planck mass and electron rest mass is close to Avogadro number/8π. This is a very interesting and surprising result.

Key Concepts in Unification

Concept-1: In the expanding cosmic Hubble volume, characteristic cosmic Hubble mass is the product of the cosmic critical density and the Hubble volume. If the critical density is $\rho_c \cong \left(3H_0^2/8\pi G\right)$ and characteristic Hubble radius is $R_0 \cong (c/H_0)$, mass of the cosmic Hubble volume is

$$M_0 \cong \frac{c^3}{2GH_0} \tag{4}$$

Concept-2: There exists a charged heavy massive elementary particle M_X in such a way that, inverse of the fine structure ratio is equal to the natural logarithm of the sum of number of positively and negatively charged M_X in the Hubble volume. If the number of positively charged particles is $\left(\frac{M_0}{M_X}\right)$ and the number of negatively charged particles is also $\left(\frac{M_0}{M_X}\right)$ then $\frac{1}{\alpha} \cong \ln\left(\frac{M_0}{M_X}+\frac{M_0}{M_X}\right) \cong \ln\left(\frac{2M_0}{M_X}\right)$ (5)

From experiments $1/\alpha \cong 137.0359997$ and from the current observations [20,21,22], magnitude of the Hubble constant is, $H_0 \cong 70.4^{+1.3}_{-1.4}$ Km/sec/Mpc. Thus

$$M_X \cong e^{-\frac{1}{\alpha}}\left(\frac{c^3}{GH_0}\right) \cong e^{-\frac{1}{\alpha}} \cdot 2M_0 \tag{6}$$

$\cong (5.32 \text{ to } 5.53)\times 10^{-7}$ Kg .

If $N \cong 6.022141793\times 10^{23}$ is the Avogadro number and m_e is the rest mass of electron, surprisingly it is noticed that, $N.m_e \cong 5.485799098\times 10^{-7}$ Kg and this is close to the above estimation of M_X. Thus it can be suggested that,

$$\frac{M_X}{m_e} \cong N \tag{7}$$

In this way, Avogadro number can be coupled with the cosmic, atomic and particle physics. Then with reference to $(N.m_e)$, the obtained cosmic Hubble mass is $M_0 \cong 8.957532458\times 10^{52}$ Kg and thus the obtained Hubble's constant is $H_0 \cong \frac{c^3}{2GM_0} \cong 69.54$ Km/sec/Mpc. Note that large dimensionless constants and compound physical constants reflect an intrinsic property of nature [23,24]. 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.

Concept-3: For any observable charged particle, there exist two kinds of masses and their mass ratio is 295.0606339. Let this number be represented by X_E. First kind of mass seems to be the 'gravitational or observed' mass and the second kind of mass seems to be the 'electromagnetic' mass. This idea can be applied to proton and electron.

This number is obtained in the following way. 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.

$$M_C \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} \cong 1.859210775\times 10^{-9} \text{ Kg} \tag{8}$$

$$M_C c^2 \cong \sqrt{\frac{e^2 c^4}{4\pi\varepsilon_0 G}} \cong 1.042941\times 10^{18} \text{ GeV} \tag{9}$$

Here e is the elementary charge. How to interpret this mass unit? Is it a primordial massive charged particle? If two such oppositely charged particles annihilate, 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 Hubble volume, with its pair annihilation, origin of the CMBR can be understood. Clearly speaking, gravitational and electromagnetic force ratio of M_X is X_E^2.

$$\frac{M_X}{M_C} \cong \sqrt{\frac{4\pi\varepsilon_0 G M_X^2}{e^2}} \cong 295.0606338 \tag{10}$$

It can be interpreted that, if 5.486×10^{-7} Kg is the observable or gravitational mass of M_X, then M_C is the electromagnetic mass of M_X. With reference to the electron rest mass,

$$\left(\frac{M_X}{m_e}\right)^2 \cong X_E^2 \cdot \frac{e^2}{4\pi\varepsilon_0 G m_e^2} \cong N^2 \tag{11}$$

