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THE UNIVERSE ACCELERATION AND GRAVITATION PROPERTIES

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An analysis of observation data of distant supernovae for the Universe acceleration from the viewpoint of gravitation equations proposed by one of the authors is given. The observation data are in a good accordance with the theory without introduction of the cosmological constant. It follows from the data analysis that the deceleration parameter q_0 is a positive for nearest objects and become negative for the sufficient remote ones. It is shown that the negative magnitude of q_0 is a consequence of a peculiarity of the gravity force in the theory under consideration.

1. Introduction

The recent results by two teams (the Supernova Cosmology Project and the High-z Supernova Search Team) [1], [2] lead to fundamental problems. (Several of them are reviewed by S. Weinberg [3]). In particular, the results show that the deceleration parameter q_0 in the standard cosmological model is negative. It means that the acceleration of the Universe is positive. It is inconsistent with Newtonian gravitation law and in general relativity can be explained only by a nonzero cosmological constant [3].

First in paper [4] and after that in [5] has been considered a model of the expending dust ball from the viewpoint of our gravitation equations [6], [7]. It follows from the results that the acceleration of the expansion of a self-gravitating dust ball can be positive at a sufficient large its size and mass. This unexpected from the viewpoint of the Newtonian mechanics fact is a consequence of the peculiarity of the gravitational force affecting a moving particle. The spherical symmetric solution of these equations have not an events horizon at the Schwarzschild radius r_g. At the distances from the center of an attractive mass of the order of r_g or less than that gravitational force affecting a free moving test particle are repulsive. Just it occurs when we observe objects in the Universe at distances R of the order of $8\pi R^3\rho/3c^2$, where ρ is the matter density and c is the speed of light.

In the present paper a detail analysis of the observation data [1] from the viewpoint of the above-mentioned model is given. It is shown that the negative value of q_0 is the consequence of the peculiarity of the gravitation force.

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2. Evolution of an expanding dust-ball. Dependence "distance – redshift"

Our analysis of the problem is based on the spherically symmetric solution of the vacuum metric-field equations of gravitation [6], [8], (in detail in [7]).

Consider in flat space-time the dynamics of a self-gravitating spherically symmetric homogeneous expanding dust-ball with the mass M.

In a spherical coordinates system the motion of the specks of dust with the masses m_p in the spherically symmetric field are described by the Lagrangian [6]

$$L = -m_p c \times \left[c^2 C - A\dot{r}^2 - f^2\left(\dot{\varphi}^2 sin^2\theta + \dot{\theta}^2\right)\right]^{1/2}, \tag{2.1}$$

where $A = r^4/f^4\,(1 - r_g/f)$, $C = 1 - r_g/f$, $f = (r_g^3 + r^3)^{1/3}$, $r_g = 2GM/c^2$, G is the gravitation constant, c is the speed of light and the points denote derivatives with respect to t.

The differential equation of particles radial motion of the ball surface is given by [6]

$$\dot{R}^2 = \frac{c^2 C}{A}\left(1 - \frac{C}{\overline{E}^2}\right), \tag{2.2}$$

where R is the radius of the ball, $\overline{E} = E/m_p c^2$ and E is the energy of the specks of dust, C and A are the functions of R.

We can apply the above model to a real local area of the Universe if in the theory under consideration the matter outside of the ball does not create gravitational field inside the one. It indeed takes place in the theory for the spherically symmetric solution. Therefore, such a model can be used for the homogeneous isotropic Universe as the first step to consideration of the problem.

In flat space-time approximation the luminosity distance D_L is the following function of the redshift $z = (\omega - \omega_0)/\omega_0$, where ω and ω_0 are frequencies of the emitted and received light wave, correspondingly, [9]:

$$D_L = R(z)(1+z)^2, \tag{2.3}$$

where $R(z)$ is the distance to a remote supernova with the redshift parameter z.

