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ЦЕНТРАЛЬНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ
ИНФОРМАЦИИ И ТЕХНИКО-ЭКОНОМИЧЕСКИХ ИССЛЕДОВАНИЙ
ПО АТОМНОЙ НАУКЕ И ТЕХНИКЕ

R.M.MURADIAN

COSMOLOGICAL CONSTANT AND ROTATION OF THE UNIVERSE

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COSMOLOGICAL CONSTANT AND ROTATION OF THE UNIVERSE

The expression for the angular momentum of the Universe via fundamental constants

$$J = \hbar \left(\frac{\hbar c}{G m_p^2}\right)^3$$

is shown to agree with the expression for the cosmological constant

$$\Lambda = \frac{G^2 m_p^6}{\hbar^4} .$$

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КОСМОЛОГИЧЕСКАЯ ПОСТОЯННАЯ И ВРАЩЕНИЕ ВСЕЛЕННОЙ

Показано, что выражение для углового момента Вселенной через фундаментальные константы

$$J = \hbar \left(\frac{\hbar c}{G m_p^2} \right)^3$$

находится в согласии с выражением для космологической постоянной

$$\Lambda = \frac{G^2 m_p^6}{\hbar^4}$$

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1. Parameters of the Universe, the radius, mass and possible angular momentum, may be expressed via combinations of quantum and classical fundamental constants as follows:

$$R = \frac{\hbar}{m_p c} \frac{\hbar c}{G m_p^2} \tag{1a}$$

$$M = m_p \left(\frac{\hbar c}{G m_p^2}\right)^2 \tag{1b}$$

$$J = \hbar \left(\frac{\hbar c}{G m_p^2}\right)^3 \tag{1c}$$

Here $\hbar$ is Planck's constant; m_p is the proton mass; c is the velocity of light; G is the gravitational constant.

Relations (1a,b) are known from 1930-s due to the works by Eddington and Dirac and are sometimes termed the hypothesis of "Large Numbers". The relation (1c) is obtained in [1] (see also [2,3]).

On the other hand, proceeding from various cosmological models, these parameters may be expressed via classical fundamental constants G and c and the cosmological constant Λ

as follows:

$$R \approx \frac{1}{\sqrt{\Lambda}} \tag{2a}$$

$$M \approx \frac{c^2}{G\sqrt{\Lambda}} \tag{2b}$$

$$J \approx \frac{c^3}{G\Lambda} \tag{2c}$$

The first two relations are satisfied in Einstein's model with an accuracy of constant coefficients of the order of a unit, and the relation (2c) is true in Gödel's model, where the angular velocity is related to Λ by the relation $\omega = c\sqrt{\Lambda}$. Besides, all the three relations (2a)-(2c) obviously follow from a simple dimensional analysis.

Taking into account the vacuum polarization (the gravitational analog of the Cazimir effect) Ya.B.Zel'dovich has obtained a new physical foundation for the relations (1a) and (1b). As a starting point he has used the following expression for the cosmological constant:

$$\Lambda = \frac{G^2 m_p^6}{\hbar^4} \equiv \left(\frac{\hbar}{m_p c}\right)^{-2} \left(\frac{G m_p^2}{\hbar c}\right)^2 \tag{3}$$

where m is the elementary particle mass. The value Λ strongly depends on the choice of a specific type of elementary particle (proton, electron, pion ...), since the mass enters (3) in the sixth power. One may approximately assume that $m = m_p$, i.e. to the proton mass. The substitution of the value Λ from (3) into (2a,b,c) at such a choice of mass leads to (1a,b,c).

We have thus obtained a new confirmation of the self-consistency of the expressions (1a,b,c). On the other hand, this fact may also be interpreted as an independent indication of the validity of the relation (3).

2. Let us make some remarks concerning the order of the values in the expressions under consideration. As has been shown in [1-3], the angular momentum of the Universe in the units of Planck's constant looks like a "Large Number" of the following form:

$$J = \hbar \left(\frac{M}{m_p} \right)^{3/2} = 10^{120} \hbar \qquad (4)$$

On the other hand, the observational data lead to the restriction on the cosmological constant, that in the units of Planck's length $\ell_{\varphi} = \sqrt{\frac{\hbar G}{c^3}} \approx 10^{-33}$ cm has the form:

$$\Lambda \leqslant 10^{-120} \ell_{\varphi}^{-2} \qquad (5)$$

or

$$\Lambda \leqslant 10^{-120} \frac{c^3}{\hbar G} \qquad (6)$$

The comparison of (6) with (2c) shows that the "Large Number" 10^{120} for the angular momentum of the Universe is directly connected with the number 10^{-120} for the cosmological constant Λ expressed in Planck's units. Note also that the possibility of imposing a restriction on Λ by means of the data on the rotation of the Universe has been discussed in a recent paper by D.D.Ivanenko [6].

3. If we assume that the "effective radius" of gravitational forces is of the order of the radius of the Universe,

we may express the cosmological constant via Compton wavelength of a hypothetical graviton as follows:

$$\Lambda = \left(\frac{\hbar}{m_g c}\right)^{-2} \qquad (7)$$

From here one may estimate the mass of the graviton $m_g = 10^{-65}$ g, or in the units of Planck's mass ($m_\varphi = \sqrt{\frac{\hbar c}{G}} \approx$ $\approx 10^{-5}$ g) . $m_g = 10^{-60} m_\varphi$. On the other hand, introducing $m = m_p$ in the relation (3) and comparing it with the relation (7), one can find the following expression for the graviton mass via fundamental constants:

$$m_g = m_p \left(\frac{\hbar c}{G m_p^2}\right)^{-1} \qquad (8)$$

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