Concept-4: If $\hbar$ is the quantum of the gravitational angular momentum, then the electromagnetic quanta can be expressed as $\left(\frac{\hbar}{X_E}\right)$. Thus the ratio,

$$\left(\frac{\hbar}{X_E}\right) \div \left(\frac{e^2}{4\pi\varepsilon_0 c}\right) \cong \left(X_E \alpha\right)^{-1} \cong 0.464433353 \cong \sin\theta_W \tag{12}$$

where $\sin\theta_W$ is very close to the weak mixing angle

Concept-5: In modified quark SUSY [25], if Q_f is the mass of quark fermion and Q_b is the mass of quark boson, then

$$\frac{m_f}{m_b} \cong \Psi \cong 2.2627062 \tag{13}$$

and $\left(1-\frac{1}{\Psi}\right)Q_f$ represents the effective quark fermion mass. The number Ψ can be fitted with the following empirical relation

$$\Psi^2 \ln\left(1+\sin^2\theta_W\right) \cong 1 \tag{14}$$

With this idea super symmetry can be observed in the low and high energy strong interactions [25] and can also be observed in the electroweak interactions [26-28].

Concept-6: For electron, starting from infinity, its characteristic interaction ending range can be expressed as

$$r_{ee} \cong \frac{e^2}{4\pi\varepsilon_0 \left(m_e / X_E\right)c^2} \cong X_E \frac{e^2}{4\pi\varepsilon_0 m_e c^2} \cong 8.315\times10^{-13} \text{ m} \tag{15}$$

Similarly, for proton, its characteristic interaction starting range can be expressed as

$$r_{ss} \cong \frac{e^2}{4\pi\varepsilon_0 \left(m_p / X_E\right) c^2} \cong X_E \frac{e^2}{4\pi\grave{o}_0 m_p c^2} \cong 4.53 \times 10^{-16} \text{ m} \tag{16}$$

Concept-7: Ratio of electromagnetic ending interaction range and strong interaction ending rage [29] can be expressed as

$$\frac{r_{ee}}{r_{se}} \cong \frac{GM_X^2}{\hbar c} \cong 635.3131866 \tag{17}$$

Thus if $r_{ee} \cong 8.315 \times 10^{-13}$ m, $r_{se} \cong 1.309 \times 10^{-15}$ m,

$$\left(\frac{r_{ee}}{r_{se}}\right)^2 \cong \left(\frac{GM_X^2}{\hbar c}\right)^2 \tag{18}$$

Interesting observation is

$$\frac{r_{ss} + r_{se}}{2} \cong 0.881 \times 10^{-15} \text{ m} \tag{19}$$

This can be considered as the mean strong interaction range and is close to the proton rms radius [30]!

Concept-8: For any elementary particle of charge e, electromagnetic mass $\left(m / X_E\right)$ and characteristic radius R , it can be assumed as

$$\frac{e^2}{4\pi\varepsilon_0 R} \cong \frac{1}{2}\left(\frac{m}{X_E}\right)c^2 \tag{20}$$

This idea can be applied to proton as well as electron. Electron's characteristic radius is

$$R_e \cong 2X_E \frac{e^2}{4\pi\varepsilon_0 m_e c^2} \cong 1.663 \times 10^{-12} \text{ m} \tag{21}$$

Similarly proton's characteristic radius is

$$R_p \cong 2X_E \frac{e^2}{4\pi\varepsilon_0 m_p c^2} \cong 0.906 \times 10^{-15} \text{ m} \tag{22}$$

This obtained magnitude can be compared with the rms charge radius of the proton [30]. With different experimental methods its magnitude varies from 0.84184(67) fm to 0.895(18) fm.

