Project report

Tools And Concepts In Particle Cosmology

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Current Status : With reference to the current physics concepts, implementing the gravitational constant in atomic and nuclear physics and studying its consequences is beyond the scope. 10 dimensional String theory is also not in a position to couple the nuclear scale and planck scale. Role of dark energy or dark matter is very insignificant in understanding the basic concepts of unification of fundamental interactions. Considering the atomic and nuclear physical constants till today cosmic acceleration is not yet verified.

Project Summary: Within the expanding cosmic Hubble volume, Hubble length can be considered as the gravitational or electromagnetic interaction range. Product of 'Hubble volume' and 'cosmic critical density' can be called as the "Hubble mass". The three proposed assumptions are: 1) within the Hubble volume, each and every point in free space is influenced by the Hubble mass, 2) 'molar electron mass' can be considered as the rest mass of a new heavy charged elementary particle and 3) atomic gravitational constant is Avogadro number times the classical gravitational constant. This is a new approach and may be given a chance in understanding the four fundamental cosmological interactions. Approach may be different but involvement and encouragement may bring this subject into main stream.

Project Title : Tools and Concepts in Particle Cosmology (TCPC)

Project Team : Mr. U.V.S. Seshavatharam, Prof. S. Lakshminarayana and committee members of your esteemed organization.

Number of papers : 20 (published in international physics journals).

Objective of the project : To understand the four cosmological interactions and to verify the cosmic acceleration

Expected output from the project :

1) Hubble's constant, Gravitational constant and Avogadro number can be fitted and estimated in a unified manner.
2) A unified model of the fundamental cosmological interactions can be developed.
3) Cosmic acceleration can be verified from the atomic and nuclear physical constants.
4) A unified model of cosmology can be developed.

Time frame : 18 to 24 months

Required resources :

1) Computer, Printer and Internet facility
2) Financial support for publishing the papers in International physics journals.
3) Participating and travel supporting for national and international conferences and collecting the information on current research trend. (if necessary)
4) Travel support to interact with the field experts in India and abroad. (if necessary)

Any software development : To use C++, Java, Latex, Matlab for generating and analyzing the data

Any other particulars : Financial and technical support for subject discussions

Review : Every 6 weeks

1 INTRODUCTION

If we do not yet know whether the universe is spatially closed or open, then the idea of Hubble volume [1] can be used as a tool in cosmology and unification. This idea is very close to the Mach's idea of distance cosmic back ground. It seems to be a quantitative description to the Mach's principle. In this brief report, authors propose their interesting observations related to Mach's principle, Hubble volume and the fundamental interactions. In understanding the basic concepts of unification of the four fundamental interactions, the cosmic radius (c/H_0), can be considered as a fundamental tool. Clearly speaking, infinite range of the gravitational or electromagnetic interaction can be compared with (c/H_0). Note that large dimensionless constants and compound physical constants reflect an intrinsic property of nature [2,3,4,5].

With reference to the Planck mass $M_P \cong \sqrt{\hbar c/G}$ and the elementary charge e, a new mass unit $M_C \cong \sqrt{e^2/4\pi\varepsilon_0 G}$ can be assumed. In the universe, considering the product of cosmic critical density and the Hubble volume, present Hubble mass can be expressed as, $M_0 \cong (c^3/2GH_0)$. With this Hubble mass, it is noticed that, $\frac{\hbar c}{G m_p \sqrt{M_0 m_e}} \cong 1$ where m_p & m_e are the rest masses of proton and electron respectively. This is a very interesting result. With this relation, obtained value of the present Hubble's constant is $H_0 \cong 70.75$ Km/sec/Mpc [6]. From this relation it is clear that, in the presently believed atomic and nuclear "physical constants", there exists one cosmological variable! By observing its cosmological rate of change, the "future" cosmic acceleration can be verified.

