CHAPTER 16

16 THE COSMOLOGICAL DATA AS A CONSEQUENCE OF THE THEOREM OF INTERNAL SYMMETRY

16.1. Introduction.

The theorem 3.3, that is the theorem of internal symmetry, predicts and justifies the cosmological data. We present the relevant study in this chapter.

The emission of the electromagnetic spectrum of the far-distant astronomical objects we observe today took place a long time interval ago. At the moment of the emission the rest mass and the electric charge of the material particles had smaller values than the corresponding ones measured in the laboratory, "now", on Earth, due to the manifestation of the Self-variation. The consequences resulting from this difference are recorded in the cosmological data: the cosmological data have a microscopic and not a macroscopic cause. The Theory of Self-variation gives a new paradigm for the Universe.

Due to the Self-variation of the rest masses of the material particles the total mass/energy of the Universe asymptotically tends to zero, $m_0c^2 \to 0$ and $E_0 \to 0$. For this reason, the gravitational interaction cannot play the role attributed to it by the Standard Cosmological Model. The gravitational interaction cannot cause either the collapse or the expansion of the Universe. The Universe is flat and static, according to the principle of Self-variation. The role of gravity is limited to the creation of the large structures of the Universe.

16.2. The redshift of the distant astronomical objects.

For a non- moving particle, that is for $J_1 = J_2 = J_3 = 0$, from equation (3.12) we get that $c_1 = c_2 = c_3 = 0$ and from equation (3.9) we obtain

$$\Phi = K \exp\left(-\frac{b}{\hbar} c_0 x_0 \right)$$

$$b, K \in \mathbf{R}$$

and since $x_0 = ict$, we have

$$\Phi = K \exp\left(-\frac{bicc_0}{\hbar} t \right)$$

and from equation (3.10) we obtain

$$m_0 = m_0(t) = \pm \frac{M_0}{1 + K \exp\left(-\frac{bicc_0}{\hbar} t \right)}. \tag{16.1}$$

The rest mass m_0 of the material particle is a function of time t.

We now denote by k the constant

$$k = -\frac{bicc_0}{\hbar}$$

and from equation (3.5) we have

$$k = -\frac{bicc_0}{\hbar} = \frac{b(W+E)}{\hbar}. \tag{16.2}$$

We also denote by A the time-dependent function

$$A = A(t) = -K \exp(kt) = -\Phi. \tag{16.3}$$

With denote $A = -\Phi$, in order of the equations of this chapter to have the same parameters with the already published articles, about the consequences self-variation in cosmological scale (Manousos, 2007).

Following this notation, equation (16.1) is written as

$$m_0 = m_0(t) = \pm \frac{M_0}{1 - A}. \tag{16.4}$$

From equation (16.3) we have

$$\frac{dA}{dt} = \dot{A} = kA. \tag{16.5}$$

for the expression of the parameter $A(t)$. Similarly, using the above notation equation (3.11) is written as

$$E_0 = E_0(t) = \mp \frac{M_0 c^2 A}{1-A}. \tag{16.6}$$

We consider an astronomical object at distance r from Earth. The emission of the electromagnetic spectrum of the far-distant astronomical object we observe "now" on Earth has taken place before a time interval $\delta t = t - \frac{r}{c}$. From equation (16.3) we have that the parameter A obtained the value

$$A = A(r) = A(t) exp\left(-k\frac{r}{c}\right)$$

and from equation (16.4) we have

$$m_0(r) = \pm \frac{M_0}{1 - A\exp\left(-k\frac{r}{c}\right)}. \tag{16.7}$$

Similarly from equation (16.6) we have

$$E_0(r) = \mp \frac{M_0 c^2 A\exp\left(-k\frac{r}{c}\right)}{1 - A\exp\left(-k\frac{r}{c}\right)}. \tag{16.8}$$

From equations (16.4) and (16.7) we have

$$m_0(r) = m_0 \frac{1-A}{1 - A\exp\left(-k\frac{r}{c}\right)}. \tag{16.9}$$

We can prove that for the electric charge q of the material particles an equation analogous to equation (16.7) is valid. From equation (4.2) we derive an equation corresponding to equation (16.9), which is the following equation

$$q(r) = q\frac{1-B}{1-B\exp\left(-k_1\frac{r}{c}\right)}. \tag{16.10}$$

In equation (16.10) the parameter $B = B(t)$ is the same as the parameter $A = A(t)$ of equation (16.9). We also have corresponding to the equation (16.5), $\frac{dB}{dt} = \dot{B} = k_1 B$ (see paragraph 16.12).

In the context of the theory of Self-variation and in the macroscopic scale, the electric charge q of the electron is a function of time, as given by equation (16.10). Therefore, the fine structure constant α is defined as

$$\alpha = \frac{q^2}{4\pi\varepsilon_0 c\hbar} \tag{16.11}$$

and using equation (16.10) we obtain

$$\alpha(r) = \alpha\left(\frac{1-B}{1-B\exp\left(-k_1\frac{r}{c}\right)}\right)^2. \tag{16.12}$$