Potential Energy of Electron in Hydrogen Atom

Let E_p be the potential energy of electron in the Hydrogen atom. It is noticed that,

$$E_p \cong \frac{e^2}{4\pi\varepsilon_0 a_0} \cong \left(\frac{\hbar c}{GM_X^2}\right)\frac{\left(\hbar / X_E\right)c}{\sqrt{R_e R_p}} \cong 27.12493044 \text{ eV} \tag{23}$$

where a_0 is the Bohr radius [31,32]. With 99.6822% this is matching with $\alpha^2 m_e c^2 \cong 27.21138388$ eV. After simplification it takes the following form.

$$E_p \cong \left(\frac{\hbar c}{GM_X^2}\right)^2 \frac{\sqrt{m_p m_e}c^2}{2} \cong \alpha^2 m_e c^2 \tag{24}$$

Thus the Bohr radius can be expressed as

$$a_0 \cong \left(\frac{GM_X^2}{\hbar c}\right)^2 \frac{2e^2}{4\pi\varepsilon_0 \sqrt{m_p m_e}c^2} \tag{25}$$

Without considering the integral nature of angular momentum, here by considering the integral nature of the elementary charge e, Bohr radius in n^{th} orbit can be expressed as

$$a_n \cong \left(\frac{GM_X^2}{\hbar c}\right)^2 \frac{2(ne)^2}{4\pi\varepsilon_0 \sqrt{m_p m_e}c^2} \cong n^2 \cdot a_0 \tag{26}$$

where a_n is the radius of n^{th} orbit and $n = 1, 2, 3, ..$ Thus in Hydrogen atom, potential energy of electron in n^{th} orbit can be expressed as

$$\frac{e^2}{4\pi\varepsilon_0 a_n} \cong \left(\frac{\hbar c}{GM_X^2}\right)^2 \frac{\sqrt{m_p m_e}c^2}{2n^2} \tag{27}$$

Note that, from the atomic theory it is well established that, total number of electrons in a shell of principal quantum number n is $2n^2$. Thus on comparison, it can suggested that, $\left(\frac{\hbar c}{GM_X^2}\right)^2 \sqrt{m_p m_e}c^2$ is the potential energy of $2n^2$ electrons and potential energy of one electron is equal to $\left(\frac{\hbar c}{GM_X^2}\right)^2 \frac{\sqrt{m_p m_e}c^2}{2n^2}$.

Magnetic Moments of the Nucleon

If $(\alpha X_E)^{-1} \cong \sin\theta_W$, magnetic moment of electron can be expressed as [33]

$$\mu_e \cong \frac{1}{2}\sin\theta_W \cdot ec \cdot r_{ee} \cong 9.274 \times 10^{-24} \text{ J/tesla} \tag{28}$$

It can be suggested that electron's magnetic moment is due to the electromagnetic interaction range. Similarly magnetic moment of proton is due to the strong interaction ending range.

$$\mu_p \cong \frac{1}{2}\sin\theta_W \cdot ec \cdot r_{se} \cong 1.46 \times 10^{-26} \text{ J/tesla} \tag{29}$$

If proton and neutron are the two quantum states of the nucleon, by considering the mean strong interaction range $\left(\frac{r_{ss}+r_{se}}{2}\right)$, magnetic moment of neutron can be fitted as

$$\mu_n \cong \frac{1}{2}\sin\theta_W \cdot ec \cdot \left(\frac{r_{ss}+r_{se}}{2}\right) \cong 9.82 \times 10^{-27} \text{ J/tesla} \tag{30}$$

THE CHARACTERISTIC NUCLEAR RADII IN COSMOLOGY

Please recall that, the characteristic cosmic Hubble mass is $M_0 \cong \frac{c^3}{2GH_0} \cong 8.95\times10^{52}$ Kg and the electromagnetic mass of the proposed M_X is $M_C \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} \cong 1.859210775\times10^{-9}$ Kg.

The Characteristic Nuclear Charge Radius

If $H_0 \cong 69.54$ Km/sec/Mpc, R_S is the characteristic radius of nucleus, it is noticed that,

$$R_S \cong \left(\frac{m_p}{M_X}\right)^2 \frac{c}{H_0} \cong 1.2368\times10^{-15} \text{ m} \tag{31}$$

where m_p is the proton rest mass. This can be compared with the characteristic radius of the nucleus and the strong interaction range [29].

