

The Quantum Bang Hypothesis: An Alternative to Dark Matter and Dark Energy

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How to cite this paper: Tonin, P.G. (2020) The Quantum Bang Hypothesis: An Alternative to Dark Matter and Dark Energy. *Journal of High Energy Physics, Gravitation and Cosmology*, 6, 753-764. <https://doi.org/10.4236/jhepgc.2020.64050>

Received: September 2, 2020

Accepted: October 16, 2020

Published: October 19, 2020

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Abstract

We hypothesize that the quantum realm and the cosmos are linked by a scaling relation where the gravitational coupling constant α_G is the scale factor and decreases with cosmic time. We propose a simple cosmological model where cosmic inflation, dark energy and dark matter could be redundant concepts. We show that cosmological parameters such as the Hubble constant, the age, density and mass of the observable Universe could be derived simply from quantum parameters. Finally, we propose a fundamental MOND formula with no interpolating function and an acceleration parameter simply derived from the Hubble constant.

Keywords

Dark Matter, Dark Energy, Inflation, Cosmological Parameters, MOND

1. Introduction

The Λ CDM (Lambda Cold Dark Matter) cosmological model provides a widely accepted description of the Universe. However, the fundamental nature of the Λ CDM main components, namely cosmic inflation, dark matter and dark energy remains a mystery [1] [2]. In this paper, we propose a cosmological model where these components might not be required. Our proposal is built upon the hypothesis that the gravitational coupling constant α_G acts as a scale factor between the quantum realm and the cosmos and decreases with cosmic time. We introduce a simple correlation between the electron Compton time and the age of the Universe, between the electron Compton wavelength and the Hubble radius, and between the electron mass and the mass of the observable Universe. These correlations suggest that the Hubble parameter will always equal the inverse of the age of the Universe and that the Universe density will always equal

the Universe critical density. It is predicted that the mass and size of particles decrease with cosmic time, while the mass and size of the observable Universe increase with cosmic time. The Newtonian gravitational constant G and the Planck constant h are also predicted to decrease with cosmic time. According to our proposal, the measured acceleration of the Universe expansion is an illusion induced by the gravitational acceleration of the Universe, this same acceleration is also responsible for the discrepancy between the expected and observed velocities of stars in galaxies. We propose a modified Newtonian equation for the velocity of stars in a galaxy, which would eliminate the need for dark matter. Overall, this proposal describes a Universe where all constituents, including ourselves, are constantly changing scale (in addition to the observed Hubble expansion), but this change in scale remains unnoticed as all our surroundings, including our units of measurement and most physical constants are also changing scale with cosmic time.

2. The Age, Hubble Radius and Mass of the Universe

We hypothesize that the quantum realm and the cosmos are linked by a scale relation. We propose the following three novel equations from which our cosmological model is deduced. These equations are valid for all cosmic times, as explained in Section 5. The values used in this paper are taken from CODATA 2018 [3].

The age of the Universe t_0 is linked to the electron Compton time:

$$t_0 = \frac{t_e}{\pi\alpha_G} = \frac{2\mu t_p}{\sqrt{\alpha_G^3}} = 4.3618 \times 10^{17} \text{ s (13.822 Gyr)} \quad (1)$$

where t_e is the electron Compton time ($t_e = \lambda_e/c$), α_G is the gravitational coupling constant defined using a pair of protons ($\alpha_G = (m_{pr}/m_p)^2$), μ is the proton to electron mass ratio and t_p is the Planck time.

This value agrees with the Planck Collaboration 2018 estimate [4] of $t_0 = 13.801 \pm 0.024$ Gyr.

The Hubble radius R_h is linked to the electron Compton wavelength:

$$R_h = \frac{\lambda_e}{\pi\alpha_G} = \frac{2\mu l_p}{\sqrt{\alpha_G^3}} = 1.3076 \times 10^{26} \text{ m} \quad (2)$$

where λ_e is the electron Compton wavelength, α_G is the gravitational coupling constant defined using a pair of protons, μ is the proton to electron mass ratio and l_p is the Planck length.

The mass of the observable Universe M_u is linked to the electron mass:

$$M_u = \frac{\mu^2 m_e}{\alpha_G^2} = \frac{\mu m_p}{\sqrt{\alpha_G^3}} = 8.8043 \times 10^{52} \text{ kg} \quad (3)$$

where μ is the proton to electron mass ratio, m_e is the electron mass, α_G is the gravitational coupling constant defined using a pair of protons, and m_p is the Planck mass.