The energy of the electron in the atom is

$$E_n = -\frac{1}{n^2}\frac{Z^2K^2m_0q^4}{2\hbar^2}$$
$$n = 1, 2, 3, \ldots$$

where m_0 is the rest mass and q is the electric charge of the electron, Z is the atomic number and K is Coulomb's constant (Bohr, 1913 and Schrödinger, 1925). The wavelength λ is inversely proportional to the photon energy E, $\lambda = \frac{ch}{E}$ (Planck, 1901). Therefore, the wave length λ of the linear spectrum is inversely proportional to the factor m_0q^4. If we denote by λ_0 the wavelength of a photon emitted by an atom “now” on Earth, and by λ the same wavelength of the same atom received “now” on Earth from the far-distant astronomical object, the following relation holds:

$$\frac{\lambda}{\lambda_0} = \frac{m_0q^4}{m_0(r)q^4(r)}$$

and from equations (16.9) and (16.10) we obtain

$$\frac{\lambda}{\lambda_0}=\frac{1-A\exp\left(-k\frac{r}{c}\right)}{1-A}\left(\frac{1-B\exp\left(-k_1\frac{r}{c}\right)}{1-B}\right)^4. \tag{16.13}$$

From equation (16.13) we have for the redshift

$$z=\frac{\lambda-\lambda_0}{\lambda_0}=\frac{\lambda}{\lambda_0}-1$$

of the astronomical object that

$$z=\frac{1-A\exp\left(-k\frac{r}{c}\right)}{1-A}\left(\frac{1-B\exp\left(-k_1\frac{r}{c}\right)}{1-B}\right)^4-1. \tag{16.14}$$

Equation (16.14) can also be written as

$$z=\frac{1-Aexp\left(-k\frac{r}{c}\right)}{1-A}\left(\frac{\alpha}{\alpha(r)}\right)^2-1 \tag{16.15}$$

after considering equation (16.12).

From the cosmological data and from measurements conducted on Earth, we know that the variation of the fine structure constant is extremely small (Webb, 2011). Therefore, from equation (16.15), we obtain with extremely accurate approximation

$$z=\frac{1-A\exp\left(-k\frac{r}{c}\right)}{1-A}-1$$

$$z=\frac{A}{1-A}\left(1-e^{-\frac{kr}{c}}\right). \tag{16.16}$$

Equation (16.16) holds with great accuracy. The variation of the fine structure constant is so small, so that any contribution t redshift is overlapped by the same contributions from the far-distant astronomical objects, due to Doppler's effect (Doppler, 1842).

For small distances r, we obtain from equation (16.16)

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

$$z = \frac{kA}{c(1-A)}r$$

and comparing this with Hubble's law (Hubble, 1929)

$$cz = Hr$$

we get

$$\frac{kA}{1-A} = H \tag{16.17}$$

where H is Hubble's parameter.

From equation (16.17) we have

$$\frac{dH}{dt} = \dot{H} = \frac{k\dot{A}(1-A) + kA\dot{A}}{(1-A)^2}$$

$$\dot{H} = \frac{k\dot{A}}{(1-A)^2}$$

and with equation (16.5) we obtain

$$\dot{H} = \frac{k^2 A}{(1-A)^2}$$

and from equation (16.17) we have

$$\dot{H} = \frac{H^2}{A}. \tag{16.18}$$

For

$$\frac{m_0c^2}{M_0c^2} > 0 \wedge \frac{E_0}{M_0c^2} < 0 \text{ or } \frac{m_0c^2}{M_0c^2} < 0 \wedge \frac{E_0}{M_0c^2} > 0$$

we have

$$\frac{m_0c^2}{M_0c^2}\frac{E_0}{M_0c^2} < 0$$

and with equations (3.10) and (3.11) we have

$$\frac{\Phi}{(1+\Phi)^2} < 0$$

$$\Phi < 0$$

and with equation (16.3) we finally get

$$\begin{aligned} &\Phi < 0 \\ &A = -\Phi > 0 \end{aligned}. \qquad (16.19)$$

From equation (16.17) we have

$$\frac{kA}{1-A} > 0$$

and considering relation (16.19) we get two combinations for the constant k and the parameter A:

$$\begin{aligned} &0 < A < 1 \wedge k > 0 \Leftrightarrow 0 < 1+\Phi < 1 \wedge k > 0 \\ &A > 1 \wedge k < 0 \Leftrightarrow 1+\Phi < 0 \wedge k < 0 \end{aligned}. \qquad (16.20)$$

From equations (16.7) and (16.8) it follows that the sign change of the constant k is equivalent with the interchange of the roles of the rest masses m_0 and $\frac{E_0}{c^2}$. Hence it suffices to present the conclusions resulting from the first case of (16.20) (see transformation (8.28)).

For $k > 0$, for equation (16.16) we have

$$\lim_{r\to\infty} z = \frac{A}{1-A}. \qquad (16.21)$$

The redshift has an upper limit which depends on the value of the parameter A, even in the case that the Universe extends to infinity. In the case the Universe has finite extension, let $r_{\max} = R$ and from equation (16.16) we have

$$z_{\max} = \frac{A}{1-A}\left(1-e^{-\frac{kR}{c}}\right). \qquad (16.22)$$

Thus redshift has a maximum value. The upper redshift limit of equation (16.21) and $z_{\max}$ of equation (16.22) are almost equal.

From equations (16.16) and (16.5) we get after the calculations

$$\frac{dz}{dt} = \dot{z} = \frac{kA}{(1-A)^2}\left(1 - e^{-\frac{kr}{c}}\right)$$

and with equation (16.17) we have

$$\dot{z} = \frac{H}{1-A}\left(1 - e^{-\frac{kr}{c}}\right) = \frac{H}{A} z > 0. \tag{16.23}$$

Thus the redshift of far distant astronomical objects increases slightly with the passage of time.

