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THE NUMERICAL VALUES OF THE FUNDAMENTAL PARAMETERS OF THE MODEL OF SELFVARIATIONS AND THE AGE OF THE UNIVERSE

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ABSTRACT

The law of selfvariations determines quantitatively a slight increase of the rest masses and the electric charges of material particles as a common cause of quantum and cosmological phenomena. At cosmological scales the law of selfvariations can be expressed by two similar differential equations for the rest mass and the electric charge respectively. These equations contain information and justify the totality of the cosmological data. Solving these equations, we introduce two parameters k, A for the rest mass and another two k_1, B, for the electric charge. Knowledge of the numerical values of these four parameters suffices for the accurate determination of the predictions of the law of selfvariations at cosmological scales. In the present article we determine the intervals in which these fundamental parameters obtain their values. As an aside, the conclusion emerges that the age of the Universe is far larger than the one predicted by the Standard Cosmological Model. A very long time of evolution is predicted until the Universe takes the form in which we observe it today.

Keywords: Selfvariations, Age of the Universe

1. INTRODUCTION

The Law of Selfvariations predicts at cosmological scales (Manousos, 2013a) that the rest mass $m_0(r)$ of a material particle at distance r from Earth, i.e., before a time interval $\Delta t = \frac{r}{c}$ from "now", is given by:

$$m_0(r) = m_0(\Delta t) = m_0 \frac{1-A}{1-A\exp\left(-\frac{kr}{c}\right)} = m_0 \frac{1-A}{1-A\exp(-k\Delta t)} \quad (1)$$

where, m_0 is the laboratory value of the rest mass of the same material particle. According to Equation 1 the relation between the rest masses $m_0(r)$ and m_0 is determined by the values of the parameters k and A, while c is the velocity of light in vacuum.

Similarly, for the electric charge q(r) of a material particle, the following equation holds:

$$q(r) = q(\Delta t) = q\frac{1-B}{1-B\exp\left(-\frac{k_1 r}{c}\right)} = q\frac{1-B}{1-B\exp(-k_1\Delta t)} \quad (2)$$

where, q is the laboratory value of the electric charge of the material particle. According to Equation 2 the relation between the electric charges q(r) and q is determined by the parameters k_1 and B.

Between the parameters k and A the following relation holds:

$$\frac{kA}{1-A} = H \quad (3)$$

where, H is Hubble's parameter. Furthermore, for parameter A it holds that Equation 4:

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$$\frac{z}{1+z} < A < 1 \qquad (4)$$

For every value of the redshift z. Between the parameters k_1 and B it holds that:

$$\frac{k_1 B}{1-B} = W \qquad (5)$$

The value of parameter W is calculated (De Laeter *et al*., 1980; King *et al*., 2011; Manousos, 2013c; Meshik *et al*., 2004; Petrov *et al*., 2006; Webb *et al*., 1999; 2001; 2011) to be Equation 6:

$$W = 1.2\times10^{-4}\frac{\text{km}}{\text{sMpc}} \qquad (6)$$

This value of parameter W results from the measurements of the variation of the fine structure constant α (references). Equation 3 and 5, as well as relation (4), result theoretically (Manousos, 2013b; 2013c).

2. REGARDING PARAMETERS K AND A

Relation (4), which is derived theoretically, confines in a relatively small interval the values of parameter A. Thus, we were able to deduce a plethora of conclusions about the justification of the cosmological data (Manousos, 2013a). Knowing the potential values of parameter A and Hubble's parameter H, we can calculate the value of parameter k from Equation 3.

Based on relation (4) we can assume that:

$$A \to 1^- \qquad (7)$$

Condition (7) is compatible with all of the equations of the cosmological model of the selfvariations. The redshift z of distant astronomical objects is given by equation:

$$z = \frac{1-\exp\left(-\frac{kr}{c}\right)}{1-A} - 1 \qquad (8)$$

where, r is the distance of the astronomical object. For $A\to1^-$, Equation 8 gives (Manousos, 2013a) Hubble's law:

$$z = \frac{H}{c}r \qquad (9)$$

Practically, for A>0.999 Equation 8 and 9 coincide.

