Review

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Using a modified Valve's proposed general solution for the mass dimension expression to connect the electromagnetic coupling Constant to the Cosmological Parameters

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Review

Using a Modified Valve's Proposed General Solution for the Mass Dimension Expression to Connect the Electromagnetic Coupling Constant to the Cosmological Parameters

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Abstract

In this review article, the electromagnetic coupling constant (fine structure), a microscopic dimensionless constant is connected to the macroscopic world using a corrected Valev's proposed general solution for the mass dimension expression suggesting a link between the evolution of fundamental constants and cosmological parameters, like the cosmological constant. From the corrected and modified mass dimension expression $M=m_p\gamma^{1/2}$ (where m_p is the Planck mass and γ = 4.4702596×10^{121} is a large dimensionless quantity defined as a quantum cosmological dimensionless constant), we calculate the total mass of ordinary matter in the universe in agreement with that found by the Planck(2018) collaboration and the Lambda CDM. In section six, we connect the fine structure constant to the cosmological parameters (the present root mean square matter fluctuation averaged over a sphere of radius $8h^{-1}$Mpc, the baryon density, the dark energy density and the reduced Hubble dimensionless parameter).In the results, the S8 tension is calculated and found to be in agreement with the recently observed CMB satellite value. A modification of the Einstein constant in the field equations also connects the fine structure constant and the cosmological parameters from which a new calculation of the S8 tension without the amplitude of the mass fluctuations is derived. Also In the results, exact equation of the Dirac large number 6.686×10^{60} has been found, connecting cosmological parameters and Planck units. Thus a precise formulation and evidence of Dirac large number hypothesis and fine structure constant has been found, connecting the microscopic worlds and the macroscopic worlds.

Keywords: dark energy; S8 tension; dark matter; Dirac large number hypothesis; coupling constants; dimensionless numbers; matter fluctuations; cosmology; large scale structures; planck length scales

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1. Introduction

In various papers by Dimitar Valev [1–4] it was shown that the observed mass of the universe or the mass of ordinary matter in the universe can be calculated or deduced by dimensional analysis methods. However the mass that was derived in [1] was off by 0.81402434 from the one calculated using the Planck (2018) units in Lambda CDM [5] of 4.8% of the total critical density ($0.85\times10^{-26}\text{kg/m}^3$) at $\text{H}_\text{o}=2.176\times10^{-18}s^{-1}$ or $4.08\times10^{-28}\,kg/\text{m}^3$ and using the commoving distance (radius) of about 46.6 billion light-years. The mass obtained by Aghanim, N.., et al. (2020) was $1.5\times10^{53}\,kg$. This discrepancy shows that Valev's proposed general solution or result [1] for the mass dimension expression $M=m_p\gamma^p$ (1) – (where $m_p=2.176\times10^{-8}kg$ is the Planck mass, $\gamma=1.23\times10^{-61}$ is a small dimensionless quantity and p is an arbitrary parameter in the interval -1,1), does not agree with experiment. In this paper we give corrections to the γ^p dimensionless quantity in a bid to make (1) universal and in agreement with the Planck(2018) and Lambda CDM results for the mass of the observable universe, the S8 tension

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and the observable cosmological parameters. The ingredients of γ as we shall see below, will be used to connect the electromagnetic coupling constant (Fine structure constant) to the cosmological parameters with implications for cosmology (with more emphasis on the S8 tension).

2. The Definition of a Quantity γ^p

In [6], it was shown that a large number N corresponds to the ratio $\frac{M}{m_p} = N \sim 10^{60}$. If we do a reverse calculation, where M is the mass of ordinary matter in the universe whose value is known from [5] and m_p is the Planck mass, then the value of γ^p can be deduced from (1) as, $\gamma^p = 6.686 \times 10^{60}$ which corresponds to Valev's result in [6] where N is denoted as a Dirac Large number although here it is more than Valev's value by only 1.16684. We therefore define γ^p as a Dirac Large Number Hypothesis (DLNH), meaning that the largest and the smallest things in the universe are related with a number of order 6.686×10^{60} .