According to equation (16.21) it is

$$z < \frac{A}{1-A}$$

and because of $1 - A > 0$ we have

$$\frac{z}{1+z} < A$$

and because of $A < 1$ we have

$$\frac{z}{1+z} < A < 1. \tag{16.24}$$

From the inequality (16.24) it follows that

$$A \to 1^{-}. \tag{16.25}$$

We prove now that as $A \to 1^{-}$ the equation (16.16) tends to Hubble's law $cz = Hr$. Let $x = \frac{1-A}{A}$ then $x \to 0^{+}$ for $A \to 1^{-}$, while from equation (16.17) we get $k = xH$ and equation (16.16) may be written as

$$z = \frac{1}{x}\left[1 - \exp\left(-x\frac{Hr}{c}\right)\right].$$

Hence we get

$$\lim_{A \to 1^{-}} z = \lim_{x \to 0^{+}} \frac{1}{x}\left[1 - \exp\left(-x\frac{Hr}{c}\right)\right] = \frac{Hr}{c}.$$

From relation (16.5) follows the conclusion that

$$\frac{dA}{dt} = kA > 0\,. \tag{16.26}$$

Thus the parameter A increases with the passage of time. Hence according to the aforementioned proof, the equation (16.16) tends to the Hubble law with the passage of time.

16.3. The rate of change of the rest mass of the electron as a function of the redshift of distant astronomical objects.

Combining equations (16.9) and (16.16) we have

$$m_0(z) = \frac{m_0}{1+z}\,. \tag{16.27}$$

The equation (16.27) has multiple consequences on the cosmological scale.

According to equation (16.27) the gravitational interaction between two astronomical objects is smaller than expected by the factor $\frac{1}{1+z}$. The redshift z depends on their distance r as given in equation (16.16). This is the redshift that an observer on one object would measure by observing the other object. As a consequence of self-variation, the redshift is due to the different position of objects in cosmological scale.

For the solar system or for the structure of a galaxy or a galaxy cluster, equation (16.27) has no consequences. On this distance scale we practically have $z = 0$. However we can seek consequences on this scale from another equation. From equation (16.4) we have

$$\frac{dm_0}{dt} = \dot{m}_0 = \pm \frac{M_o \dot{A}}{(1-A)^2}$$

and from equation (16.4) we have

$$\dot{m}_0 = m_0 \frac{\dot{A}}{1-A}$$

and with equation (16.5) we get

$$\frac{\dot{m}_0}{m_0} = \frac{kA}{1-A}$$

and with equation (16.17) we get

$$\frac{\dot{m}_0}{m_0} = H \qquad (16.28)$$

for the rest mass of the electron.

Equation (16.28) concerns the mass $m_0 = m_0(t)$. Therefore its consequences can be found in the stellar systems of our galaxy or even in the solar system. In any case the experimental verification of equation (16.28) requires measurements with sensitive instruments of observation. The currently existing projects for the measurement of a possible variant of the constant of gravity G, can measure the consequences of the equation $m_0 = m_0(t)$.

16.4. The energy of distant astronomical objects as a function of the redshift.

From equations $E = mc^2$ (Einstein, 1905) and (16.27) we have

$$E(z) = \frac{E}{1+z} \qquad (16.29)$$

in every case of transformation of mass m to energy E. The production of energy in the Universe is mainly achieved via hydrogen fusion and nuclear reactions. Therefore the energy produced in the past in the far distant astronomical objects was smaller than the corresponding energy produced today in our galaxy through the same mechanism. This fact has two immediate consequences.

The first is that equation (16.16) is valid for the redshift z_a of the radiation which results from accelerated/decelerated electrons

$$z_a = \frac{A}{1-A}\left(1 - e^{-\frac{kr}{c}}\right). \qquad (16.30)$$

And hence for the continuous spectrum. Similar mechanisms which accelerate electrons in our galaxy and in far distant astronomical objects do not give the same amount of energy to the electrons. According to equation (16.29) the energy which is supplied to the electrons in far distant astronomical objects is less than the corresponding energy in our galaxy.

The second consequence concerns the luminosity distance D of far distant astronomical objects. The overall decrease of the energy produced in the past, due to equation (16.29) has as a consequence the overall decrease of luminosities of distant astronomical objects. From the definition of the luminosity distance D it follows easy that

$$D = r\sqrt{1+z}\,. \tag{16.31}$$

Between the distance r of the astronomical object and the distance D measured from its luminosity. The luminosity distance D is measured always larger than the real distance of the astronomical object. In the frame of Self-variation Theory, the real distance r of the distant astronomical object is given by equation

$$r = \frac{c}{k}\ln\left(\frac{A}{1-z(1-A)}\right) \tag{16.32}$$

which follows from equation (16.16). The distance measurement from equation (16.32) can be made if we know the constant k and the parameter A. Generally, due to equation (16.17), $(1-A)H = kA$, it suffices to know two of the parameters k, A, H.

16.5. The ionization and excitation energies of atoms as a function of redshift of the distant astronomical objects.

The ionization energy as well as the excitation energy X_n of atoms is proportional to the factor $m_0 q^4$, where m_0 is the rest mass and q the electric charge of the electron. Hence we get

$$\frac{X_n(r)}{X_n} = \frac{m_0(r)}{m_0}\left(\frac{q(r)}{q}\right)^4$$

$$\frac{X_n(r)}{X_n} = \frac{m_0(r)}{m_0}\left(\frac{\alpha(r)}{\alpha}\right)^2$$

and because of

$$\frac{\alpha(r)}{\alpha} \approx 1$$

we have

$$\frac{X_n(r)}{X_n} = \frac{m_0(r)}{m_0}$$

and with equation (16.27) we have

$$\frac{X_n(r)}{X_n} = \frac{X_n(z)}{X_n} = \frac{1}{1+z}$$

$$X_n(r) = X_n(z) = \frac{X_n}{1+z} \tag{16.33}$$

From equation (16.33) we conclude that the ionization and excitation energies of atoms decrease with increasing redshift. This fact has consequences on the degree of ionization of atoms in the distant astronomical objects.