The luminosity distance R of distant astronomical objects is given as a function of the redshift z (Manousos, 2013a) by equation:

$$R = \frac{cA}{H(1-A)}\sqrt{1+z}\,\ln\left(\frac{A}{A-(1-A)z}\right) \qquad (10)$$

For $A\to1^-$ Equation 10 becomes:

$$R = \frac{c}{H}z\sqrt{1+z} \qquad (11)$$

Practically, for A>0.999 Equation 10 and 11 coincide.

Equation 11 is confirmed by the measured luminosity distances of supernovae (Riess *et al*., 1998; Perlmutter *et al*., 1999) up to z = 1.5. For larger values of the redshift z, the luminosity of supernovae is affected by additional factors (Manousos, 2013a); therefore the measured values can potentially deviate from the prediction of Equation 11.

All equations of the Model of Selfvariations are compatible with the condition $r\to\infty$. They allow us to go as far as we want in the past. We can calculate the value of any parameter, such as the rest mass and electric charge of material particles, the ionization energies of atoms, the binding energies of nucleons, the degree of atomic ionization and the opacity coefficient of the Universe, at any instant in time before «now». Beyond the observable part of the Universe, an enormous Universe that evolved during an enormous time interval is predicted and not the Big Bang (Manousos, 2013a).

One of the predictions of the equations is that the very early Universe asymptotically tends to the vacuum. From Equation 1, for $r\to\infty$, we get:

$$m_0(\infty) = m_0(1-A) \qquad (12)$$

Equation 12 combined with condition $A\to1^-$ gives:

$$m_0(\infty) = m_0(1-A) \to 0 \qquad (13)$$

The physical content of condition (7) is that it predicts that the Universe comes from the vacuum.

One way to take into consideration relations (4) and (7) is to express parameter A in the form:

$$A = 1-10^{-n} \qquad (14)$$

where, $n \in \mathbb{N}, n > 0$. For large values of $n \in \mathbb{N}$ we obtain condition (7).

By combining Equation 1 and 3 we get:

$$m_0(\Delta t) = m_0 \frac{1-A}{1 - A\exp\left(-\frac{H(1-A)}{A}\Delta t\right)} \quad (15)$$

It is easily proven that:

$$\lim_{A \to 1^-} \frac{1-A}{1 - A\exp\left(-\frac{H(1-A)}{A}\Delta t\right)} = \frac{1}{1+H\Delta t}$$

So Equation 15 is written:

$$m_0(\Delta t) = m_0 \frac{1}{1+H\Delta t} \quad (16)$$

From Equation 16 we get:

$$\Delta t = \frac{1}{H}\left(\frac{m_0}{m_0(\Delta t)} - 1\right) \quad (17)$$

From Equation 17 we can calculate the time interval Δt before the present time, for every value of the ratio $\frac{m_0(\Delta t)}{m_0}$. For $\frac{m_0(\Delta t)}{m_0} = 10^{-5}$ Equation 17 gives:

$$\Delta t = \frac{10^5}{H} \quad (18)$$

The time interval Δt is much larger than the age $\frac{1}{H}$ predicted by the Standard Cosmological Model for the Universe. The time interval $\frac{1}{H}$ refers to the recent time interval, in which the Universe has attained the state in which we observe it today and not to the age of the Universe. There has been an enormous amount of time during which the Universe, starting from a state barely different from the vacuum, has evolved because of the selfvariations into the form in which we observe it today.

By considering relation (13) we can give as small a value as we want to the ratio $\frac{m_0(\Delta t)}{m_0}$. Then, through Equation 17, the time interval Δt can obtain any large value.

From Equation 1 we obtain:

$$\Delta t = \frac{1}{k}\ln\left(\frac{A}{1-(1-A)\frac{m_0(\Delta t)}{m_0}}\right) \quad (19)$$

Combining Equation 19 and 3 we get:

$$\Delta t = \frac{A}{H(1-A)}\ln\left(\frac{A}{1-(1-A)\frac{m_0(\Delta t)}{m_0}}\right) \quad (20)$$

For every value of the ratio $\frac{m_0(\Delta t)}{m_0}$ and for every value of parameter A, that is, for every value of $n \in \mathbb{N}$ in Equation 14, we calculate Δt from Equation 20. For large values of $n \in \mathbb{N}$ Equation 17 and 20 coincide.

