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NEGATIVE MASSES AND THE ENERGY-SOURCE  
OF THE UNIVERSE<sup>\*</sup>

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1. Allowing the existence of the particles with negative mass we assume (<sup>1,2</sup>) that all the prohibitory rules, which exclude their existence emerge not from the dynamical theories (Mechanics, Theory of relativity, Quantum Mechanics) but from the complementary assumptions (Causality Principle, noninversibility in time, Complementary Principle, which, in fact, are the consequences of the second law of thermodynamics (<sup>3</sup>)). Hence considering the existing thermodynamics to be valid only for the systems of particles of positive mass, if we assume that the system of interacting positive and negative masses obey some generalized, considerably non-equilibrium, thermodynamics then all the known prohibitions of the existence of particles with negative mass can be ignored (<sup>5</sup>).

<sup>\*</sup>Ce texte constitue une partie de la contribution de l'auteur à la Conférence d'Erice tenue au mois de Mai 1981 sur les Problèmes de la Gravitation.

2. To be precise we call the particles with negative and positive masses "NEGATONS" and "POSITONS" respectively (previously (2, 4, 5) we called them minus-particles and plus-particles).

According to the equivalence principle the distribution of the negatons in the universe is approximately uniform (2, 4, 7, 9, 10). The system, consisting of positons, tends to equilibrium at positive absolute temperatures while the system of negatons at negative absolute temperatures (5, 8). The combined system of positons and negatons can, therefore, be considered as a set of two interacting systems with positive absolute temperatures and negative absolute temperatures. Then a spontaneous heating of both the systems must occur (8). This process can be one of the means of the acceleration of the particles of primary component in the cosmic rays (2, 6). It can also be the cause of anomalous energy-extraction in quasars and in the nuclei of the galaxies (2, 4, 6).

3. Starting from the time-symmetry of the flow of processes in the combined system of positons and negatons we must consider the possibility of their multi-creation the same as the possibility of their mutual annihilation. Hence we, in our consideration, can confine ourselves to their elastic collisions ignoring the processes of their multi-creation and annihilation. A negaton while falling into the stars, planets ect. penetrates through them, continuously acquiring acceleration in the process, and consequently moves practically in a straight line with ultra-relativistic energies E. According to (2, 6)

$$\frac{d}{dt}|E| = (n_+ \delta_{-+} c) |E|,$$

where  $n_+$ -concentration of the positons,  $\delta_{-+}$ -elastic scattering cross-section of negaton on positons. Hence the energy of the negatons, after the penetration through a

layer of thickness L, changes according to the formula

$$|E| = |E_0| \exp(n_+ \delta_{-+} L).$$

As a result the energy of the positons increases by the same amount. The energy extracted in one second in a spherical body of radius R when a flux of negatons  $\pi R^2 n_- c$  where  $n_-$ -concentration of negatons, falls on it is given by the formula

$$Q = \pi R^2 c n_- |E_0| \exp(n_+ \delta_{-+} R).$$

From this formula it is clear, that the extraction of energy will *increase catastrophically* if

$$n_+ \delta_{-+} R \gg 1.$$

For the estimation of  $\delta_{-+}$  let us equate Q to the quantity of energy extracted in the sun, which is  $3,8 \cdot 10^{33}$  erg/sek. Q cannot exceed this quantity. Following (2, 10) we put  $n_- = 10^{-6}$ ,  $|E_0| = 0,2 \cdot 10^{-16}$  erg, and for sun  $R_\odot = 7 \cdot 10^{10}$  cm,  $n_+ \approx 10^{24}$ . Then we get

$$\delta_{-+} < 1,4 \cdot 10^{-35} \text{ cm}^2.$$

Such estimation for the neutron star gives

$$\delta_{-+} < 2 \cdot 10^{-45} \text{ cm}^2$$

if we put  $m = 2m_\odot$   $n_- = 10^6$  cm.

I.e. the interaction of negatons with positons is less than the nucleon-nucleon interaction however it can exceed the weak interaction.

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