From Equations (1), (2) and (3), we deduce further equations and 12 key predictions which are presented in the following sections.

3. The Hubble Constant

From Equations (1) and (2), we deduce the following equation for the Hubble constant H_0 :

$$H_0 = \frac{c}{R_h} = \frac{\pi\alpha_G}{t_e} = \frac{\sqrt{\alpha_G^3}}{2\mu t_p} = \frac{1}{t_0} = 70.74 \text{ km} \cdot \text{s}^{-1} \cdot \text{Mpc}^{-1} \quad (4)$$

where c is the speed of light, R_h is the Hubble radius, t_e is the electron Compton time, α_G is the gravitational coupling constant defined using a pair of protons, μ is the proton to electron mass ratio, t_p is the Planck time and t_0 is the age of the Universe.

This value falls between the Planck Collaboration 2018 estimate [4] of $H_0 = 67.37 \pm 0.54 \text{ km} \cdot \text{s}^{-1} \cdot \text{Mpc}^{-1}$ and the distance-ladder estimate from the SH0ES project 2019 [5] of $H_0 = 74.03 \pm 1.42 \text{ km} \cdot \text{s}^{-1} \cdot \text{Mpc}^{-1}$.

Prediction 1: The Hubble constant will always equal the inverse of the age of the Universe.

We note that this statement is in agreement with the $R_h = ct$ model proposed by Melia Shevchuk [6].

4. The Universe Density

From Equations (1), (2) and (3), we deduce the following equation for the mass of the observable Universe M_u :

$$M_u = \frac{R_h c^2}{2G} = \frac{t_0 c^3}{2G} = \frac{c^3}{2GH_0} = 8.8043 \times 10^{52} \text{ kg} \quad (5)$$

where R_h is the Hubble radius, c is the speed of light, G is the Newtonian gravitational constant, t_0 is the age of the Universe and H_0 is the Hubble constant.

The Universe Hubble volume is defined as:

$$V_h = \frac{4\pi R_h^3}{3} = 9.3662 \times 10^{78} \text{ m}^3 \quad (6)$$

Using Equations (5) and (6), and considering that the observable Universe volume is equal to the Hubble volume (as per our hypothesis), we propose the following equation for the Universe density ρ_u :

$$\rho_u = \frac{M_u}{V_h} = \frac{3c^3}{8\pi G H_0 R_h^3} = \frac{3H_0^2}{8\pi G} = 9.400 \times 10^{-27} \text{ kg} \cdot \text{m}^{-3} \quad (7)$$

This equation matches the equation for the critical density of a Friedmann-Robertson-Walker (FRW) universe.

Prediction 2: The Universe density will always equal the Universe critical density.

5. The Fundamental Units of Time, Length and Mass

In order for Equation (1) to be valid as the Universe ages, either the gravitational

coupling constant α_G or the electron Compton time t_e , or both, have to vary. We propose that the age of the Universe and the electron Compton time are respectively scaled up and scaled down values of a fundamental unit of time (that we will call T_0), the scale factor is represented by the square root of the gravitational coupling constant. This unit of time represents a fundamental reference and is invariant under the scale transformation.

The same principle is applied to Equations (2) and (3) to obtain the fundamental unit of length L_0 and the fundamental unit of mass M_0 .

In relation to these units, the Universe expands and gains mass while the elementary particles shrink and lose mass.

The fundamental unit of time T_0 is defined as:

$$T_0 = t_0 \pi \sqrt{\alpha_G} = \frac{t_e}{\sqrt{\alpha_G}} = \frac{2\pi\mu t_P}{\alpha_G} = 0.10531 \text{ s} \tag{8}$$

While the age of the Universe t_0 increases, the gravitational coupling constant α_G decreases. While the gravitational coupling constant α_G decreases, the electron Compton time t_e decreases.

From Equation (8), we deduce how the gravitational coupling constant α_G varies with cosmic time t :

$$\alpha_G(t) = \frac{T_0^2}{\pi^2 t^2} \propto t^{-2} \tag{9}$$

From Equation (8), we deduce how the electron Compton time t_e varies with cosmic time t :

$$t_e(t) = \frac{T_0}{\pi t} \propto t^{-1} \tag{10}$$

The fundamental unit of length L_0 is defined as:

$$L_0 = R_h \pi \sqrt{\alpha_G} = \frac{\lambda_e}{\sqrt{\alpha_G}} = \frac{2\pi\mu l_P}{\alpha_G} = 3.15714 \times 10^7 \text{ m} \tag{11}$$

While the Hubble radius R_h increases, the gravitational coupling constant α_G decreases.