3. REGARDING PARAMETERS K_1 AND B

Parameter B obeys the inequality (Manousos, 2013a; 2013b; 2013c):

$$0 < B < 1 \quad (21)$$

Therefore, we can write B as:

$$B = 1 - 10^{-v} \quad (22)$$

Here, $v \in \mathbb{R}, v > 0$.

At a distant astronomical object located at distance r, the fusion temperature T(r) of hydrogen compared with the corresponding laboratory temperature $T \sim 2 \times 10^8$K, is given (Manousos, 2013c) by equation:

$$T(r) = T\left(\frac{1-B}{1 - B\exp\left(-\frac{k_1 r}{c}\right)}\right)^2 \quad (23)$$

At the same time, the binding energy $\Delta m_0(r)c^2$ of the nucleons at the distant astronomical object is smaller than the corresponding laboratory value $\Delta m_0 c^2$ (Manousos, 2013b), according to equation:

$$\frac{\Delta m_0(r)c^2}{\Delta m_0 c^2} = \frac{1-A}{1-A\exp\left(-\frac{kr}{c}\right)} \quad (24)$$

Therefore, at the very distant past, in the very early Universe, nucleosynthesis and hydrogen fusion can take place at very low temperatures, close to 0K. Indeed, for r→∞ Equation 24 gives:

$$\frac{\Delta m_0(r)c^2}{\Delta m_0 c^2} \to 1-A \to 0 \quad (25)$$

From this starting point, we can estimate a lower value for parameter B. In the very early Universe, for r→∞, Equation 23 gives:

$$T(\infty) = T(1-B)^2 \quad (26)$$

If the fusion of hydrogen took place before the creation of the Cosmic Microwave Background Radiation (CMBR), we see that:

$$T(\infty) < 2.726\text{K}$$

From Equation 26 we obtain:

$$T(1-B)^2 < 2.726\text{K}$$

And for $T \sim 2\times10^8$ K we get:

$$2\times10^8(1-B)^2 < 2.728$$

That is:

$$1-B < 1.16\times10^{-4} \quad (27)$$

From relation (27) we get:

$$B > 1-1.16\times10^{-4} \quad (28)$$

After combining relations (27) and (22) we obtain:

$$10^{-v} < 1.16\times10^{-4}$$

And finally:

$$v > 3.93 \quad (29)$$

Furthermore, by combining relations (21) and (28) we get:

$$1-1.16\times10^{-4} < B < 1 \quad (30)$$

Relation (30) is a good estimation of the values taken by parameter B. We get the same estimation from inequality (29) through Equation 22.

From Equation 23 we get:

$$\frac{r}{c} = \frac{1}{k_1}\ln\left(\frac{B}{1-(1-B)\sqrt{\frac{T}{T(r)}}}\right) \quad (31)$$

From Equation 31 we obtain the time interval $\Delta t = \frac{r}{c}$ before «now», when the temperature of the Universe had a specific value T(r) = T (Δt):

$$\Delta t = \frac{1}{k_1}\ln\left(\frac{B}{1-(1-B)\sqrt{\frac{T}{T(\Delta t)}}}\right) \quad (32)$$

Combining Equations 32 and 5 we see that:

$$\Delta t = \frac{B}{W(1-B)}\ln\left(\frac{B}{1-(1-B)\sqrt{\frac{T}{T(\Delta t)}}}\right) \quad (33)$$

It is easy to see that, for v>5 in Equation 22, the time interval given by Equation 33 does not depend on v and is given by equation:

$$\Delta t = \frac{1}{W}\left(\sqrt{\frac{T}{T(\Delta t)}}-1\right) \quad (34)$$

Given that $T \sim 2\times10^8$ K and that we know the value of parameter W:

$$W \approx 1.2\times10^{-4}\frac{\text{km}}{\text{sMpc}} \approx 4\times10^{-24}\text{s}^{-1} \quad (35)$$

We can calculate the time interval Δt for every value of the temperature T(Δt)<2.726K. For example, if T(Δt)

= 2K, from Equation 34 we get $\Delta t = \frac{1}{W}\left(10^{-4} - 1\right)$ and with Equation 35 we have that Δt = 2.5×10^{27} s = 8×10^{19} year. For T(Δt)<2K the time interval Δt resulting from Equation 34 is even larger.