The number of excited atoms in a gas in a state of thermodynamic equilibrium is given by Boltzmann's equation

$$\frac{N_n}{N_1} = \frac{g_n}{g_1}\exp\left(-\frac{X_n}{KT}\right) \tag{16.34}$$

where N_n is the number of atoms at energy level n, X_n the excitation energy from the 1st to the n^{th} energy level, $K = 1.38\times10^{-23}\,JK^{-1}$ Boltzmann's constant, T the temperature in degrees Kelvin, and g_n the multiplicity of level n, i.e. the number of levels into which level n is split apart inside a magnetic field.

Combining equations (16.33) and (16.34) we get

$$\frac{N_n}{N_1} = \frac{g_n}{g_1}\exp\left(-\frac{X_n}{KT(1+z)}\right). \tag{16.35}$$

For the hydrogen atom for $n = 2, X_2 = 10.5eV = 16.4\times10^{-19}J, g_1 = 2, g_2 = 8$ and at the surface of the Sun where $T = 6000K$ equation (16.34) implies that just one in 10^8 atoms is at state $n = 2$. Correspondingly from equation (16.35) and for $z = 1$ we have $\frac{N_2}{N_1} = 2.2\times10^{-4}$, for $z = 2$ we have $\frac{N_2}{N_1} = 5.8\times10^{-3}$, and for $z = 5$ we have $\frac{N_2}{N_1} = 0.15$.

Considering equation (16.21) we get from equation (16.33)

$$X_n(r\to\infty) = X_n\cdot(1-A). \tag{16.36}$$

Considering relations (16.24) and (16.25) we conclude that the ionization and excitation energies of atoms tend to zero in the very early Universe. The Universe went through an ionization phase in until this point.

16.6. The Thomson and Klein-Nishina scattering coefficients as a function of redshift of the distant astronomical objects.

The laboratory value of the Thomson scattering coefficient is given by equation

$$\sigma_{\mathrm{T}} = \frac{8\pi}{3}\frac{q^4}{m_0^2 c^4} \tag{16.37}$$

where m_0 is the rest mass and q the electric charge of the electron. Thus we have

$$\frac{\sigma_T(z)}{\sigma_T} = \left(\frac{m_0}{m_0(z)}\right)\left(\frac{\alpha}{\alpha(z)}\right)^2$$

and because of $\alpha(z) \sim \alpha$ we get

$$\frac{\sigma_T(z)}{\sigma_T} = \left(\frac{m_0}{m_0(z)}\right)^2$$

and with equation (16.27) we have

$$\frac{\sigma_T(z)}{\sigma_T} = (1+z)^2 . \tag{16.38}$$

The Thomson coefficient concerns the scattering of photons with low energy E. For photons with high energy E the photon scattering is determined from the Klein-Nishina coefficient:

$$\sigma = \frac{3}{8}\sigma_T \frac{m_0}{E}\left[\ln\left(\frac{2E}{m_0 c^2}\right) + \frac{1}{2}\right] \tag{16.39}$$

in the laboratory and

$$\sigma(z) = \frac{3}{8}\sigma_T(z)\frac{m_0(z)c^2}{E(z)}\left[\ln\left(\frac{2E(z)}{m_0(z)c^2}\right) + \frac{1}{2}\right] \tag{16.40}$$

in astronomical objects with redshift z. From equations (16.27) and (16.29) we have

$$\frac{m_0(z)}{E(z)}=\frac{m_0}{E}$$

hence from equation (16.40) we get

$$\sigma(z)=\frac{3}{8}\sigma_T(z)\frac{m_0c^2}{E}\left[\ln\left(\frac{2E}{m_0c^2}\right)+\frac{1}{2}\right]$$

and with equation (16.38) we have

$$\frac{\sigma(z)}{\sigma}=\frac{\sigma_T(z)}{\sigma_T}=(1+z)^2. \tag{16.41}$$

From equation (16.41) we conclude that the Thomson and Klein-Nishina scattering coefficients increase with redshift and indeed in the same manner. Considering equation (16.21) we have

$$\frac{\sigma(r\to\infty)}{\sigma}=\frac{\sigma_T(r\to\infty)}{\sigma_T}=\frac{1}{(1-A)^2}. \tag{16.42}$$

Considering equations (16.24) and (16.25) we conclude that the Thomson and Klein-Nishina scattering coefficients had enormous values in the very early Universe. In its initial phase the Universe was totally opaque. From this initial phase stems the Cosmic Microwave Background Radiation (Penzias and Wilson, 1965) we observe today.

The internal symmetry theorem 3.3 predicts that the initial Universe was at a 'vacuum state' with temperature $T\to 0K$. Due to the Self-variation the Universe evolved to the state we observe today. This evolution agrees with the fact that the Cosmic Microwave Background Radiation corresponds to a black body radiation with temperature T about $2.73K$.