Scattering Distance between Electron and the Nucleus

If $R_S \cong 1.21$ to 1.22 fm is the minimum scattering distance between electron and the nucleus, it is noticed that,

$$R_S \cong \left(\frac{\hbar c}{GM_X^2}\right)\left(\frac{\hbar c}{Gm_e^2}\right)\cdot\frac{2Gm_e}{c^2} \tag{32}$$

$$\cong 1.21565\times10^{-15} \text{ m}$$

Here M_X is the molar electron mass. Here it is very interesting to consider the role of the Schwarzschild radius of the 'electron mass'. Thus the two macroscopic physical constants N and G can be expressed in the following way.

$$N \cong \sqrt{\frac{2\hbar^2}{Gm_e^3 R_S}} \tag{33}$$

$$G \cong \frac{2\hbar^2}{(M_X)^2 m_e R_S} \tag{34}$$

In this way, either the Avogadro number or the gravitational constant can be obtained. Combining the relations (31) and (32) and if $H_0 \cong 69.54$ Km/sec/Mpc, it is noticed that,

$$\frac{\hbar c}{Gm_p\sqrt{M_0 m_e}} \cong 0.991415 \tag{35}$$

Surprisingly this ratio is close to unity! How to interpret this ratio? From this relation it can be suggested that, along with the cosmic variable, H_0, in the presently believed atomic and nuclear physical constants, on the cosmological time scale, there exists one variable physical quantity. 'Rate of change' in its magnitude may be a measure of the present cosmic acceleration. Thus independent of the cosmic red shift and CMBR observations, from the atomic and nuclear physics, cosmic acceleration can be verified. Based on the above coincidence, magnitude of the present Hubble's constant can be expressed as

$$H_0 \cong \frac{Gm_p^2 m_e c}{2\hbar^2} \cong 70.75 \text{ Km/sec/Mpc} \tag{36}$$

To Fit the Radius of Proton

Let R_p be the radius of proton. It is noticed that,

$$R_p \cong \left(\frac{M_X}{m_p}\right) \cdot \frac{2GM_C}{c^2} \cong 9.0566 \times 10^{-16} \text{ m} \tag{37}$$

This obtained magnitude can be compared with the rms charge radius of the proton [30]. With different experimental methods its magnitude varies from 0.84184(67) fm to 0.895(18) fm. Here also it is very interesting to consider the role of the Schwarzschild radius of M_C. This type of coincidence cannot be ignored in the unification scheme. Here the strange observation is: the ratio $\frac{M_X}{m_p}$. Please note that mass nature in both of the cases is the assumed 'gravitational mass' only. But the very strange observation is $\frac{2GM_C}{c^2}$. Here in this expression, M_C is playing a key role instead of M_X. But M_C is the assumed electromagnetic mass of M_X. If this logic is having any sense, then similar to M_C, 'electromagnetic mass of the proton' must play a key role in nuclear physics. In this direction, in the following subsection, an attempt is made.

Strong Interaction Range in Cosmology

Considering the above coincidences it can be suggested that, there exists a strong connection in between modern cosmology and the nucleus. It is noticed that,

$$R_S \cong \frac{2G\sqrt{M_0\left(m_p / X_E\right)}}{c^2} \cong 1.0493 \times 10^{-15} \text{ m} \tag{38}$$

where $H_0 \cong 70.75$ Km/sec/Mpc and $M_0 \cong 8.80434 \times 10^{52}$ Kg. Here R_S represents the Schwarzschild radius of $\sqrt{M_0\left(m_p / X_E\right)}$. How to understand this radius! Here the very peculiar and careful observation is

$$R_S \cong \frac{2G\sqrt{M_0\left(m_p / X_E\right)}}{c^2} \cong \sqrt{\left(\frac{2GM_0}{c^2}\right)\left(\frac{2G\left(m_p / X_E\right)}{c^2}\right)} \cong 1.0493 \times 10^{-15} \text{ m} \tag{39}$$