Since our aim is to find the main ingredients in γ , we are led to an assumption that to arrive at the value of N, the values in γ must have been squared. Such that the free parameter (p) would take on a value of $p = 1/2$.

Finally we have a very large dimensionless quantity $\gamma = 4.4702596 \times 10^{121}$ in disagreement with Valev's value of $= 1.23 \times 10^{-61}$. But the question still remains. what is this dimensionless quantity?

3. The Definition of a Large Dimensionless Quantity γ

In [7] section 3.1, it has been stated that; the presence of the cosmological constant (Λ) implies that there is a dimensionless constant in the (quantum) theory $\frac{\Lambda\hbar G}{c^3} \sim 10^{-120}$ but because the cosmological constant is close to the scale of the Hubble radius curvature of the universe, Its measured value is the ratio between the largest things and the smallest things (namely the cosmological scale and the Planck scale) in the universe. This is approximately $\frac{c^3}{\Lambda\hbar G} \sim 10^{120}$ as given in [7]. This is a very large number in quantum gravity.

This value as can be seen in here is very nearer to our deduced large dimensionless quantity γ given above. Therefore a devised definition of γ that is required to agree with experiments will be according to this paper:-

γ is a quantum cosmological dimensionless number, the ratio between the quantum electrodynamics scale (electromagnetic coupling constant-fine structure constant, α_e) and a dimensionless constant in the (quantum) theory (a very small number, α_c) as, $\gamma = {}^{\alpha_e}/_{\alpha_c}$ (2) –(where $\alpha_c = \Omega_k \Lambda {l_p}^2 = \frac{\Omega_k \Lambda\hbar G}{c^3}$ and Ω_k is the ratio of the square of the baryon density parameter, Ω_b and the reduced Hubble dimensionless parameter, h expressed as $\Omega_k = \left({}^{\Omega_b}/_{h}\right)^2$). The quantity Ω_k has just been put into α_c by hand in order to generate a precise value of γ as calculated in section 2 but its significance will be seen later and it will be there concluded that it cannot be separated from our quantum cosmological dimensionless number if we are to make any verifiable predictions .

We have therefore defined and made corrections to Valev's dimensionless quantity γ as was expected. Thus (1) can be simplified as,

$$M = m_p \gamma^{1/2} \quad (3)$$

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4. Calculation of the Total Mass of Ordinary Matter in the Universe

Using (3) and (2), the observable mass of the universe (a macro object), is deduced as,

$$M_U = \frac{c^2}{G}\sqrt{\frac{\alpha_e}{\Omega_k \Lambda}} = \frac{c^3}{H_o G}\sqrt{\frac{\alpha_e}{3\Omega_k \Omega_\Lambda}} \quad (4)$$

Where:-

$\mathrm{H}_o = c\left(\frac{\Lambda}{3\Omega_\Lambda}\right)^{1/2}$, is the Hubble constant parameter and Ω_Λ-is the density parameter of dark energy

When the results of the cosmological parameters from the Planck (2018) Collaboration [5],

$$H_o = 2.1928 \times 10^{-18}\mathrm{s}^{-1} \text{ (67.67km/s/Mpc)},$$
$$\Omega_k = 0.00533 \text{(Where,} \Omega_b = 0.04933 \text{ and,} h = 0.6755\text{)},$$
$$\Omega_\Lambda = 0.6889,$$

are used together with the fine structure constant value of $\alpha_e = 1/137$ [12]. Then the total mass of ordinary matter in the universe is precisely calculated to be in agreement with that found in [5] as,

$$M_U = \frac{c^3}{H_o G}\sqrt{\frac{\alpha_e}{3\Omega_k \Omega_\Lambda}} = 1.5 \times 10^{53}\mathrm{kg}$$

5. The Present Root Mean Square Matter Fluctuation (σ_8)

Let the ratio of the mass of the universe and the Hubble sphere mass be defined as the amplitude of the mass fluctuations.

