Table 1

E_e	$E_e < E_{eo}$	$E_e > E_{eo}$
γ_e	2.5	3.3

Table 2

E_γ	$\gamma_{\gamma\,\mathrm{exp}}$	$\gamma_{\gamma\,\mathrm{theor}} = (\gamma_e + 1)/2$
$E_\gamma < E_{\gamma o}$	1.7 [3]	1.75
$E_\gamma > E_{\gamma o}$	2.4 ±0.2 [7]	2.15

Table 3

E_{eo}, eV from x-ray spectrum		E_{eo}, eV from radio spectrum	
$z_i << 1$	$z_i \sim 3$	$H \sim 10^{-4}$ Oe	$H \sim 10^{-5}$ Oe
$5 \cdot 10^9$	$2 \cdot 10^9$	$2 \cdot 10^9$	$5 \cdot 10^9$

Table 2 lists values of γ_γ determined directly by experiment and calculated in accord with the hypothesis of the decisive role of the inverse Compton effect. In Table 3 are gathered some data on the electron-spectrum "kink" points calculated under various assumptions concerning the magnitudes of the magnetic fields in the radiogalaxies and their evolution. In this table, z_i is the effective value of the red shift for the electron sources; the calculation was made for $E_{\gamma 0}$ = 30 keV and a radio-emission frequency of 1000 MHz at the kink. As seen from Tables 1 - 3, the hypothesis of a single mechanism producing the isotropic x-rays via the inverse Compton effect leads to compatible results. This offers independent indirect evidence favoring the cosmological origin of the relict radiation.

The authors thank V. N. Kuril'chik for valuable discussions.

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DENSITY OF RELICT PARTICLES WITH ZERO REST MASS IN THE UNIVERSE

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Submitted 20 January 1969
ZhETF Pis. Red. 9, No. 5, 315 - 317 (5 March 1969)

So far, one cannot exclude the possible existence in the universe of a large number of difficult-to-observe particles with zero rest mass (DZP), left over from the superdense phase (neutrinos, gravitons, etc). Estimates of their density, based on the gravitational influence during the later expansion stages, leads to a value [1]

$$\rho_{m=0} < 3\rho_c \approx 5\times 10^{-29}\ \mathrm{g/cm^3}$$

(ρ_c = critical density). On the other hand, the gravitational action of similar particles in the early expansion changes, by changing the rate of the expansion, changes the course of the nuclear reactions in the primordial matter [4, 5]. In the present paper we develop this idea further and take into account the fact that the helium content in a number of stars is known to be less than 40%; we then obtain for the case of the Friedmann model with small or zero "specific" lepton charge[1] a stronger limit on the DZP density:

$$\rho_{m=0} < 5\rho_\gamma \approx 2\times10^{-33}\ \mathrm{g/cm}^3, \tag{1}$$

where ρ_γ is the density of the background radio emission with temperature $T = 2.7^\circ$K.

Let us turn to the formula relating the temperature T of the primordial matter with the time t elapsed from the start of the expansion:

$$\rho_\Sigma = \kappa\sigma T^4/c^2 = 3/32\pi G t^2. \tag{2}$$

Here ρ_Σ - density of all of the matter, σ - Stefan-Boltzmann constant, G - gravitational constant, and κ - dimensionless quantity characterizing the ratio of the density of all the particles to the density of the gamma quanta (equilibrium γ, e^+, e^-, ν_e, $\bar{\nu}_e$, ν_μ, and $\bar{\nu}_\mu$ correspond to $\kappa = 9/2$). We note that the change of κ involves a change in the connection between T and t.

At high temperatures, the reactions

$$\begin{gathered} e^+ + n \rightleftarrows p + \bar{\nu} \\ \nu + n \rightleftarrows p + e^- \end{gathered} \tag{A}$$

ensure an equilibrium ratio of the neutron concentration n to the proton concentration p:

$$n/p = \exp(-\Delta mc^2/kT).$$

Here Δm is the mass difference between the neutron and the proton.

The time of establishment of equilibrium is

$$\tau = 1/\sigma nc \approx \mathrm{const}/T^5, \tag{3}$$

where σ is the cross section and n_ν is the density of the neutrino; the electron rest mass is neglected. During the course of the expansion, an instant $t \approx \tau$ is reached at which the equilibrium no longer has time to be established: "quenching" of the neutrons takes place [2]. The corresponding temperature can be readily estimated from Eqs. (2) and (3):

$$T \approx \mathrm{const}\cdot\kappa^{1/6}.$$

Thus, larger κ correspond to higher quenching temperatures: the number of remaining neutrons is larger. An examination of the subsequent processes shows that almost all the neutrons have time to combine with the protons and to form helium nuclei; the corresponding estimates can be found in the table. ρ_n stands for the present-day nucleon density, which determines the specific entropy (see [2]), and ρ is the density of the difficultly-observed matter with zero rest mass, while the index "q" indicates the instant of quenching. We have already

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1) We refer to the lepton charge of electronic neutrinos and antineutrinos; its smallness is connected with the condition $|\rho_{\nu e} - \rho_{\bar{\nu}e}| \ll \rho_{\nu e} + \rho_{\bar{\nu}e}$ (ρ = density). We recall that here $\rho_{\nu e} + \rho_{\bar{\nu}e} = (7/8)(8/11)^{4/3}\rho_\gamma$. A similar fraction is obtained for the muonic neutrinos and antineutrinos under suitable limitations on their lepton charge.

$\rho_{m=0}/\rho_\gamma$	$(\kappa/4{,}5)_q$	$(n/p)_q$	He^4		
			$\rho_H = 3\cdot10^{-29}$	$\rho_H=3\cdot10^{-30}$	$\rho_H=3\cdot10^{-31}$
0.45	1	0.16	0,29	0.27	0.25
1,45	1.9	0,20	0.36	0,34	0,31
5.45	5.3	0,26	0,48	0.45	0,43
10,45	9,6	0,29	0,54	0,50	0,48

mentioned that the hydrogen content in the protostars certainly exceeded 60%, and consequently $\rho_{m=0} < 5\rho_\gamma$.

To which particles does this limit pertain?

1. To muonic neutrinos and antineutrinos. The deviation of their density from the equilibrium value is connected with the possibility of a larger leptonic (muonic) charge per unit of the co-moving volume of the universe.

2. To gravitons. The latter do not have any time at all to enter in equilibrium with the primordial matter [3], and their amount is determined by the initial conditions.

3. To still-unknown ultra-weakly-interacting particles left from the superdense phase[1].

The question of the electronic neutrinos and antineutrinos calls for a separate analysis. The point is that the presence of a chemical potential in ν_e ($\bar{\nu}_e$) leads not only to an increase of their density, but also to a direct change of the dynamics of the reactions (A), and this can cause cancellation of the indicated mechanism and lead to an arbitrarily low helium content [4]; the latter does not contradict the observations. In other words, if the specific leptonic (electronic) charge of the universe is large, the flux of DZP may exceed 2×10^{-33} g/cm^3.

In conclusion, we call attention of the adherents of the variable gravitational constant to the fact that G enters in formula (2) in the same manner as κ, and that variability of G would lead to an entirely different behavior of the nuclear processes in the primordial matter.

The author is sincerely grateful to Ya. B. Zel'dovich for interest in the work and significant remarks, and to R. A. Syunyaev for useful discussions.

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[1] We note that the limitation on the number of species of the undiscovered DZP is weaker than the limitation on their density; the earlier the particles leave the equilibrium state, the smaller the fraction of the total energy that they acquire [3].