In this relation, $\frac{2GM_0}{c^2}$ is the Schwarzschild radius of the Hubble mass! It means, from unification point of view [10,11], if the above relation (39) receives any significance, then it can be suggested that, in the flat universe, for any observer - cosmic observations and events seem to be confined to the Hubble volume [33]. Some scientists may say: this is a play with numbers. Some scientists may say: it seems to be a fun. Some scientists may say: it is very interesting. Some scientists say: nobody understands Mach's principle this way. Here, the fundamental question to be answered is - if the atom (and therefore all material rulers) expands, in what relation should the cosmic expansion then be measured? Answer is very simple. If the universe is really accelerating, based on the galactic red shift, for the observer - the receding and accelerating galaxy must show a continuous increase in its red shift [33]. There is no such evidence. If we do not yet know whether the universe is spatially closed or open, then the idea of Hubble mass can be used as a tool in cosmology and unification. It is very close to the Mach's idea of distance cosmic back ground and is a quantitative description to the Mach's principle. Anyhow whatever may be their physical meaning, it is sure that these relations will help in understanding the characteristic properties of strong interaction, unification, cosmic acceleration and Mach's principle.

COSMIC CRITICAL DENSITY, MATTER DENSITY AND THERMAL ENERGY DENSITY

Pair particles creation and annihilation is a characteristic phenomena in `free space', and is the basic idea of quantum fluctuations of the vacuum. 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. At any time t, it can be suggested that

$$k_B T_t \cong \sqrt{\frac{M_C}{M_t}} \cdot 2M_C c^2 \tag{40}$$

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

$$T_t \cong \sqrt{\frac{M_C}{M_0}} \cdot \frac{2M_C c^2}{k_B} \cong 3.52\ {}^0\mathrm{K} \tag{41}$$

Qualitatively and quantitatively this can be compared with the present CMBR temperature $2.725\ {}^0\mathrm{K}$. But it has to be discussed in depth. It seems to be a direct consequence of the Mach's principle.

A Quantitative Approach to Understand the CMBR Radiation

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,

$$\left(\frac{\rho_c}{\rho_m}\right)_t \cong \left(\frac{\rho_m}{\rho_T}\right)_t \cong 1 + \ln\left(\frac{M_t}{M_C}\right) \tag{42}$$

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/cm^3 or Kg/m^3. Considering the Planck - Coulomb scale, at the beginning if $M_t \cong M_C$

$$\left(\frac{\rho_c}{\rho_m}\right)_C \cong \left(\frac{\rho_m}{\rho_T}\right)_C \cong 1 \tag{43}$$

$$\left(\rho_c\right)_C \cong \left(\rho_m\right)_C \cong \left(\rho_T\right)_C \tag{44}$$

Thus at any time t,

$$\rho_m \cong \sqrt{\rho_c \cdot \rho_T} \tag{45}$$

$$\rho_m \cong \left[1 + \ln\left(\frac{M_t}{M_C}\right)\right]^{-1} \rho_c \tag{46}$$

$$\rho_T \cong \left[1+\ln\left(\frac{M_t}{M_C}\right)\right]^{-2} \rho_c \cong \left[1+\ln\left(\frac{M_t}{M_C}\right)\right]^{-1} \rho_m \quad (47)$$

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.

Present Matter Density of the Universe

From (36) at present if $H_0 \cong 70.75$ Km/sec/Mpc,

$$\left(\rho_m\right)_0 \cong \left[1+\ln\left(\frac{M_0}{M_C}\right)\right]^{-1} \left(\rho_c\right)_0 \quad (48)$$

$\cong 6.573\times10^{-32}$ gram/cm^3 where $\left(\rho_c\right)_0 \cong 9.4\times10^{-30}$ gram/cm^3 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 [6]

$$\left(\rho_m\right)_0 \cong 1.5\times10^{-32}\eta h_0 \text{ gram/cm}^3 \quad (49)$$

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, $\eta h_0^{-1} \cong 9\pm1$ and for elliptical galaxies, $\eta h_0^{-1} \cong 10\pm2$. For our galaxy inner part, $\eta h_0^{-1} \cong 6\pm2$. Thus the average ηh_0^{-1} is very close to 8 to 9 and its corresponding matter density is close to $\left(6.0 \text{ to } 6.76\right)\times10^{-32}$ gram/cm^3 and can be compared with the above proposed magnitude of 6.573×10^{-32} gram/cm^3.