16.7. The position-momentum uncertainty as a function of redshift of the distant astronomical objects.

Combining equations (3.11) and (16.3) we have in the laboratory

$$J_i=\frac{c_i}{1-A(t)}, i=0,1,2,3$$

and

$$J_i(r) = \frac{c_i}{1 - A\left(t - \frac{r}{c}\right)} = \frac{c_i}{1 - A\exp\left(-\frac{kr}{c}\right)}, i = 0,1,2,3$$

for an astronomical object at distance r, and combining these two equations with equation (16.9) we get

$$\frac{J_i(r)}{J_i} = \frac{m_0(r)}{m_0}$$

and with equation (16.27) we have

$$\frac{J_i(z)}{J_i} = \frac{1}{1+z}$$

$$J_i(z) = \frac{J_i}{1+z}, i = 0,1,2,3. \tag{16.43}$$

From the position-momentum uncertainty (see equations (19.4), (19.7)), for the axis $x_1 = x$ we have

$$J_1 \Delta x = \hbar$$

in the lab, and

$$J_1(z)\Delta x(z) = \hbar$$

for the astronomical object, and combining these two relations we get

$$J_1(z)\Delta x(z) = J_1 \Delta x$$

and with equation (16.43) we have

$$\Delta x(z) = (1+z)\Delta x. \tag{16.44}$$

From equation (16.44) we conclude that the uncertainty $\Delta x(z)$ of position of a material particle increases with redshift. Moreover as the Universe evolved towards the state we observe today, the uncertainty of position of material particles was decreasing.

From equations (16.44) and (16.21) we have

$$\Delta x(r \to \infty) = \frac{\Delta x}{1-A}. \tag{16.45}$$

Considering relations (16.24) and (16.25) we conclude that in the very early Universe there existed great uncertainty of position of material particles. The same conclusions arise for the Bohr radius R_{Bohr},

$$R_{Bohr}(z) = (1+z) R_{Bohr}$$

$$R_{Bohr}(r \to \infty) = \frac{R_{Bohr}}{1-A}. \tag{16.45b}$$

In the chapter 19 we will see that the theory of Self-variation agrees with the uncertainty principle (see equations (19.4), (19.8)).

16.8. The early Universe. The evolution of the Universe.

From equation (16.33) it follows that as the Universe evolved to the state we observe today the ionization energy increased. This prediction is generally valid for any kind of negative dynamical energies which bind together material particles to produce more complex particles. From equation (16.27) we have

$$\Delta m_0(z) c^2 = \frac{\Delta m_0 c^2}{1+z} \tag{16.46}$$

for the energy $\Delta m_0 c^2$, the mass deficiency, which ties together the particles which constitute the nuclei of the elements. According to equation (16.46) the energy $\Delta m_0 c^2$, like the ionization energies, increased as the Universe evolved towards its present state.

Particles like the electron, which today are considered fundamental may in fact be composed of other particles. Our inability to break them apart could be due to the strengthening of the binding energies of the constituent particles. The mass M_0 in equation (3.10) has many chances to the only really fundamental rest mass, from which the masses of all other particles are composed.

From equations (16.27) and (16.21) we have

$$m_0(r \to \infty) = m_0 \cdot (1-A) \neq 0. \tag{16.47}$$

Considering the relations (16.24) and (16.25) we conclude that, towards the initial state of the Universe, the rest masses of material particles tend to zero:

$$m_0(r \to \infty) = m_0 \cdot (1-A) \to 0. \tag{16.48}$$

From equation (16.8) we have

$$E_0(r \to \infty) = 0 . \quad (16.49)$$

According to the relations (16.48) and (16.49) the initial state of the Universe slightly differed from vacuum. Considering the conservation of energy-momentum, we conclude that the total mass/energy of the Universe asymptotically tend to zero. The same conclusion arises in the case that the Universe is finite, taking $r_{\max} = R < \infty$ instead of the condition $r \to \infty$ we have used. Therefore, the gravitational interaction cannot play the role attributed to it by the Standard Cosmological Model. The gravitational interaction cannot cause either the collapse or the expansion of the Universe.

The gravitational interaction strengthens with the passage of time, as the rest masses of material particles increase. From one point and on this is in position to accumulate matter within "small" regions of space. The role of gravity is limited to the creation of the large structures of the Universe.

The theory of General Relativity correlates the gravitational interaction with the curvature of spacetime. According to the theory of Self-variation, gravitational interaction is a consequence of the external symmetry, i.e. the anisotropy of spacetime which results from the Self-variation of the rest masses of material particles. This is a clear difference between the two theories. We expect that the combination of the two theories on this distance scale will give important results for the physical reality.

We have studied the case of $J_1 = J_2 = J_3 = 0$ in equation (3.12) in order to bypass the consequences on the redshift produced by the proper motion of the electron. Thus, from equation (3.6) we obtain

$$M_0 = \pm \frac{ic_0}{c} .$$

From equation (16.2) we also have

$$M_0 = \pm \frac{\hbar k}{bc^2} . \quad (16.50)$$

From equation (16.17) we obtain that the constant k obtains an extremely small value. Therefore, the same holds and for the rest mass M_0 as a result of equation (16.50), which, however, also depends on the constant b of the Self-variation principle.

From equation (16.5) we conclude that the parameter A varies only very slightly with the passage of time. The age of the Universe is correlated at a greater degree with the value of the parameter A we measure today, and less with Hubble's parameter H . In any case the two parameters A and H are correlated via equation (16.17), $(1-A)H = kA$. The value of $13.8 \times 10^9\ yrs$, derived from the Standard Cosmological Model as the age of the Universe, refers only to the last phase of evolution of the Universe, according to the theory of Self-variation. It is preceded by another time interval, where the particles currently considered as elementary, like the electron and quarks, were created. The rest mass of the fundamental particle of matter is given by equation (16.50), and/or a variation of it which we consider below. From this equation, considering the rate of evolution of the Self-variation, we can calculate the time interval where the particles currently considered as elementary, where created. The calculations show that this time interval was immense. Theoretically it is not excluded that this time interval was infinite.