The right hand side of (4) has an expression for the Hubble sphere mass given as $M_H = \frac{c^3}{H_o G}$. The 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. Therefore the ratio of the total mass of ordinary matter in the universe to the Hubble mass sphere from (4) is found to be a parameter that follows a power law (around 8 h^{-1} Mpc scale) as,

$$\frac{M_U}{M_H} = \left(\frac{\alpha_e}{3\Omega_k \Omega_\Lambda}\right)^{1/2} \quad (5)$$

This ratio is here defined as the present root mean square matter fluctuation, averaged over a sphere of radius 8h^{-1}Mpc as defined in [8].(The root mean square mass density fluctuation in spheres of mass M). Where M_U is the mean mass within a sphere and M_H the horizon mass. Therefore the left hand side of (4) is denoted by σ_8 [9], giving an expression;

$$\left(\frac{\alpha_e}{3\Omega_k \Omega_\Lambda}\right)^{1/2} = \sigma_8 = 0.81402434 \quad (6)$$

The above calculated value is in agreement with that observed in [9] of 0.811 ± 0.006 . It provides critical constraints for cosmological models, helping scientists to determine parameters like the universe's composition and the nature of dark matter.

6. Connecting the electromagnetic coupling Constant and the Cosmological Parameters

Taking square roots on both sides of (6) we get an expression connecting the fine structure constant to the present cosmological parameters as,

$$\alpha_e = 3{\sigma_8}^2 \Omega_k \Omega_\Lambda = 3{\sigma_8}^2 \left(\frac{\Omega_b}{h}\right)^2 \Omega_\Lambda = 1/137 \quad (7)$$

We have therefore connected the fine structure constant to the Planck (2018) cosmological parameters with implications for cosmology as we are yet to find out below.

It should be noted that in the results section we shall see that the fine structure constant is also related to the redshift value of z=0.6626 with implications for cosmology and the S8 tension.

7. Results and Discussions

7.1. The Constant Mass of the Universe and the S8 Tension Formula Without the Root Mean Square Matter Fluctuation Parameter

The total mass of ordinary matter in the universe calculated in section four agrees with that obtained by other methods[i] [5]. The fact that the obtained mass agrees with that calculated using the Lambda CDM is proof that our proposed general solution for the mass dimension expression (3) is true on cosmological grounds and also puts a constraint on the used physical constants of nature which is proof that the mass of the universe depends on the given cosmological parameters and the fine structure constant.

We have therefore found a solution (4) such that the observable mass of the universe is a constant related to the cosmological constant $\sqrt{\Lambda}=\frac{c^2h\sqrt{\alpha_e}}{\Omega_b G M_U}=\frac{1}{kM_U}$, Where $k=\frac{\Omega_b G}{c^2h\sqrt{\alpha_e}}$ is a gravitational constant related to Einstein constant in the general relativity theory as, $k=\frac{29.403\Omega_b G}{c^2h\sqrt{\alpha_e}}=\frac{8\pi G}{c^2}$. From which we deduce an expression for fine structure constant in terms of the baryon density as $\alpha_e=\left(\frac{29.403\Omega_b}{8\pi h}\right)^2$. When this value is equated to (7) we once again deduce the present root mean square matter fluctuation in terms of the density parameter as $\sigma_8=\left(\frac{0.456}{\Omega_\Lambda}\right)^{1/2}$ enabling us to express the S8 tension in terms of both the matter and dark energy density parameters as,

$$S_8=\left(\frac{0.456}{\Omega_\Lambda}\right)^{1/2}\left(\frac{\Omega_m}{0.3}\right)^{1/2}=\left(1.52\frac{\Omega_m}{\Omega_\Lambda}\right)^{1/2}=1.233\left(\frac{\Omega_m}{\Omega_\Lambda}\right)^{1/2}.$$