While the gravitational coupling constant α_G decreases, the electron Compton wavelength λ_e decreases.

From Equations (8) and (11), we deduce how the Hubble radius R_h varies with cosmic time t :

$$R_h(t) = \frac{L_0 t}{T_0} \propto t \tag{12}$$

From Equations (8) and (11) we deduce how the electron Compton wavelength λ_e varies with cosmic time t :

$$\lambda_e(t) = \frac{L_0 T_0}{\pi t} \propto t^{-1} \tag{13}$$

The fundamental unit of mass M_0 is defined as:

$$M_0 = \frac{M_u}{\mu^2} \alpha_G = \frac{m_e}{\alpha_G} = \frac{m_p}{\mu \sqrt{\alpha_G}} = 15.4235 \times 10^7 \text{ kg} \quad (14)$$

While the mass of the observable Universe M_u increases, the gravitational coupling constant α_G decreases. While the gravitational coupling constant α_G decreases, the electron mass m_e decreases.

From Equations (8) and (14), we deduce how the mass of the observable Universe M_u varies with cosmic time t :

$$M_u(t) = \frac{\pi^2 \mu^2 M_0 t^2}{T_0^2} \propto t^2 \quad (15)$$

From Equations (8) and (14), we deduce how the electron mass m_e varies with cosmic time t :

$$m_e(t) = \frac{M_0 T_0^2}{\pi^2 t^2} \propto t^{-2} \quad (16)$$

Prediction 3: The mass and size of the Universe increase with cosmic time.

Prediction 4: The mass and size of particles decrease with cosmic time.

We note that in our hypothesis, the speed of light c remains constant over cosmic time:

$$c = \frac{L_0}{T_0} = 299792458 \text{ m} \cdot \text{s}^{-1} \quad (17)$$

6. The Newtonian Gravitational Constant G

From Equations (5) and (15), we deduce how the Newtonian gravitational constant G varies with cosmic time t :

$$G(t) = \frac{L_0^3}{2\pi^2 \mu^2 T_0 M_0 t} \propto t^{-1} \quad (18)$$

where T_0 , L_0 and M_0 are the fundamental units of time, length and mass as defined in Equations (8), (11) and (14), and μ is the proton to electron mass ratio.

Prediction 5: The Newtonian gravitational constant G decreases with cosmic time as $G \propto t^{-1}$.

We note that this statement is in agreement with Dirac's variable G hypothesis [7].

7. The Planck Constant h

From Equations (10) and (16), we deduce how the Planck constant h varies with cosmic time t :

$$h(t) = \frac{M_0 L_0^2 T_0^2}{\pi^3 t^3} \propto t^{-3} \quad (19)$$

where T_0 , L_0 and M_0 are the fundamental units of time, length and mass as defined in Equations (8), (11) and (14), and μ is the proton to electron mass ratio.

Prediction 6: The Planck constant h decreases with cosmic time as $h \propto t^{-3}$.

8. The Universe Density Time Variation

From Equations (4), (7) and (15), we deduce how the Universe density ρ_u varies with cosmic time t :

$$\rho_u(t) = \frac{3\pi\mu^2 T_0 M_0}{4L_0^3 t} \propto t^{-1} \tag{20}$$

where T_0 , L_0 and M_0 are the fundamental units of time, length and mass as defined in Equations (8), (11) and (14), and μ is the proton to electron mass ratio.

Prediction 7: The Universe density ρ_u decreases with cosmic time as $\rho_u \propto t^{-1}$.

9. The Number of Protons in the Observable Universe

Using Equation (3), we can estimate the number of protons in the observable Universe as follows:

$$N_{pr} = \frac{M_u}{m_{pr}} = \frac{\mu}{\alpha_G^2} = 5.2637 \times 10^{79} \tag{21}$$

where M_u is the mass of the observable Universe, m_{pr} is the proton mass, μ is the proton to electron mass ratio and α_G is the gravitational coupling constant defined using a pair of protons.

From Equations (15) and (16), we deduce how the number of protons in the observable Universe varies with cosmic time t :

$$N_{pr}(t) = \frac{\mu\pi^4 t^4}{T_0^4} \propto t^4 \tag{22}$$

where T_0 , L_0 and M_0 are the fundamental units of time, length and mass as defined in Equations (8), (11) and (14), and μ is the proton to electron mass ratio.

Prediction 8: The number of protons in the Universe increases with cosmic time as $N_{pr} \propto t^4$.