With the exception of equations (16.16) and (16.32), the theory of Self-variation equations for cosmology do not depend on the values of the parameters k, A and H. They solely depend on z, which is accurately measured. Equation (16.27) allows us to express all the fundamental astrophysical equations as a function of z. For measurements of higher accuracy, and whenever allowed by the observation instruments, we have to consider equations (16.10) and (16.12).

16.9. A possible variation of redshift.

The redshift in equation (16.14) comes from the Self-variation of the rest mass and the electric charge of the electron. The redshift in the main volume of the linear spectrum we observe from distant astronomical objects, is actually caused by this effect. Today, however, we have the capability to perform high sensitivity measurements of the effects of the Self-variation. The structure of matter predicted by theory of Self-variation must be taken into account in these measurements. The fundamental rest mass M_0 of equation (16.50) is by far smaller than the neutrino mass. Neutrinos, not to speak of other particles, have internal structure. This structure could influence the sum $W+E$ in the right part of equation (16.2). In such a case, we will obtain a different value for the constants k and c_0 for different material particles.

Writing equation (16.2) in the form

$$k_p = -\frac{bic_{0,p}}{\hbar} = \frac{b\left(W_p + E_p\right)}{\hbar} \qquad (16.51)$$

we can introduce an index "p" in the equations of this chapter. Every index "p" corresponds to a specific particle when the constant $-ic_{0,p} = W_p + E_p$ in the right part of equation (16.51) is not unique. It is very likely that there exists a small set of elementary particles with rest masses

$$M_0 = \frac{\hbar k_p}{bc^2}$$

and not just one elementary particle of rest mass

$$M_0 = \frac{\hbar k}{bc^2}.$$

The measurements we perform on a cosmological scale depend on the physical quantity

$$\frac{k_p A_p}{1 - A_p} = H_p. \tag{16.52}$$

The main volume of the linear spectrum we get from distant cosmological objects comes from the process of atomic excitation/relaxation, thus the Hubble parameter H as given by equation (16.17)

$$\frac{kA}{1 - A} = H$$

expresses the consequences of the Self-variation of the electron rest mass. In equations (16.14), (16.16), (16.22), (16.32), (16.33), (16.35), (16.41) and (16.42) the rest mass of the electron comes into play. Therefore, these equations are unaffected by equation (16.51).

The energy of the γ radiation that comes from nuclear reactions, and not from accelerated/decelerated electrons, depends on the particles that take part in the reaction. Consequently, their energy depends on equation (16.51). In this case equation (16.9) takes the form

$$m_0(r) = m_0 \frac{1 - A_p}{1 - A_p \exp\left(-k_p \frac{r}{c}\right)} \tag{16.53}$$

and considering that

$$\frac{\lambda_\gamma(r)}{\lambda_\gamma} = \frac{\Delta m_0 c^2}{\Delta m_0(r) c^2}$$

we get

$$\frac{\lambda_\gamma(r)}{\lambda_\gamma} = \frac{1 - A_p \exp\left(-k_p \frac{r}{c}\right)}{1 - A_p}$$

and we finally get

$$z_\gamma = \frac{A_p}{1 - A_p}\left(1 - \exp\left(-k_p \frac{r}{c}\right)\right). \tag{16.54}$$

For relatively small distances, from equation (16.54) we get

$$z_\gamma = \frac{k_p A_p}{1-A_p}\frac{r}{c} = H_p \frac{r}{c}. \qquad (16.55)$$

Correlating a source of γ radiation from nuclear reactions with a galaxy, we can compare the z and z_γ redshifts. From this comparison we can draw important conclusions about equation (16.51) as well as about the predictions of the theory of Self-variation. We note that the Standard Cosmological Model, in explaining the redshift through the hypothesis of Universal expansion, does not predict any difference between the z and z_γ redshifts.

Equation (16.28)

$$\frac{\dot{m}_0}{m_0} = H$$

holds for the rest mass of the electron. For other particles "p" it is written in the form

$$\frac{\dot{m}_0}{m_0} = \frac{k_p A_p}{1-A_p} = H_p. \qquad (16.56)$$

The mass of the electron represents a small part of the mass of the atom. Therefore, in measurements based on the gravitational interaction, the consequences of the mass Self-variation are governed by equation (16.56).

The rest mass $m_{0,H}$ of the hydrogen atom is

$$m_{0,H} = m_{0,p} + m_{0,e} \qquad (16.57)$$

where $m_{0,p}$ and $m_{0,e}$ the rest mass of the proton and the electron respectively. From equation (16.57) we have

$$\dot{m}_{0,H} = \dot{m}_{0,p} + \dot{m}_{0,e}$$

and with equations (16.56) for the proton and (16.28) for the electron we have

$$\dot{m}_{0,H} = H_p m_{0,p} + H m_{0,e}. \qquad (16.58)$$

From equations (16.57) and (16.58) we have

$$\frac{\dot{m}_{0,H}}{m_{0,H}} = \frac{H_p m_{0,p} + H m_{0,e}}{m_{0,p} + m_{0,e}}$$

and considering that today it is

$$m_{0,e} = 5.4\times10^{-4} m_{0,p}$$

we have

$$\frac{\dot{m}_{0,H}}{m_{0,H}} = \frac{H_p m_{0,p} + H\times5.4\times10^{-4} m_{0,p}}{m_{0,p} + 5.4\times10^{-4} m_{0,p}}$$

$$\frac{\dot{m}_{0,H}}{m_{0,H}} = \frac{m_{0,p}\left(H_p + 5.4\times10^{-4} H\right)}{m_{0,p}\left(1+5.4\times10^{-4}\right)}$$

$$\frac{\dot{m}_{0,H}}{m_{0,H}} = \frac{H_p + 5.4\times10^{-4} H}{1+5.4\times10^{-4}} = H_p + 5.4\times10^{-4} H \ . \qquad (16.59)$$

From equation (16.59) we conclude that the ratio

$$\frac{\dot{m}_{0,H}}{m_{0,H}}$$

of the hydrogen atom depends on the relation of the parameter H_p for the proton with the Hubble parameter H. Similarly we obtain

$$\frac{\dot{m}_{0,a}}{m_{0,a}} = \frac{Z}{A} H_p + \left(1-\frac{Z}{A}\right) H_n + \frac{Z}{A}\times5.4\times10^{-4} H \qquad (16.60)$$

for any atom, where Z is the atomic number and A is the nucleon number of the atom, and H_n the parameter of the neutron.