The magnitude $R(z)$ is a distance r from the center of the ball at the moment when a supernova emitted the photon and had the redshift z. The equation of the radial motion of a photon is given by [6]

$$\dot{r} = -c\left(\frac{C}{A}\right)^{1/2}. \tag{2.4}$$

Therefore, (in an analogy with [9]) $R(z)$ can be found by solution of the differential equation

$$\frac{dr}{dz} = -c\left(\frac{C}{A}\right)^{1/2}\left(\frac{dz}{dt}\right)^{-1} \tag{2.5}$$

In this equation C and A are the functions of $r(z)$. It follows from the relation $z = R_0/R - 1$ that the dz/dt is given by

$$\frac{dz}{dt} = -\frac{R_0}{R^2}\dot{R} = -H(1+z), \tag{2.6}$$

where $H = \dot{R}/R$ is Hubble parameter. By using eq. (2.2) we obtain

$$H = \frac{c}{R}\left[\frac{C}{A}\left(1 - \frac{C}{\overline{E}^2}\right)\right]^{1/2}. \tag{2.7}$$

In this equation the constant $\overline{E}^2$ is determined from the parameters of the ball at the moment and is given by

$$\overline{E}^2 = \frac{c^2 f_0 (f_0 - r_g)^3}{c^2 f_0^2 (f_0 - r_g)^2 - H_0^2 R_0^6}, \tag{2.8}$$

where $f_0 = (R_0^3 + r_g^3)^{1/3}$, $r_g = 8\pi G \rho_0 R_0^3/3c^2$, ρ_0 is the density, and the index zero denotes the magnitudes refereed to the present moment $t = t_0$.

The radial photon motion is conditioned by the matter mass contained inside the radius $r(t)$. Therefore, finally, by the substitution eqs.(2.6) and (2.7), where R is replaced by r, into eq.(2.5) the following equation is obtained

$$\frac{dr}{dz} = \frac{r}{(1+z)\left(1 - C/\overline{E}^2\right)^{1/2}}. \tag{2.9}$$

In this equation $\overline{E}$ and C are given by eqs.(2.8) and (2.) where R_0 is replaced by $r_0 = r(1+z)$. The solution of the eq.(2.9) at the initial condition $r(z = 0, H_0, \Omega) = 0$ is the path of photon from the supernova to the observer, which yields the function $R = R(z, H_0, \Omega)$, where $\Omega = \rho_0/\rho_c$ and $\rho_c = 3H_0^2/8\pi G$. The parameters H_0 and Ω are determined from observations.

3. Comparison with observation data

In paper [1] the distance modulus

$$\mu = 5 \log D_L + 25, \tag{3.1}$$

for 10 Type Ia supernovae (SNe Ia) in range $0.16 \le z \le 0.97$ and 27 nearby supernovae with $z \le 0.1$ were presented. Value of μ was determined by the multicolored light curve shape method (MLCS) and by the template - fitting method.

The likelihood for the cosmological parameters H_0 and Ω can be determined from a χ^2 statistic, where

$$\chi^2(H_0, \Omega) = \sum_i \frac{\left[\mu_i(z_i, H_0, \Omega) - \mu_{0,i}\right]^2}{\sigma^2_{\mu_{0,i}} + \sigma^2_\nu}, \tag{3.2}$$

$\mu_{0,i}$ and $\sigma_{\mu_{0,i}}$ are the distance modulus and the dispersion in galaxy redshift (in units of the distance modulus), respectively. We use value of $\sigma_\nu = 200$ km/s for SNe Ia with small z and $\sigma_\nu = 2500$ km/s for SNe Ia with large z [1]. We found that the Hubble parameter $H_0 = 65.7 \pm 1.4$ $km\ s^{-1}\ Mpc^{-1}$ by using MLCS - method and $H_0 = 63.3 \pm 1.5$ $km\ s^{-1}\ Mpc^{-1}$ by using template - fitting method. Starting from this value of H_0 and following to Riess et. al. [1] argumentation, we assume here that $H_0 = 65 \pm 7$ $km\ s^{-1}\ Mpc^{-1}$

Proceed from the data of paper [1] we found that $\Omega = 0.93 \pm 0.36$ at the 93.5% (1.9σ) confidence level for MLCS-method, and $\Omega = 0.39 \pm 0.24$ at the 91.0% (1.7σ) confidence level for template-fitting method. It must be noted that the value of found parameter Ω does not depend on the above found value

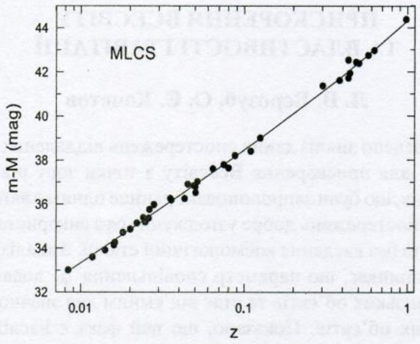

Fig. 1. *The function μ of z. The MLCS-method.* $\Omega = 0.93$.