It is noticed that cosmic thermal energy density, matter energy density and the critical energy density are in geometric series and the geometric ratio is $1+\ln(M_0/M_C)$. Thus, $\left(\frac{\rho_0 c^2}{\rho_m c^2}\right)_0 \cong 1+\ln\left(\frac{M_0}{M_C}\right)$, $\left(\frac{\rho_0 c^2}{\rho_T c^2}\right)_0 \cong \left[1+\ln\left(\frac{M_0}{M_C}\right)\right]^2$ where $\rho_m c^2$ is the present cosmic matter energy density, $\rho_T c^2 \cong a T_0^4$ is the present cosmic thermal energy density, $\rho_0 c^2$ is the present cosmic critical energy density. It is another interesting observation and the corresponding present CMBR temperature [7] is 2.718 ^{0}K. Independent of the cosmic redshift and CMBR observations, with these coincidences it is possible to understand and decide the cosmic geometry. 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.

2 ABOUT THE AVOGADRO NUMBER

The subject of unification is very interesting and very complicated. By implementing the Avogadro number N as a scaling factor in unification program [8], one can probe the constructional secrets of elementary particles. The Planck's quantum theory of light, thermodynamics of stars, black holes and cosmology totally depend upon the famous Boltzmann constant k_B which in turn depends on the Avogadro number. 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. One interesting observation is that, ratio of Planck mass and electron rest mass is close to Avogadro number/8π.

3 THE TWO PRIMARY ASSUMPTIONS

Within the expanding cosmic Hubble volume, Hubble length can be considered as the gravitational or electromagnetic interaction range. Product of 'Hubble volume' and 'cosmic critical density' can be called as the "Hubble mass". The two proposed assumptions are: 1) within the Hubble volume, each and every point in free space is influenced by the Hubble mass, 2) 'molar electron mass' can be considered as the rest mass of a new heavy charged elementary particle [8-12]. Thus the current methods of estimating the Avogadro number can be refined and unified.

4 PARTICLE COSMOLOGY AND THE FUNDAMENTAL INTERACTIONS

We know that nuclear volume is proportional to the number of nucleons in the nucleus [13] and the nuclear matter is distributed within a radius of 1 to 9 fm. Here the fundamental question to be answered is: why and how the nuclear matter is confined to radius of 1 fm? To answer this question, scientists proposed many interesting concepts and models. String theory and Super gravity etc are in the race. K.P. Sinha, C. Sivaram, Abdus Salam, E. Recami and colleagues developed the subject in a unified gravitational approach [4,5]. The most interesting questions are : What is the relation between one fm and the proton rest mass? What is the

relation between one fm and the characteristic size (c/H_0)?

In a unified approach, it is assumed that, there exists a massive elementary particle $(M_X)^{\pm}$ whose mass is Avogadro number times the rest mass of electron $(\cong 3.0773\times10^{20}\ \text{GeV})$. Surprisingly it is noticed that, natural logarithm of twice of the number of $(M_X)^{\pm}$ in the Hubble universe of mass $(c^3/2GH_0)$ is matching with the inverse of the fine structure ratio $(1/\alpha)$. This coincidence motivated us to think that, there exists a strong inter-relation in between the cosmic mass and the nuclear matter. The two best examples are, $R_s \cong \left(\frac{m_p}{M_X}\right)^2\left(\frac{c}{H_0}\right) \cong 1.22$ fm and $R_s \cong \left(\frac{\hbar c}{GM_X m_e}\right)^2 \frac{2Gm_e}{c^2} \cong 1.21565$ fm where N is the Avogadro number. This is a new approach and may be given a chance in understanding the four fundamental cosmological interactions.