Equations (16.59) and (16.60) are valid for relatively small distances, up to a few hundred kpc. For larger distances we have to repeat the procedure of the proof using equations (16.9) and (16.53) instead of (16.28) and (16.56), from which we get

$$\frac{dm_0(r)}{dt} = \dot{m}_0(r) = m_0 \frac{kA\exp\left(-\frac{kr}{c}\right)}{1-A\exp\left(-\frac{kr}{c}\right)} \qquad (16.61)$$

$$\frac{dm_0(z)}{dt} = \dot{m}_0(z) = m_0 H \frac{A-(1-A)z}{A(1+z)}$$

and

$$\frac{dm_{0,p}(r)}{dt} = \dot{m}_{0,p}(r) = m_{0,p} \frac{k_p A_p \exp\left(-\frac{k_p r}{c}\right)}{1 - A_p \exp\left(-\frac{k_p r}{c}\right)} \tag{16.62}$$

$$\frac{dm_{0,p}(z_\gamma)}{dt} = \dot{m}_{0,p}(z_\gamma) = m_{0,p} H_p \frac{A_p - (1 - A_p) z_\gamma}{A_p (1 + z_\gamma)}$$

after the calculations.

The measurement of parameters H_p and H_n can be made by matching some sources of γ radiation from nuclear reactions to the galaxy they are coming from. By comparing the redshifts z and z_γ we can find the relation of H_p and H_n with the Hubble parameter H. The cosmological models that attribute the redshift to the expansion of the Universe predict equal z and z_γ redshifts. On the contrary, the theory of Self-variation predicts that $z_\gamma = z$ only if $H_p = H$ for every particle " p ".

Equation (16.51) affects equations (16.27), (16.29), (16.30) and (16.31), which are written in the form

$$m_0(z_\gamma) = \frac{m_0}{1 + z_\gamma} \tag{16.63}$$

$$E(z_\gamma) = \frac{E}{1 + z_\gamma} \tag{16.64}$$

$$z_a \sim z_\gamma \tag{16.65}$$

$$D = r\sqrt{1 + z_\gamma} \,. \tag{16.66}$$

16.10. On the type Ia supernovae.

The energy produced in the past at distant astronomical objects was smaller than the corresponding energy produced today in our galaxy. The production of energy in the Universe is mainly through hydrogen fusion and nuclear reactions. Therefore, equation (16.64) is of greater accuracy than equation (16.29). Nevertheless, the Self-variation of the electron's rest mass played a defining role in the energy produced in the past at distant cosmological objects. This is due to the fact that the fundamental astrophysical parameters depend on the rest mass of the electron. Therefore, these parameters depend on the redshift z, and not on the z_γ, according to equations (16.27), (16.33), (16.35), (16.36), (16.38), (16.41), (16.42), (16.44) and (16.45). In any case it is obvious which of the performed measurements are affected by redshift z and which by z_γ.

A characteristic example concerns type Ia supernovae. The value of the rest mass of the electron, given as a function of the redshift z from equation (16.27), plays a defining role at all phases of evolution of a star undergoing type Ia supernova. As a consequence of equations (16.27) and (16.64) the intrinsic luminosity of supernovae of type Ia depends on redshifts z and z_γ. The dependence of brightness on redshift is recorded at the seemingly long distances of type Ia supernovae (Riess, 1998 and Perlmutter, 1999).

16.11. A comparison of the cosmological predictions of the Theory of Self-variation versus the Standard Cosmological Model.

We present the predictions of the two models of the universe in parallel so that the differences but also the similarities are highlighted:

	Cosmological data	Standard Cosmological Model	Theory of Self-variation
1	Big Bang	Justified by the interpretation of redshift as expansion velocities.	Predicts that the Universe started asymptotically from a vacuum state in the distant past.
2	Redshift	Direct consequence of the expansion of the Universe.	Direct consequence of the self-variation of rest mass of the electron. In the past (large redshift) the electron transition energies inside the atom were much smaller.

3	Cosmic Microwave Background Radiation	Remnant of the Big Bang.	Consequence of the enormous values of the Thomson and Klein-Nishina scattering coefficients in the distant past. Equations (16.41), (16.42) and (16.25).
4	Increased luminosity distances of type Ia	Not in agreement. The Dark Energy case is required. The prevailing model today is the accelerated expansion of the universe.	Direct consequence of the self-variation of the fundamental parameters of astrophysics (mass of electron, ionization energy and degree of ionization of atoms, Thomson and Klein-Nishina scattering coefficients, Bohr radius, production of energy via hydrogen fusion and nuclear reactions). In the distant past these parameters had different values. Equations (16.27), (16.33), (16.35), (16.41), (16.44), (16.45b), (16.29), (16.64).
5	Flatness of the Universe	An attempt is made to justify it with the Inflation hypothesis.	The total energy content of the Universe is predicted to be zero, therefore the Universe on the grand scale is and was always flat. Equations (16.48), (16.49).
6	Nucleosynthesis of the chemical elements	Prediction in agreement with observations, for a particular decrease rate of the temperature versus the expansion rate of the universe that is adopted.	Predicts a minute fundamental rest mass of the universe (equation (16.50)) on which all other particles depend. Further investigation is required on this subject