4. COMPARISON OF PARAMETERS A AND B

If we know the values of parameters A and B, we can calculate the values of parameters k and k_1 from Equation 3 and 5 respectively. Thus, we focus our study on parameters A and B.

The analysis of the equations of the cosmological model of the selfvariations leads to the conclusion that:

$$B < A \tag{36}$$

According to Equation 12 the rest mass of the material particles in the very early Universe tends to zero, as $A \to 1^-$. This conclusion is absolutely normal within the framework of the theory of selfvariations. But we cannot make the same claim for the electric charge.

From Equation 2 and for the very early Universe, theoretically for $r \to \infty$, we get:

$$q(\infty) = q(1 - B) \tag{37}$$

In contrast to the rest mass, the electric charge exists in the Universe as pairs of opposite physical quantities. Therefore, we cannot claim that $q(\infty) \to 0$, which is equivalent to the condition $B \to 1^-$. The initial value q(1-B)<q of the electric charge can have any value smaller than the laboratory value q. Therefore, comparing Equation 12 and 37 we obtain $1 - A = \frac{m_0(r)}{m_0} < \frac{q(r)}{q} = 1 - B$ and, therefore, B<A. We arrive at the same conclusion by different calculations. In this paragraph we will perform one such calculation based on the Thomson και Klein-Nishina scattering coefficients in the very early Universe.

Before a time interval $\Delta t = \frac{r}{c}$ from «now», for the Thomson and Klein-Nishina scattering coefficients it holds that:

$$\frac{\sigma(r)}{\sigma} = \frac{\sigma(\Delta t)}{\sigma} = \left[\frac{1 - A\exp\left(-\frac{kr}{c}\right)}{1 - A}\left(\frac{1 - B}{1 - B\exp\left(-\frac{k_1 r}{c}\right)}\right)^2\right]^2 \tag{38}$$

where, σ is the laboratory value. The selfvariation of the electric charge evolves at a much slower rate ($\sim10^{-6}$) than the selfvariation of the rest mass. Thus, considering that the value of the electric charge remains practically constant for a large enough distance r, we can neglect, at a first approximation, the consequences of the selfvariation of the electric charge (Manousos, 2013a) writing Equation 38 in the form:

$$\frac{\sigma(r)}{\sigma} = \frac{\sigma(\Delta t)}{\sigma} = \left[\frac{1 - A\exp\left(-\frac{kr}{c}\right)}{1 - A}\right]^2 \tag{39}$$

In the very distant past, for large values of r, theoretically for $r \to \infty$, we obtain from Equation 39:

$$\frac{\sigma(\infty)}{\sigma} = \frac{1}{(1 - A)^2} \tag{40}$$

From Equation 39 for $A \to 1^-$ we see that the Thomson και Klein-Nishina scattering coefficients σ(∞) obtained enormous values in the very distant past, rendering the very early Universe opaque.

Taking also into account the selfvariation of the electric charge, we obtain from Equation 38 for $r \to \infty$, equation:

$$\frac{\sigma(\infty)}{\sigma} = \left[\frac{(1 - B)^2}{(1 - A)}\right]^2 \tag{41}$$

According to Equation 41 the opacity of the very early Universe depends both upon the value of parameter A, as well as on the value of parameter B. By demanding that:

$$\frac{\sigma(\infty)}{\sigma} = \left[\frac{(1 - B)^2}{(1 - A)}\right]^2 >> 1 \tag{42}$$

We correlate parameters A and B.

From relation (42) we get $(1-B)^2 > 1-A$ and with Equation 14 and 22 we get $10^{-2v} > 10^{-n}$ and finally:

$$v < \frac{n}{2} \tag{43}$$

For example we can set n = 14, v = 5 and from Equation 41 we get $\frac{\sigma(\infty)}{\sigma} = 10^8$. For different values of n and v this ratio can obtain extremely large values, rendering the very early Universe opaque.

We can perform accurate calculations regarding the Thomson and Klein-Nishina scattering coefficients based on Equation 38. However, it is not certain that the sensitivity of the observational instruments at our disposal suffices to confirm the prediction of such detailed calculations. At any case, Equation 38 gives the values of the scattering coefficients at a time interval $\Delta t = \frac{r}{c}$ before «now».

