Adv. Studies Theor. Phys., Vol. 5, 2011, no. 6, 269 - 274

The Model of a Flat (Euclidean) Expansive Homogeneous and Isotropic Relativistic Universe and the Wilkinson Microwave Anisotropy Probe (WMAP) Observations

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Abstract

The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe with the total zero and local non-zero mass (energy) corresponds—within the measurement uncertainty—with the Wilkinson Microwave Anisotropy Probe **(**WMAP) observations.

Keywords: General relativity and gravitation, Cosmology: Observational cosmology, Theoretical cosmology, Mathematical and relativistic aspects of cosmology

1 Introduction

At present time the physical-mathematical foundations of the *relativistic cosmology* are represented by the *Friedmann equations of the homogeneous and isotropic relativistic universe dynamics* [1, 2], which—using the *Robertson-Walker metrics* [3, 4, 5, 6]—can be expressed in the following form:

$$\dot{a}^2 = \frac{8\pi G\rho a^2}{3} - kc^2 + \frac{\Lambda a^2 c^2}{3}, \tag{1a}$$

$$2a\ddot{a} + \dot{a}^2 = -\frac{8\pi G p a^2}{c^2} - kc^2 + \Lambda a^2 c^2, \tag{1b}$$

$$p = w\varepsilon, \tag{1c}$$

where a is the gauge factor, ρ mass density, k curvature index, Λ cosmological constant, p pressure, w state equation constant, and $\varepsilon = \rho c^2$ energy density.

In 2003 N. Bennett et al. published the article *First year Wilkinson Microwave Anisotropy Probe (WMAP) observations: Preliminary maps and basic results* [7] with these cosmological parameters:

total density

$$\Omega_{tot} = 1.02 \pm 0.02, \tag{2}$$

age of universe

$$t_0 = 13.7 \pm 0.2 \text{ Gyr}, \tag{3}$$

Hubble constant

$$H_0 = 71^{+4}_{-3} \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{4}$$

The relations (2)-(4) make it possible to determine one from the solutions of the *Friedmann-Robertson-Walker (FRW) equations* (1a), (1b) and (1c), which describes observed *expansive homogeneous and isotropic relativistic universe* in the first (linear, Newtonian or classical-mechanical) approximation [8].

2 The model of observed expansive homogeneous and isotropic relativistic universe

From the relation (2) it results that observed expansive homogeneous and isotropic relativistic universe in the linear approximation (in which we abstract from its relativistic and quantum-mechanical properties) is—within the measurement uncertainty—a *flat (Euclidean)* one.

In the flat (Euclidean) universe model the *Euclid geometry* is valid. Therefore, using the known relation for the volume of Euclidean sphere V with the radius r:

$$V = \frac{4}{3}\pi r^3, \tag{5}$$

some further relations of the *flat (Euclidean) expansive homogeneous and isotropic relativistic universe model* can be determined.

For example, using the relation (5), the defined relation:

$$a := r, \tag{6}$$

and the critical mass density ρ_c, the relation for its mass

$$m = \frac{4}{3}\pi a^3 \rho_c, \tag{7}$$

can be obtained.

The FRW equations (1a), (1b) and (1c) fulfil the restrictive condition, determined by the relation (7), only with $k = 0$, $\Lambda = 0$ and $w = -1/3$ [8, 9].

It means that a *flat (Euclidean) expansive homogeneous and isotropic relativistic universe (ERU) model*, which is determined by the FRW equations (1a) and (1b) with $k = 0$, $\Lambda = 0$ and

total zero energy state equation [10]

$$p = -\frac{1}{3}\varepsilon, \tag{8}$$

is the only model of the relativistic universe with the total zero and local non-zero mass (energy) in which the Euclid geometry is valid, i.e. it is the only one non-formal model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe.

According to the *Hubble law* [11]

velocity of a remote cosmic object

$$v = HR, \tag{9}$$

where H is the Hubble "constant" and R distance of a remote cosmic object.

Using the FRW equations (1a), (1b) and (1c) with $k = 0$, $\Lambda = 0$ and $w = -1/3$ and the relation (9) the parameters of the ERU model can be determined [10]:

$$a = ct = \frac{c}{H} = \frac{2Gm}{c^2} = \sqrt{\frac{3c^2}{8\pi G\rho_c}}. \tag{10}$$

The concrete analysis of the properties of a homogeneous and isotropic relativistic universe models you can see in the article *The model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe in the light of the general relativity, quantum mechanics, and observations* [12].

3 The ERU model and the WMAP observations

The dimensionless density Ω is defined by the relations:

$$\Omega = \frac{\rho}{\rho_c} = \frac{\varepsilon}{\varepsilon_c}, \tag{11}$$

where ε_c is the critical energy density.

From the relations (10) and (11) it results:

$$\Omega_{tot} = 1. \tag{12}$$

The value of Ω_{tot}, determined by the relation (12), is within the measurement uncertainty of the value of Ω_{tot}, determined by the relation (2).

From the relations (3) and (10) it results:

$$H_0 = \frac{1}{t_0} = 71.37^{+1.06}_{-1.03} \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{13}$$

The value of H_0, determined by the relation (13), is within the measurement uncertainty of the value of H_0, determined by the relation (4).

In 2010 N. Jarosik et al. published the article *Seven-year Wilkinson Microwave Anisotropy Probe (WMAP) observations: Sky maps, systematic errors, and basic results* with the improved cosmological parameters, derived from the WMAP measurements, and with the cosmological parameters, derived from the WMAP data combined with the distance measurements from the *Baryon Acoustic Oscillations (BAO)* and the *Hubble Constant (H_0)* [13].

According to the WMAP observations [13]:

$$\Omega_{tot} = 1.080^{+0.093}_{-0.071}, \tag{14}$$

$$t_0 = 13.75 \pm 0.13 \text{ Gyr}, \tag{15}$$

$$H_0 = 71.0 \pm 2.5 \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{16}$$

The value of Ω_{tot}, determined by the relation (12), differs from the minimum value of Ω_{tot}, determined by the relation (14), by the value – 0.009.

From the relations (10) and (15) it results:

$$H_0 = \frac{1}{t_0} = 71.11^{+0.68}_{-0.67} \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{17}$$

The value of H_0, determined by the relation (17), is within the measurement uncertainty of the value of H_0, determined by the relation (16).

According to the WMAP+BAO+H_0 observations [13]:

$$\Omega_{tot} = 1.0023^{+0.0056}_{-0.0054}, \tag{18}$$

$$t_0 = 13.75 \pm 0.11 \text{ Gyr}, \tag{19}$$

$$H_0 = 71.4^{+1.3}_{-0.4} \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{20}$$

The value of Ω_{tot}, determined by the relation (12), is within the measurement uncertainty of the value of Ω_{tot}, determined by the relation (18).

From the relations (10) and (19) it results:

$$H_0 = \frac{1}{t_0} = 71.11^{+0.57}_{-0.56} \text{ km s}^{-1} \text{ Mpc}^{-1}. \tag{21}$$

The value of H_0, determined by the relation (21), is within the measurement uncertainty of the value of H_0, determined by the relation (20).

4 Conclusions

From the relations (2)-(4) and (12)-(21) it results that the model of a flat (Euclidean) expansive homogeneous and isotropic relativistic universe, determined by the FRW equations (1a), (1b) and (1c) with $k = 0$, $\Lambda = 0$ and $w = -1/3$ [10], corresponds—within the measurement uncertainty—with the WMAP and with the WMAP+BAO+H_0 observations [7, 13].

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Received: October, 2010