This formula allows us to calculate the value of S8 without the root mean square matter fluctuation parameter. It also takes into account the effects of dark energy on the S8 tension, in fact it is the σ_8 that depends on Ω_Λ (a similar expression is derived below)

7.2. The New Hubble Parameter and the Radius of the Universe

It can also be seen from the general solution for the mass dimension expression (3), that the ratio of the mass of the universe and the Planck mass is equal to the ratio of the radius or length of the universe and the Planck length which is equal to the Dirac large number, $N=\gamma^{1/2}=6.686\times10^{60}$. This result proves the Dirac and Eddington large number hypothesis that the fundamental constants of atomic physics and cosmology involve large dimensionless numbers that seem coincidentally related, hence connecting the micro to the macro as, $\frac{M_U}{m_p}=\frac{R_U}{l_p}=\frac{c}{l_pH_o}\sqrt{\frac{\alpha_e}{3\Omega_k\Omega_\Lambda}}=N$, where the length of this universe is deduced from (3) to be, $R_U=\frac{c}{H_o}\sqrt{\frac{\alpha_e}{3\Omega_k\Omega_\Lambda}}=1.0807\times10^{26}m$ (i.e 11.423billion light years). It should be noted that the Hubble parameter required to obtain the above given radius must have a value that scales with the present root-mean- square matter fluctuation as, $H_U=H_o\sqrt{\frac{3\Omega_k\Omega_\Lambda}{\alpha_e}}=H_o\sqrt{3\beta\Omega_\Lambda}=\frac{H_o}{\sigma_8}=2.6938\times10^{-18}s^{-1}$ (83.13km/s/Mpc). Thus our model predicts a universe with a modified

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Hubble scale and a new cosmological parameter, $\beta = \frac{{\Omega_b}^2}{h^2 \alpha_e} = 0.73$ which behaves as dark energy.

7.3. The Definition of the Dirac LNH

The quantum cosmological dimensionless number is also found to be a constant dimensionless number made up of fundamental physical constants and cosmological parameters as deduced from (2):

$$\gamma = \frac{\alpha_e \, c^3}{\Omega_k \Lambda \hbar G} = \frac{h^2 k_e e^2 \, c^4}{3{\Omega_b}^2 \Omega_\Lambda {H_o}^2 \hbar^2 G} = 4.4702596 \times 10^{121}$$

This large number is what connects the microcosm to the macrocosm because it is connected to the Dirac large number as: $N = \gamma^{1/2} = \frac{hec^2}{H_o \hbar \Omega_b}\sqrt{\frac{k_e}{3\Omega_\Lambda G}}$, meaning that the Dirac large number is a composition of both fundamental physical constants and cosmological parameters which makes it a constant purely connected with nature and the universe's evolution. Therefore the large number N is not simply ratio of two quantities but it is an exact formula expressed by means of the fundamental constants. Therefore, the ratios $\frac{M_U}{m_p} = \frac{R_U}{l_p}$, given above represent a precise formulation of Dirac LNH. The large number N connects cosmological parameters (mass of the observable universe and length of the universe) and the respective fundamental microscopic properties of the matter (Planck mass and Planck length).Thus, a precise formulation and evidence of Dirac LNH has been found connecting the microworld and the macroworld.

7.4. The CMB Satellite S8 Tension and the Total Matter Density Parameter

The S8 tension (a measure of the clumpiness or inhomogeneity of matter in the universe) is hereby calculated by assuming a universe with total density, $\Omega_0 = \Omega_m + \Omega_\Lambda = 1$, giving a total matter density of $\Omega_m = 0.3111$. At this matter density we have a value of the S8 tension $S_8 = \sigma_8 \sqrt{\frac{\Omega_m}{0.3}} = 0.82895$ in agreement with the 2013 Planck mission (a high-precision CMB satellite) calculated S8 value of 0.83, above the gravitational-lensing estimates.

