Letters to the Editor

COSMOLOGY AND ELEMENTARY PARTICLES

D. F. KURDGELAIDZE

Moscow State University

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IN the construction of a theory of elementary particles the question also arises as to the connection between cosmological and local properties.[1] It is not excluded that phenomena on a cosmic scale, such as, for example, the expansion of our part of the universe with a preponderance of particles, not antiparticles, and other facts, are connected with properties of elementary particles.[2]

Thus, the well known ratio of the neutron and electron masses

$$m_N / m_e = g^2 / e^2, \qquad e^2 / 4\pi\hbar c = 1/137, \qquad g^2 / 4\pi\hbar c = 13.5 \tag{1}$$

allows us to introduce the idea of a universal mass

$$m_0 = m_N / (g^2 / 4\pi\hbar c) = m_e / (e^2 / 4\pi\hbar c) = 1.25 \cdot 10^{-25}\,\text{g}. \tag{2}$$

Taken together, the quantities m_0, c, h form a complete set of fundamental constants with independent dimensions. By means of them we can introduce in addition to the masses m_N and m_e associated with the strong and electromagnetic interactions a mass m_G associated with the gravitational interaction. From dimensional considerations we have[1)]

$$m_G = G m_0^2 m_0 / \hbar c = 4 \cdot 10^{-66}\,\text{g}, \qquad G = 6.67 \cdot 10^{-8}\ \text{cm/g} \cdot \text{sec}^2. \tag{3}$$

The introduction of m_G brings with it the validity of the Klein-Gordon equation for the potentials $\eta_{\mu\nu}$ of a weak gravitational field:

$$\{\Box - (m_G c / \hbar)^2\}\eta_{\mu\nu} = 0. \tag{4}$$

The corresponding characteristic time $H_0 = m_G c^2/\hbar = 3.6 \times 10^{-18}\ \text{sec}^{-1}$ is practically identical with the well known experimental value of the Hubble constant $H = 2.5 \times 10^{-18}\ \text{sec}^{-1}$.

The fact that H_0 can be associated with the Hubble constant also follows from the empty-space Einstein equation with cosmological constant: $R_{\mu\nu} = -\lambda_0 g_{\mu\nu}$. From this we get for a small perturbation $\delta h_{\mu\nu} \equiv \eta_{\mu\nu}$ of a weak gravitational field ($h_{\mu\nu} = g_{\mu\nu} - \delta_{\mu\nu}$) the equation (4) with

$$(m_G c / \hbar)^2 = 2\lambda_0 / c^2. \tag{5}$$

If we use the idea that the cosmological constant λ_0 is connected with the Hubble constant by the relation[4] $\lambda_0 \approx H^2$, we find $H \approx H_0/2^{1/2} = 2.5 \times 10^{-18}\ \text{sec}^{-1}$.

Because of the extreme importance of the problem, these curious relations between atomic and cosmological quantities should evidently be taken seriously.

I take occasion to express my gratitude to Prof. D. Ivanenko for a discussion of this question.

1)The question of the mass of the graviton is also discussed in papers by a number of authors.[3]

[1] P. A. M. Dirac, Proc. Roy. Soc. **A165**, 199 (1938). J. A. Wheeler, Neutrinos, Gravitation, and Geometry, Rend. Scuola Int. Fisica "Enrico Fermi," Corso XI, Bologna, 1960, pp. 67-196.

[2] D. Ivanenko, Introduction to Collection: Noveĭshee razvitie gravitatsii (Recent Developments in Gravitation), IIL, 1962.

[3] F. M. Gomide, Nuovo cimento **30**, 672 (1963). K. P. Stanyukovich, Abstracts of the First Gravitational Conference, Moscow, 1961, page 103. A. Sapar, ibid., page 163.

[4] G. C. McVittie, General Relativity and Cosmology, Chapman and Hill Ltd., London, 1956.

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THE POSSIBILITY OF DETERMINING RELAXATION RATES BY MEANS OF A HYDROGEN ATOM BEAM MASER

N. G. BASOV, A. I. NIKITIN, G. M. STRAKHOVSKIĬ, and A. V. USPENSKIĬ

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

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THE hydrogen atom beam maser[1,2] is a highly stable standard of frequency. In addition, it can be utilized in various physical experiments: precise