5. RESULTS

The fundamental parameters A and B are given by equations A = $1\text{-}10^{-n}$ and B = $1\text{-}10^{-v}$, respectively. Knowledge of the real numbers n and v determines the values of parameters A and B. Then, through relations $\frac{kA}{1-A} = H$ and $\frac{k_1 B}{1-B} = W$ we calculate parameters k and k_1. The calculation of parameters k, A, k_1, B suffices for the accurate determination of the predictions of the cosmological model of the selfvariations.

As a side consequence of our calculations, it emerges that the age of the Universe is far larger than the one predicted by the Standard Cosmological Model. The time interval $\frac{1}{H}$ corresponds to the very recent past, when the Universe had the form we observe today. This was preceded by a much longer time interval, during which the Universe evolved, because of the selfvariations, from an initial state only slightly different from the vacuum, into the state in which we observe it today. Beyond the limits of the observable Universe, the law of selfvariations predicts an entirely different state than the Big Bang.

6. DISCUSSION

At the end of the last century, Physics possessed a large amount of knowledge, both at the theoretical as well as the experimental level. We made the estimation that this knowledge would suffice to attempt to determine a common cause, if it existed, which could justify it. A cause for experimental and observational data, as well as theoretical results, which at first glance seemed unrelated. At the same time, we expected this cause to simplify the way we comprehend physical reality. Following this reasoning we arrived at the law of selfvariations. Of course, a large theoretical analysis had to be done, since the consequences of the selfvariations permeate the whole corpus of the science of Physics. This was expected, since we were seeking a common cause for the enormous amount of data we possessed.

From the very beginning, it was obvious that the first branch of Physics where we could test the validity and the consequences of the law of selfvariations was Cosmology. The reason is simple: With observations made at cosmological scales, the consequences of the selfvariations are directly recorded by the observational instruments. Today we know that the law of selfvariations justifies the totality of the cosmological data. Furthermore, we know that the measurement of only two numbers, n and v, is enough for the exact determination of the predictions of the law. But in order to reach this point, we had to have the measurement of Hubble's parameter H and of parameter W by J.K. Webb and all the researchers who worked for this purpose for more than twenty years. It is telling that, although we knew the whole theoretical framework regarding the selfvariation of the electric charge, we could not predict its consequences because we did not know the value, or even the order of magnitude of parameter W. After its measurement, it emerged that the law of selfvariations includes as information and justifies a set of cosmological data recorded by modern observational instruments, which cannot be justified by the Standard Cosmological Model. The same weakness is shared by all cosmological models that have at their core the expansion of the Universe as the cause of cosmological data. We are referring to the temperature difference between the Northern and Southern hemispheres of the Universe, the fluctuation of the fine structure constant, the fluctuation of the CMBR temperature, the absence of antimatter from the Universe and other detailed measurements we are now in a position to perform. The selfvariation of the electric charge evolves at an extremely slow rate, as results from the relation $\frac{W}{H} = 1.8 \times 10^{-6}$ between parameters H and W. The greater sensitivity of modern observational instruments and the persistent efforts of the researchers resulted in the eventual measurement and recording of the consequences from the selfvariation of the electric charge.

At cosmological scales, the law of selfvariations gives two similar differential equations for the rest mass and the electric charge, respectively. The solution of the two differential equations leads to specific conclusions that cannot be altered or modified a posteriori. In other words, we cannot follow the tactic of the standard cosmological model to introduce further assumptions as the set of cosmological data expands. The hypotheses of inflation and dark energy are just two, perhaps the most characteristic, introduced by the standard cosmological model. Until we arrived at the measurement of the consequences of the selfvariation of the electric charge (the ones we mentioned in the previous paragraph), when there is no longer a hypothesis that could be made by the Standard Model to justify them.

In the solution of the differential equations of the law of selfvariations, only the integration constants are introduced. Thus, we are led to the fundamental parameters A and B, whose measurement suffices for the accurate determination of the predictions of the cosmological model of selfvariations. In this article we presented the study of the numerical values obtained by parameters A and B.

7. CONCLUSION

There exist specific values of the fundamental parameters of the cosmological model of selfvariations, which justify the totality of the cosmological data. The consequences of a physical law are directly recorded in the cosmological data, despite their great variety. The selfvariations affect the totality of our knowledge in Physics and their consequences are directly observable at cosmological distances. Therein lies the reason for the great variety of cosmological data recorded by modern observational instruments.

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