Present Thermal Energy Density of the Universe

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

$$\left(\rho_T\right)_0 \cong \left[1+\ln\left(\frac{M_0}{M_C}\right)\right]^{-2} \left(\rho_c\right)_0 \cong 4.6\times10^{-34} \text{ gram/cm}^3 \quad (50)$$

and thus

$$\left(\rho_T c^2\right)_0 \cong \left[1+\ln\left(\frac{M_0}{M_C}\right)\right]^{-2} \left(\rho_c c^2\right)_0 \cong 4.131\times10^{-14} \text{ J/m}^3 \quad (51)$$

At present if

$$\left(\rho_T c^2\right)_0 \cong aT_0^4 \quad (52)$$

where $a \cong 7.56576\times10^{-16}$ J/m^{3}K^4 is the radiation energy density constant, then obtained CMBR temperature is, $T_0 \cong 2.718$ ^{0}Kelvin. This is accurately fitting with the observed CMBR temperature [22] , $T_0 \cong 2.725$ ^{0}Kelvin. Thus in this way, the present value of the Hubble's constant and the present CMBR temperature can be co-related with the following trial-error relation.

$$\left[1+\ln\left(\frac{c^3}{2GH_0M_C}\right)\right]^{-1} H_0 \cong \sqrt{\frac{8\pi G a T_0^4}{3c^2}} \tag{53}$$

DISCUSSIONS & CONCLUSIONS

String theory or QCD is not in a position to address the basics of cosmic structure. In understanding the basic concepts of unification or TOE, role of dark energy and dark matter is insignificant. Even though string theory was introduced for understanding the basics of strong interaction, its success seems to be a dilemma because of its higher dimensions and the non-coupling of the nuclear and planck scale. Based on the proposed relations and applications, Hubble volume or Hubble mass, can be considered as a key tool in unification as well as cosmology. From relations (31-39), if it is possible to identify the atomic cosmological physical variable, then by observing the rate of change in its magnitude (on the cosmological time scale), the cosmic acceleration can be verified and thus the cosmic geometry can be confirmed from atomic and nuclear physics! Without the advancement of nano-technology or fermi-technology this may not be possible. Not only that, independent of the cosmic red shift and CMBR observations cosmic acceleration can be checked in this new direction. In this connection, it is noticed that, proton mass is a cosmic variable and not a fundamental physical constant. "Molar electron mass" seems to be the planck scale mass of the proton. By this time if the observed proton is the present cosmological characteristic nuclear mass unit, then abundance of the first proton products like Hydrogen and Helium may be high. In other words, compared to the heavy atoms, light atoms generation/abundance may be high. Thus in a very simple way, the basic and main observation of the big bang cosmology can be understood. In section 4.3, authors proposed the relation between CMBR energy density and the presently believed critical density in a growing Hubble volume.

Giving a fundamental importance to the 3 dimensional geometry rather than the existence of matter, it is possible to say that, Hubble mass or Hubble volume is a growing and light speed rotating primordial black hole [33]. Then automatically presently believed critical density comes into picture. Please recall the present concept of Hubble volume - after crossing the Hubble size, galaxies recedes with super luminal speeds. That means at the Hubble length, speed is luminal! Here the major conceptual question is : whether the galaxy is receding or revolving (with luminal speed)? At this junction, this is a very sensitive and critical issue to confirm and authors are working on this in different angles like basics of primordial black holes formation, basics of space-time geometry, cosmic axis of evil [33], unification and low and high energy super symmetry [25,26]. Considering the proposed relations and concepts it is possible to say that there exists a strong relation between cosmic Hubble mass and unification. Authors request the science community to kindly look into this new approach.

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