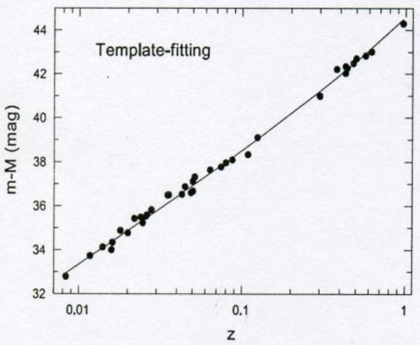

Fig. 2. *The function μ of z. The template -fitting method.* $\Omega = 0.39$.

of the Hubble constant. The function $\mu = \mu(z)$ determined by the both methods are shown in figs. 1 and 2 by the continuous curves. The points denote μ versus z for SNe Ia from paper [1].

Using the above values of H_0 and Ω we can find the deceleration parameter

$$q = -\frac{\ddot{R}R}{\dot{R}^2}, \tag{3.3}$$

where $\ddot{R} = \left(d\dot{R}\big/dR\right)\dot{R}$ and $\dot{R}$ is given by eq. (2.2). The deceleration parameter is not a constant and according to [5] is a function of the distance to supernova. The following equation is valid

$$q_0 = R_0\left[\frac{C'}{C}\frac{2C-\overline{E}^2}{2(\overline{E}^2-C)}+\frac{A'}{2A}\right]_{R=R_0}, \tag{3.4}$$

where the prime denotes a derivative with respect to R.

Plot of the resulting function $q_0(R_0)$ for two used methods is shown in fig. 3.

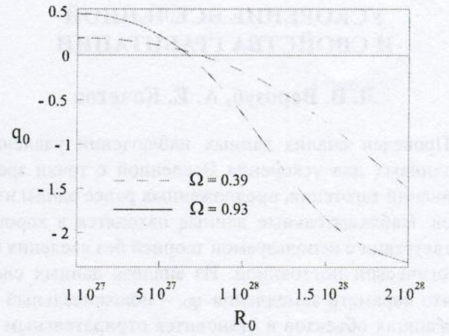

Fig. 3. *The deceleration parameter found by the MLCS method ($\Omega = 0.93$) and by the template-fitting method ($\Omega = 0.39$) versus R_0.*

4. Conclusion

I spite of all limitation of the used model, it demonstrate a good agreement with the observation data. The fact that the deceleration parameter changes its sign to a negative at the real distances to supernovae and the last observation data [1] give confidence that we have dealt with the peculiarity gravitation force for big masses.

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УСКОРЕНИЕ ВСЕЛЕННОЙ И СВОЙСТВА ГРАВИТАЦИИ

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Проведен анализ данных наблюдений удаленных сверхновых для ускорения Вселенной с точки зрения уравнений тяготения, предложенных ранее одним из авторов. Наблюдательные данные находятся в хорошем соответствии с используемой теорией без введения космологической постоянной. Из анализа данных следует, что параметр замедления q_0 – положительный для ближайших объектов и становится отрицательным для существенно удаленных объектов. Показано, что этот факт есть следствие особенности силы тяготения в рассматриваемой теории.

ПРИСКОРЕННЯ ВСЕСВІТУ ТА ВЛАСТИВОСТІ ГРАВІТАЦІЇ

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Наведено аналіз даних спостережень віддалених наднових для прискорення Всесвіту з точки зору рівнянь тяжіння, що були запропоновані раніше одним з авторів. Дані спостережень добре узгоджуються з використаною теорією без введення космологічної сталої. З аналізу даних випливає, що параметр сповільнення q_0 додатний для близьких об'єктів та стає від'ємним для значно віддалених об'єктів. Показано, що цей факт є наслідком особливості сили гравітації у використаній теорії.