5 THE THIRD (POSSIBLE) ASSUMPTION

The very interesting observation is the ratio $\frac{GM_X^2}{\hbar c}$ can be expressed as $\frac{(NG)M_X m_e}{\hbar c}$ where (NG) can be considered as the 'atomic gravitational constant'. Instead of (GM_X^2), $(NG)M_X m_e$ can be used. In this way, the third assumption can be stated as, in atomic and nuclear physics, atomic gravitational constant is Avogadro number times the classical gravitational constant. From these expressions, it is possible to say that, role of 'proton mass' is taken up by $(M_X)^{\pm}$. If so, the important consequence is that, the presently believed 'proton mass' may be a cosmological variable. If this is the case, at present, in the universe, abundance of the first proton products like Hydrogen, Helium etc. may be high. It is noticed that, ratio of M_X and $\sqrt{e^2/4\pi\varepsilon_0 G}$ is $\gamma \cong 295.0606338$.

With this number it is assumed that, for any charged particle there exist 2 kinds of masses: one is the observed or the gravitational mass and the second one is the electromagnetic mass and their mass ratio is 295.06. With this idea, proton's radius can be fitted and thus the strong interaction range can be fitted. In a similar way the electromagnetic interaction range and electron's radius can be assumed. Thus electron and nucleons magnetic moments can also be fitted with the corresponding interaction ranges. Ratio of electromagnetic and strong interaction range is close to $\frac{GM_X^2}{\hbar c}$ or $\frac{(NG)M_X m_e}{\hbar c}$. For any elementary particle of charge e, electromagnetic mass (m/γ) and characteristic radius R, it can be assumed as $\frac{e^2}{4\pi\varepsilon_0 R} \cong \frac{1}{2}\left(\frac{m}{\gamma}\right)c^2$. With this relation, proton's rms radius can be obtained or fitted as $R_p \cong 2\gamma\frac{e^2}{4\pi\varepsilon_0 m_p c^2} \cong 0.906\times10^{-15}$ m. One very interesting cosmological relation [14] is $R_s \cong \frac{2G\sqrt{M_0(m_p/\gamma)}}{c^2} \cong 1.05$ fm and is very close to the strong interaction range. Further it is noticed that, if $\hbar$ is the observed quantum of the gravitational angular momentum, then its corresponding electromagnetic quantum of the angular momentum is $(\hbar/\gamma)$. With these ideas, in the Hydrogen atom [15], it is noticed that, potential energy of electron in different orbits is $\left(\frac{\hbar c}{(NG)M_X m_e}\right)^2 \frac{\sqrt{m_p m_e}\,c^2}{2n^2}$ where n = 1,2,3,... Inverse of the strong coupling constant can be expressed as $\frac{1}{\alpha_s} \cong \ln\sqrt{\frac{4\pi\varepsilon_0(NG)M_X m_e}{e^2}} + \ln\sqrt{\frac{(NG)M_X m_e}{\hbar c}} \cong 8.91424$. In the semi empirical mass formula [16], the ratio of coulombic energy constant and the proton rest energy is equal to the product of fine structure ratio and the strong coupling constant. Ratio of surface and coulombic energy constants is close to $\sqrt{\frac{(NG)M_X m_e}{\hbar c}}$. Ratio of volume and coulombic energy constants is close to $\sqrt{\frac{(NG)M_X m_e}{\sqrt{2}\,\hbar c}}$. Sum of volume and surface energy constants is close to the sum of asymmetry and pairing energy constants. The asymmetry energy constant is close to $(2/3)$ of the sum of volume and surface energy constants and pairing energy constant is close to $(1/3)$ of the sum of volume and surface energy constants. Thus the five energy coefficients can be expressed as $a_c \cong 0.7681$, $a_s \cong 19.36$, $a_v \cong 16.28$, $a_a \cong 23.76$ and $a_p \cong 11.88$ MeV respectively. Thus for light and heavy stable (A,Z), $A \cong 2Z + (0.0063Z^2)$. For light and medium stable (A,Z), $A \cong 2Z + (\alpha Z^2)$. In this way, starting from nuclear size to nuclear binding energy can be fitted. Extending the third assumption, proton and

neutron rest masses can also be fitted. Authors are working in this new direction [17].