7.5. The Unchanging Fine Structure Constant

It has been proved in section 6 that the fine structure constant does not change with cosmic time which proves [13,14] methodology wrong. In fact the fine structure constant depends on the values of the chosen cosmological parameters. In this case the fine structure constant is what it is because of the unchanging values of the following used cosmological parameters, $\Omega_b = 0.04933$, $\Omega_\Lambda = 0.6889$, $h = 0.6755$ and $\sigma_8 = 0.81402434$. A change in the values of the parameters given will lead to a change in the value of the fine structure constant and the value for the mass of the universe. Therefore the microcosm (The Fine-Structure Constant) is connected to the macrocosm (Cosmological Parameters) through equation (7).

7.6. On a New Model for the Calculation of the S8 Tension

However if we propose that the transition from decelerating to accelerating expansion (the second derivative $\ddot{a}$ crossing zero) of the universe occurred when, $a = \left(\frac{\Omega_m}{2\Omega_\Lambda}\right)^{1/n}$ (where n is a positive number) then when n=3.616, we have a=0.663 or the redshift z=0.6626. Taking the square root

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of z we get a value equal to the ratio (5) or the root mean square matter fluctuation. This then allows us to connect the redshift value to the fine structure constant as,

$$\alpha_e = 3z\Omega_k\Omega_\Lambda = 3\left(\frac{\Omega_b}{h}\right)^2\left(\frac{\Omega_m}{2}\Omega_\Lambda{}^{6.232}\right)^{1/7.232} = 1/137,$$

Equating this equation to (7) we have the expression for the S8 tension parameter in terms of the total matter density and the density parameter of dark energy as, $S_8 = \left(\frac{1}{2\Omega_\Lambda}\right)^{1/7.232}\left(\frac{\Omega_m}{0.3893}\right)^{1/1.567}$ .This result modifies the S8 tension formula by proving that the root mean square matter fluctuation parameter is related to the density parameter (Ω_Λ) by $\sigma_{8(\Lambda)} = \left(\frac{1}{2\Omega_\Lambda}\right)^{1/7.232}$. If the above expressions are true then it follows that at $\Omega_\Lambda = 0.6889$ and $\Omega_m = 0.3111$ we have $\sigma_{8(\Lambda)} = 0.9566523$ and $\left(\frac{\Omega_m}{0.3893}\right)^{1/1.567} = 0.8666684$ respectively. The value $\sigma_{8(\Lambda)}$ is higher than, for example, the value obtained from the CMB by Planck (2018) collaborations. Keeping $\sigma_{8(\Lambda)}$ a constant and calculating S8 at $\Omega_m = 0.2765$ we get a value of S8 equal to that measured by KiDS-1000 and DES Y3 [10] of 0.769, a calculation not possible with the usual formula of $S_8 = \sigma_8\sqrt{\frac{\Omega_m}{0.3}}$. We have thus derived a method that can measure, for the first time, the amplitude σ8, nearly independent of Ωm. The method is based on the evolution rate of cluster abundance to z ~ 0.6626; this evolution breaks the degeneracy that generally exists between Ωm and σ8 and allows the first determination of each of the parameters independently.

Disclaimer: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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[i] Using the Planck (2018) units in Lambda CDM of 4.8% of the total critical density ($0.85 \times 10^{-26}\mathrm{kg/m^3}$) at $\mathrm{H_o} = 2.176 \times 10^{-18} s^{-1}$ or $4.08 \times 10^{-28}\ kg/\mathrm{m}^3$ and using the commoving distance (radius) of about 46.6 billion light-years, they got a volume equals $3.58 \times 10^{80}\mathrm{m}^3$ and the mass of ordinary matter equals density ($4.08 \times 10^{-28}\ kg/\mathrm{m}^3$) times volume ($3.58 \times 10^{80}\mathrm{m}^3$) or $1.5 \times 10^{-53}\ kg$.