			(as to the synthesis of larger particles).
7	Ionization of atoms in the early Universe	Predicted as a consequence of the high temperatures after the Big Bang.	Direct consequence of the dependence of the ionization energy from redshift. In the past (large redshift) the ionization energy was much smaller. Equations (16.33), (16.35), (16.36) and (16.25).
8	Size and age of the Sloan Great Wall	Not predicted.	The universe tends asymptotically to a vacuum in the distant past. The evolution of the universe due to the self-variation is accomplished in a time incomparably larger than the one predicted by the SCM. Even larger structures are compliant with the theory of Self-variation.
9	Variation of the fine structure constant	Not predicted.	Direct consequence of the Self-variation of the electric charge.

10	The Horizon problem	An attempt is made to justify it with the Inflation hypothesis.	The Self-variation model predicts that the position-momentum uncertainty is huge in the early universe, tending to infinity in the distant past. Therefore everything was connected in the early universe. Equations (16.44), (16.45) and (16.25).
11	Absence of magnetic monopoles in the universe	Magnetic monopoles have never been observed, hence the problem that their supposed nonexistence remains under investigation.	The Self-variation model forbids the existence of magnetic monopoles in four-dimensional spacetime (paragraph 10.7).
12	The larger than expected velocities of astronomical objects at the edge of large structures in the Universe (Zwicky, 1937)	The Dark Matter Hypothesis explains this.	The precise predictions of the Self-variation model will emerge after an extensive study of the external symmetry in macroscopic scale.
13	Cosmological distance scale	The distance estimations at cosmological scales solely relies on the connection with the expansion of the universe.	Cosmological distances can be connected with the exact self-variation rates, once the self-variation parameters have been measured with sufficient accuracy. We expect a significant discrepancy with the standard cosmological distance ladder, increasing further

			in the distant past. Equation (16.32).

For the confirmation of the predictions of the theorem 3.3 for the initial state of the Universe the improvement of our observational instruments is demanded. We also recommend evaluating the data recorded in Cosmic Microwave Background Radiation, based on the equations of the theory of Self-variation.

In the observations conducted for distances of cosmological scales, we observe the Universe as it was in the past. That is, we observe directly the consequences of the Self-variation. We do not possess this possibility for the distances of smaller scales. The cosmological data are the result of the immediate observation of the Self-variation and its consequences.

16.12. The self-variation of the charge at cosmological scale.

The equations of internal symmetry follow from equations (2.11), (3.5) for $T=0$, namely for $\alpha_{ki}=0 \forall k \neq i$, $k,i=0,1,2,...,N-1$, $N \in \mathbf{N}=\{1,2,3,...\}$:

$$\frac{\partial J_i}{\partial x_k}=\frac{b}{\hbar}P_k J_i$$
$$J_k+P_k=c_k \qquad (16.67)$$

From equations (16.67) for $k=i=0$ ($x_0=ict$) we get

$$\frac{dJ_0}{dx_0}=\frac{b}{\hbar}P_0 J_0$$
$$J_0+P_0=c_0$$

and then we have

$$\frac{d}{dx_0}(c_0 - P_0) = \frac{b}{\hbar} P_0 (c_0 - P_0)$$

$$-\frac{d}{dx_0} P_0 = \frac{b}{\hbar} P_0 (c_0 - P_0)$$

$$P_0 = \frac{c_0}{1 - C_1 \exp\left(\frac{bc_0}{\hbar} x_0\right)} \tag{16.68}$$

where C_1 is a dimensionless constant.

From equation (4.2) we have

$$\frac{dq}{dx_0} = \frac{b}{\hbar} P_0 q$$

for the electric charge q, and with equation (16.68) we get

$$\frac{dq}{dx_0} = \frac{b}{\hbar} \frac{c_0}{1 - C_1 \exp\left(\frac{bc_0}{\hbar} x_0\right)} q$$

and then we have

$$q = \frac{C_2}{1 - C_1 \exp\left(\frac{bc_0}{\hbar} x_0\right)}.$$

Considering that $x_0 = ict$ we have then

$$q = q(t) = \frac{C_2}{1 - C_1 \exp\left(\frac{bicc_0}{\hbar} t\right)} \tag{16.69}$$

where C_2 is a physical constant with the dimensions of electric charge.

From equation (16.69) we have

$$q = q(t) = \frac{C_2}{1 - C_1 \exp(k_1 t)} \tag{16.70}$$

where k_1 symbolizes the constant

$$k_1 = \frac{bicc_0}{\hbar}. \qquad (16.71)$$

The equation (16.70) corresponds to equation (16.1). From equation (16.70) we get equation (16.10),

$$q(r) = q\frac{1-B}{1-B\exp\left(-\frac{k_1 r}{c}\right)} \qquad (16.72)$$

in the same way we derived equation (16.7) from equation (16.1) where we set

$$B = B(t) = C_1\exp(k_1 t). \qquad (16.73)$$

From equation (16.73) we have

$$\frac{dB}{dt} = \dot{B} = k_1 B. \qquad (16.74)$$

The equations of this paragraph are valid for every generalized charge Q at cosmological scale. The form of equations $Q = Q(t)$ and $Q = Q(r)$ is the same, though the values of the constants c_0, C_1, C_2, k_1, differ with respect to the generalized charge Q (see the comments for the four-vector P after equation (4.2)).

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