6 GRAM MOLE IN PARTICLE COSMOLOGY

If $H_0 \cong 70.75$ Km/sec/Mpc, it is noticed that, $\left(N\sqrt{\frac{\rho_T c^2}{\rho_0 c^2}}\right)^3 \sqrt{\frac{m_u^3}{\gamma M_0}} \cong M_g \cong 9.99165\times10^{-4}$ Kg where, M_g is the gram mole and $m_u \cong 1.660538782\times10^{-27}$ Kg is the unified atomic mass unit numerically equal to $\left(\frac{1}{1000N}\right)$. In a simple form $\left(\frac{1}{N}\sqrt{\frac{\rho_0 c^2}{\rho_T c^2}}\right)\sqrt{\frac{\left(\gamma M_0 . M_g^2\right)^{1/3}}{m_u}} \cong 1$. By the original definition if $Nm_u \cong M_g$, $\left(\frac{1}{N}\cdot\frac{\rho_0 c^2}{\rho_T c^2}\right)^3 \gamma M_0 \cong M_g$. This is a very interesting observation and needs a critical and sensitive analysis.

7 TO FIT THE RMS RADIUS OF PROTON

Let R_p be the rms radius of proton. R_1 and R_2 be two radii, $R_1 \cong \left(\frac{\hbar c}{G_A m_p^2}\right)^2 \frac{2G_C m_p}{c^2} \cong 1.9637\times10^{-25}$ m $R_2 \cong \left(\frac{\hbar c}{G_A m_p^2}\right)^3 \frac{2G_C m_p}{c^2} \cong 5.521\times10^{-11}$ m. Then it is noticed that, $R_p \cong \left(R_1 R_2^2\right)^{\frac{1}{3}} \cong 8.4278\times10^{-16}$ m $R_p \cong \left(\frac{\hbar c}{G_A m_p^2}\right)^{8/3} \frac{2G_C m_p}{c^2}$. This can be compared with the 2010 CODATA recommended rms radius of proton $0.8775(51)$ fm. Recent work on the spectrum of 'muonic hydrogen' indicates a significantly lower value for the proton charge radius [18], $R_p \cong 0.84184(67)$ fm and the reason for this discrepancy is not clear. This is 10 times more precise than all the previous determinations. From proton rest mass and rms radius, it is possible to express

$$G_A \cong \left(\frac{2G_C m_p}{R_p c^2}\right)^{\frac{3}{8}}\left(\frac{\hbar c}{m_p^2}\right), \quad N \cong \left(\frac{2G_C m_p}{R_p c^2}\right)^{\frac{3}{8}}\left(\frac{\hbar c}{G_C m_p^2}\right)$$

Here the most interesting thing is that, R_2 is very close to the Bohr radius of Hydrogen atom. It is very interesting to note that, with R_2 ionic radii of atoms can be fitted very easily as $(R)_A \cong A^{1/3}\cdot\left(\frac{R_2}{\sqrt{2}}\right) \cong A^{1/3}\times3.904\times10^{-11}$ m where $(R)_A$ is the ionic radius of mass number A. If $A=7, (R)_A \cong 0.0747$ nm, if $A=23, (R)_A \cong 0.111$ nm and if $A=39, (R)_A \cong 0.132$ nm. Their corresponding recommended radii are 0.076 nm, 0.102 nm and 0.138 nm respectively.