The continuous matter creation predicted by our hypothesis could be considered to violate the law of conservation of energy. However, this would not be the case if it was counterbalanced by a continuous creation of negative gravitational potential energy. This idea has been previously proposed by Jordan [8].

10. The Acceleration of the Universe Expansion

In a Friedmann-Robertson-Walker (FRW) cosmology, the time derivative of the Hubble parameter \dot{H} can be written in terms of the deceleration parameter q :

$$\dot{H} = -H^2(1+q) \tag{23}$$

where H is the Hubble parameter and q is the deceleration parameter.

From Equation (4), we deduce the following equation for the time derivative of the Hubble parameter \dot{H} :

$$\dot{H} = -\frac{1}{t^2} = -H^2 \tag{24}$$

where t is the cosmic time and H is the Hubble parameter.

Joining Equations (23) and (24), we obtain:

$$\dot{H} = -H^2(1+q) = -H^2 \quad (25)$$

From Equation (25), we deduce that the parameter q will always equal zero and therefore the acceleration of the Universe expansion is predicted to be null at all times.

However, the acceleration of the Universe expansion has been confirmed by different measurements [9] [10] [11] [12]. We propose that the measured acceleration of the Universe expansion is merely an illusion induced by the gravitational acceleration of the Universe.

We define the Universe gravitational acceleration g_u as:

$$g_u = \frac{GM_u}{R_h^2} = \frac{c}{2t} = \frac{cH}{2} \quad (26)$$

where G is the Newtonian gravitational constant, M_u is the mass of the observable Universe, R_h is the Hubble radius, c is the speed of light, t is the cosmic time and H is the Hubble parameter.

We define the Universe gravitational acceleration per unit of length a_u as:

$$a_u = \frac{g_u}{R_h} = \frac{1}{2t^2} = \frac{H^2}{2} \quad (27)$$

In an FRW cosmology, the acceleration of the Universe expansion U_{acc} is defined as:

$$U_{acc} = -H^2(q) \quad (28)$$

where H is the Hubble parameter and q is the deceleration parameter.

We propose that the measured acceleration of the Universe expansion will have exactly the same value as the gravitational acceleration of the Universe.

Joining Equations (27) and (28) we obtain:

$$a_u = U_{acc} = -H^2(q) = \frac{H^2}{2} \quad (29)$$

From Equation (29), we deduce that the measured value of the deceleration parameter q will always be -0.5 .

We note that this value is in line with the currently accepted value of -0.55 of the Λ CDM model.

Prediction 9: The measured acceleration of the Universe expansion is an illusion induced by the Universe gravitational acceleration, the real acceleration is null.

Prediction 10: The measured acceleration of the Universe expansion will have exactly the same value as the gravitational acceleration of the Universe.

The value of q being fixed at -0.5 implies that the measured deceleration of the Hubble parameter is also affected by the Universe gravitational acceleration.

In an FRW cosmology, the deceleration of the Hubble parameter is defined as:

$$H_{dec} = H^2(1+q) \tag{30}$$

If the deceleration parameter q is always fixed at -0.5 (as implied by Equation (29)), then the measured acceleration of the Universe expansion will always equal the measured deceleration of the Hubble parameter, and both will always equal the Universe gravitational acceleration.

Joining Equations (29) and (30), we obtain:

$$-H^2(q) = H^2(1+q) = \frac{H^2}{2} \tag{31}$$

Prediction 11: The measured acceleration of the Universe expansion will always equal the measured deceleration of the Hubble parameter.

11. A Fundamental MOND Formula

The velocities of stars in galaxies are observed to be larger than expected based on Newtonian mechanics [13]. This has led scientists to invoke the presence of dark matter in the Universe. We propose that this discrepancy is induced by the Universe gravitational acceleration.

From Equation (26), we calculate the Universe gravitational acceleration g_u :

$$g_u = \frac{GM_u}{R_h^2} = \frac{c}{2t_0} = \frac{cH_0}{2} = 3.4365 \times 10^{-10} \text{ m} \cdot \text{s}^{-2} \tag{32}$$

where G is the Newtonian gravitational constant, M_u is the mass of the observable Universe, R_h is the Hubble radius, c is the speed of light, t_0 is the cosmic time and H_0 is the Hubble parameter.

Taking into account the effect of the Universe gravitational acceleration, we propose the following equation for a star rotation velocity v :

$$v = \sqrt{\frac{GM}{r} + \sqrt{GMg_u}} = \sqrt{\frac{GM}{r} + \sqrt{\frac{GMcH_0}{2}}} \tag{33}$$

where G is the Newtonian gravitational constant, M is the mass of the galaxy, r is the distance of the star from the center of the galaxy, g_u is the Universe gravitational acceleration, c is the speed of light and H_0 is the Hubble constant.

We observe that for large values of r , the equation could take the following simplified form:

$$v^4 = GMg_u \tag{34}$$

We note the similarity with Milgrom MOND's formula [14].

Prediction 12: The rotation curve of galaxies is influenced by the Universe gravitational acceleration.

12. The Weinberg Formula

In his book on Gravitation and Cosmology, Weinberg [15] presented an enigmatic empirical formula linking the mass of an elementary particle, such as a pion, to the fundamental constants G , \hbar , c and the Hubble constant H_0 . To this day, it is not known if this formula is just a coincidence or has an underlying

fundamental significance. We propose that this formula is not a coincidence.

The Weinberg formula is:

$$m_\pi \approx \left(\frac{\hbar^2 H_0}{Gc} \right)^{\frac{1}{3}} \quad (35)$$

where m_π is the mass of a pion, \hbar is the reduced Planck constant, H_0 is the Hubble constant, G is the Newtonian gravitational constant and c is the speed of light.

Equation (4) can be reformulated as:

$$H_0 = \frac{\pi\alpha_G}{t_e} = \frac{\mu^2 m_e^3 Gc}{2\hbar^2} \quad (36)$$

where α_G is the gravitational coupling constant defined using a pair of protons, t_e is the electron Compton time, μ is the proton to electron mass ratio, m_e is the electron mass, G is the Newtonian gravitational constant, c is the speed of light and \hbar is the reduced Planck constant.

Extracting the electron mass m_e and using the value of H_0 in Equation (4), we obtain the exact value for the electron mass m_e (CODATA 2018 [3]):

$$m_e = \left(\frac{2\hbar^2 H_0}{\mu^2 Gc} \right)^{\frac{1}{3}} = 9.1093837 \times 10^{-31} \text{ kg} \quad (37)$$

The equation is very similar to the Weinberg formula. It is also valid for any cosmic time as the values of m_e , G and h vary as per Equations (16), (18) and (19).

13. Discussion

In this paper, we have proposed a cosmological model based on the hypothesis that the quantum realm and the cosmos are linked by a scaling relation. This idea was first proposed by Dirac [7] and is known as the Large Numbers Hypothesis (LNH). The LNH has generated considerable interest [16] and, although it has not been recognized as a viable model, the possible variability of physical constants has not yet been completely ruled out. Unlike the LNH and other propositions with variable physical constants, our approach introduces a very precise relationship between the quantum realm and the cosmos via a set of equations for values such as the Hubble constant, the age and density of the Universe and the measured acceleration of the Universe expansion. The predicted values are in agreement with the currently accepted values and are obtained without any ad hoc parameters. From Equations (20) and (22), we deduce that the Universe started with a finite density and possibly from just one single atom, and from Equations (4) and (7), we deduce that the Universe has never expanded faster than the speed of light and has always been flat, thus removing the need to invoke a period of cosmic inflation [17] to explain the horizon problem [18] and the flatness of the Universe [19]. Our proposal predicts that the acceleration of the Universe expansion is an illusion induced by the gravitational acce-

leration of the Universe, this in turn would remove the need to invoke dark energy [20] to explain the acceleration of the Universe expansion. The same gravitational acceleration is also predicted to increase the velocities of stars in galaxies. Consequently, we have proposed a modified Newtonian equation which, if proved correct, would remove the need to invoke dark matter [21] to explain the dynamics of galaxies and clusters. We note that the problems of dark matter and dark energy could, in principle, also be solved through extended theories of gravity [22]. Our hypothesis predicts a change in scale not only at the cosmological level but also at the quantum level. Although the cosmological scale expansion can easily be confirmed through the Hubble expansion, it is unclear how a quantum scale contraction would be perceived by a human being living in such a universe. We will need to evaluate the possibility of measuring such a change in physical constants if our units of measurement are also changing scale with cosmic time. This question has been raised before with conflicting views [23] [24] and the answer remains uncertain.

14. Conclusion

We have shown that from three simple equations linking the quantum realm and the cosmos, it is possible to build a simple and coherent model of the Universe, where cosmological parameters could be derived simply from quantum parameters. Along with removing the need to invoke components like inflation, dark matter and dark energy to explain cosmological observations, our proposal could provide the basis for a much simpler cosmological model without any ad hoc parameters.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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