8 TO FIT THE CHARACTERISTIC POTENTIAL RADIUS OF NUCLEUS 1.4 fm

It is noticed that, gram mole is a black hole where the operating gravitational constant is (G_A) but not (G_C). That means for the simplest case of gram mole of electrons or gram mole of protons, there exist N number of electrons or N number of protons. Let it follows the concept of Schwarzschild radius. It can be expressed in the following way. R_3 and R_4 be two radii as $R_3 \cong \frac{2G_A(Nm_e)}{c^2} \cong 4.9066\times10^{-10}$ m and $R_4 \cong \frac{2G_A(Nm_p)}{c^2} \cong 9.009\times10^{-7}$ m then $V_3 \cong \frac{4\pi}{3}R_3^3$ and $V_4 \cong \frac{4\pi}{3}R_4^3$. For the above two cases, the characteristic mean distance (λ) in between N electrons or in between N protons, can be obtained as $\lambda_3 \cong \left(\frac{V_3}{N}\right)^{\frac{1}{3}}$ and $\lambda_4 \cong \left(\frac{V_4}{N}\right)^{\frac{1}{3}}$. It is noticed that, $\lambda_{34} \cong \left(\lambda_3\lambda_4^2\right)^{\frac{1}{3}} \cong 1.4\times10^{-15}$ m. This can be compared with the characteristic alpha scattering experimental radius of nucleus ≈ 1.4 fm. Based on the Yukawa's Pion exchange model nuclear interaction range is 1.4 fm. Thus if $m_\pi^\pm$ is the charged pion rest mass, $N \cong \left(\frac{3}{32\pi}\right)^{\frac{1}{5}}\left(\frac{\hbar c}{G_C\left(m_p^2 m_e\right)^{1/3} m_\pi^\pm}\right)^{3/5}$

9 SUSY IN ELECTROWEAK PHYSICS AND QUARK PHYSICS

In quark physics and electroweak physics, by considering a fermion-boson mass ratio of $\Psi \cong 2.2627$, one can see super symmetry in strong and weak interactions at low and high energies! No one can believe in this, but this is a fact [19-23]. The

most interesting observation is that, the weak coupling angle can be expressed as $\left(\frac{\hbar}{\gamma}\right)\div\left(\frac{e^2}{4\pi\epsilon_0 c}\right)\cong 0.4644333\cong\sin\theta_W$. The number $\Psi\cong 2.2627$ can be fitted with the empirical relation $\Psi^2\ln\left(1+\sin^2\theta_W\right)\cong 1$. In the electro weak physics, charged Higgs fermion and electron mass ratio is close to $\frac{1}{2}\left(\frac{(NG)M_X m_e}{\hbar c}\right)^2$. If Higgs fermion and Higgs boson mass ratio is 2.2627, then obtained Higgs boson mass is 45576 MeV and the most surprising thing is that, Higgs boson pair generates the neutral Z boson. Another surprising thing is that, susy boson of the top quark is nothing but the electroweak W boson. Another interesting idea is that W boson and Higgs boson generate a neutral boson of mass 126 GeV. It can be suggested that, W boson pair generates a neutral boson of rest energy 161 GeV.

10 INTEGRAL CHARGE QUARK SUSY

Till today there is no reason for the question: why there exist 6 individual quarks? Till today no experiment reported a free fractional charge quark. Authors' humble opinion is nuclear charge (either positive or negative) constitutes 6 different flavors and each flavor holds certain mass. Charged flavor can be called as a quark. It is neither a fermion nor a boson. A fermion is a container for different charges, a charge is a container for different flavors and each flavor is a container for certain matter. If charged matter rests in a fermionic container it is a fermion and if charged matter rests in a bosonic container it is a boson. The fundamental questions to be answered are : what is a charge? why and how opposite charges attracts each other? why and how there exists a fermion? and why and how there exists a boson? Here interesting thing is that if 6 flavors are existing with 6 different masses then a single charge can have one or two or more flavors simultaneously. Since charge is a common property, mass of the multiple flavor charge seems to be the geometric mean of the mass of each flavor. If charge with flavor is called as a quark then charge with multi flavors can be called as a hybrid quark. Hybrid quark generates a multi flavor baryon. It is a property of the strong interaction space - time - charge. This is just like different tastes or different smells of matter. Important consequence of this idea is that- for generating a baryon there is no need to couple 3 fractional charge quarks. It can be suggested that:

1) There exist nature friendly integral charge quark fermions. 2) For every integral charge quark fermion there exists a corresponding integral charge quark boson. Quark fermion and quark boson mass ratio is close to 2.2627. In support of this idea, it is noticed that, strange quark boson pair generates the neutral pion. 3) There exist integral charged massive quark baryons and integral charged massive mesons. 4) Quark masses can be expressed as $Q_F c^2\cong\frac{1}{2}\sin\theta_W\left[M_{Hf}^2\times Q_f\right]^{\frac{1}{3}}c^2$ and Quark meson masses can be expressed as $Q_M c^2\cong\frac{1}{2}\sin\theta_W\left[M_{Hb}^2\times Q_b\right]^{\frac{1}{3}}c^2$ where Q_f and Q_b are the rest masses of quark fermion and quark boson respectively and M_{Hf} and M_{Hb} are the Higgs charged fermion and Higgs charged boson respectively. 5) $Q_{ef}\cong Q_f-Q_b\cong\left(1-\frac{1}{\Psi}\right)Q_f$ acts as the effective quark fermion. Effective quark baryon mass is $Q_E c^2\cong\frac{1}{2}\sin\theta_W\left[M_{Hf}^2\times Q_{ef}\right]^{\frac{1}{3}}c^2$. These effective quark baryons play a vital role in fitting the unstable baryon masses. Quark meson masses play a vital role in fitting the unstable meson masses. 6) Characteristic nuclear fermion is 938.272 MeV and its corresponding nuclear boson is $938.272/\Psi\cong 414.67$ MeV. This boson couples with the light quark bosons or light quark mesons and generates neutral ground states. Thus it is the mother of presently believed strange mesons like 493, 548, 1020 MeV and 783, 890 MeV etc. 7) Charged ground state baryon rest energy is $(Q_{E1}Q_{E2})^{\frac{1}{2}}c^2$ or $\left(Q_{E1}Q_{E2}^2\right)^{\frac{1}{3}}c^2$ or $(Q_{E1}Q_{E2}Q_{E3})^{\frac{1}{3}}c^2$ where Q_{E1}, Q_{E2}, and Q_{E3} represents any of the three effective quark baryons. Integral charge light quark bosons in one or two numbers couples with the ground or excited effective quark baryons and generates doublets and triplets. This is just like 'absorption of photons by the electron'. 8) Rest energy of nucleon is close to $\left(\frac{2U_F D_F}{U_F+D_F}\right)c^2\cong 940.02$ MeV and nucleon rest energy difference is close to $\left(m_n-m_p\right)c^2\cong\sin^2\theta_W\cdot\left(\frac{2U_f D_f}{U_f+D_f}\right)c^2\cong 1.29623$ MeV. 9) Only oppositely charged quark mesons couple together to form a neutral meson. No two quark fermions couple together to form a meson. Neutral ground state meson rest energy is close to $\left(Q_{M1}+Q_{M2}\right)c^2$ where Q_{M1} and Q_{M2} represent any two quark mesons. 10) Fine rotational levels of any

ground state energy $m_x c^2$ can be expressed as, if n = 1,2,3, and $I = n(n+1)$, $\left(mc^2\right)_I \cong [I]^{\frac{1}{4}} m_x c^2$ and $\left(mc^2\right)_{I/2} \cong [I/2]^{\frac{1}{4}} m_x c^2$. Super fine rotational levels can be obtained as $\left(mc^2\right)_I \cong [I]^{\frac{1}{12}} m_x c^2$ and $\left(mc^2\right)_{I/2} \cong [I/2]^{\frac{1}{12}} m_x c^2$.

11 CONCLUSIONS

It is true that the proposed ideas are speculative to the current physics concepts. It is also true that the proposed ideas are very interesting. With reference to the current physical concepts, implementing the gravitational constant in atomic and nuclear physics is beyond the scope. Please recall the valuable words of S.W.Hawking [24], Dirac [2,3], Abdus Salam, Sivaram [4] and Recami [5]. Considering the proposed ideas, Avogadro number, gravitational constant and Hubble mass can successfully be implemented in microscopic physics. Not only that, the subject of elementary particle physics and cosmology can be studied in a unified manner. Approach may be different and for the time being it may be ad-hoc, involvement and encouragement may bring this subject into main stream. Authors hope that 'future' will decide the issue.

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