The calculations and the experiments show that the graininess of the emulsion influences not only the resolving power of the image, but also more importantly, the level of the background that distorts the brightness distribution in the image.

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REST MASS OF MUONIC NEUTRINO AND COSMOLOGY

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Low-accuracy experimental estimates of the rest mass of the neutrino [1] yield $m(\nu_e) < 200$ eV/c^2 for the electronic neutrino and $m(\nu_\mu) < 2.5 \times 10^6$ eV/c^2 for the muonic neutrino.

Cosmological considerations connected with the hot model of the Universe [2] make it possible to strengthen greatly the second inequality. Just as in the paper by Ya. B. Zel'dovich and Ya. A. Smorodinskii [3], let us consider the gravitational effect of the neutrinos on the dynamics of the expanding Universe. The age of the known astronomical objects is not smaller than 5×10^9 years, and Hubble's constant H is not smaller than 75 km/sec-Mparsec $= (13 \times 10^9 \text{ years})^{-1}$. It follows therefore that the density of all types of matter in the Universe is at the present time [1)]

$$\rho < 2 \times 10^{-28} \text{ g/cm}^3.$$

The space surrounding us is filled presently with equilibrium radiation of temperature 3°K [4]. It is proposed that this is "relict" radiation and is proof of the high temperature possessed by the plasma during the pre-stellar high-density period.

At a temperature of the order of 3 MeV for ν_e and of the order of 15 MeV for ν_μ, complete thermodynamic equilibrium existed between ν, γ, e^+, and e^-. The number of other particles in this equilibrium is small, except perhaps gravitons, which, however, have no effect on the arguments that follow. In thermodynamic equilibrium, the ratio of the number of fermions and antifermions with spin 1/2 to the number of quanta is

$$[\nu_e] + [\bar{\nu}_e] = [\nu_\mu] + [\bar{\nu}_\mu] = [e^+] + [e^-] = 2\frac{\int (e^x + 1)^{-1} x^2 dx}{\int (e^x - 1)^{-1} x^2 dx}[\gamma] = 1.5[\gamma].$$

However, during the course of the cooling from $T > m_e c^2$ (for which these relations are written) to the present time, when $T \ll m_e c^2$, these relations change, since the annihilation of the e^+e^- increases the number of quanta without changing the number of neutrinos per unit of co-moving volume [5]. At the present time we can expect

$$[e^+] + [e^-] = 0, \quad [\nu_\mu] + [\bar{\nu}_\mu] = [\nu_e] + [\bar{\nu}_e] = 0.5[\gamma].$$

At 3°K we have $[\gamma] = 550$ g/cm^3, from which we obtain for the neutrino at the present time

$$[\nu_\mu] + [\bar{\nu}_\mu] = [\nu_e] + [\bar{\nu}_e] = 300 \text{ cm}^{-3}.$$

Comparing with the density limit given above, we obtain

$$m_0(\nu_\mu) < 7 \times 10^{-31} \text{ g} = 400 \text{ eV}/c^2$$

and the same for $m_0(\nu_e)$. Thus, we obtain no new information for the electronic neutrino; for the muonic neutrino, on the other hand, the cosmological considerations reduce the upper limit of the rest mass by three orders of magnitude.

In considering the question of the possible mass of the neutrino we have, naturally, used statistical formulas for the four-component ($m \neq 0$) particles. We know, however, that in accordance with the (V - A) theory, neutrinos having a definite polarization participate predominantly in weak interactions. Equilibrium for neutrinos for opposite polarization is established only at a higher temperature. This, incidentally, can change the limit of the mass by not more than a factor of 2.

A neutrino with non-zero rest mass can become annihilated in accordance with the diagram

$$\nu_\mu + \bar{\nu}_\mu \xrightarrow[\text{(weak)}]{} \mu^+ + \mu^- \xrightarrow[\text{(el.-mag.)}]{} \gamma + \gamma$$

if $m(\nu_\mu) > m(e^\pm)$, and also either into 3γ or, in the square of the weak interaction, into a $\nu_e + \bar{\nu}_e$ pair, if it is assumed the $m(\nu_\mu) > m(\nu_e)$. When $v < c$ the annihilation cross section behaves like $1/v$. Estimates show, however, that there is no time for noticeable annihilation to take place during the course of the cosmological expansion.

The momentum of the interaction particles changes during the course of expansion like $1/R$, where R is the linear scale, independently of the presence and magnitude of the particle rest mass. At the present time the neutrino momentum should be of the same order (somewhat smaller) as the momentum of the relict quanta, i.e., $\bar{p} \approx 5 \times 10^{-4}$ eV/c.

If the neutrinos have a rest mass, then their velocity and the speed of sound in the neutrino gas are of the order of p/m, i.e, say 30 km/sec at $m = 5$ eV/c^2 and 3 km/sec at $m = 50$ eV/c^2. Strong gravitational perturbations should be produced in such a gas by the galaxies. It is possible that a more detailed analysis of these processes will allow us to lower the foregoing estimate of the upper limit of the neutrino mass.

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1) We use the asymptotic formula

$$T = \pi/2H\sqrt{\rho/\rho_c}\ ;\quad \rho_c = 3H^2/8\pi\sigma\ ;\quad \rho = 3\pi/32\sigma T^2.$$

Other more complicated estimates based on an investigation of remote objects give a similar result:

$$q_0 = \rho/2\rho_c < 2.5;\quad H \leq 120\ \text{km/sec.Mparsec},$$

$$\rho_c \leq 2.5 \times 10^{-29}\ \text{g/cm}^3,\quad \rho < 1.25 \times 10^{-28}\ \text{g/cm}^3.$$

EXCITATION OF SIGNALS IN A NEGATIVELY CHARGED POST OF AN ANTENNA UNDER THE INFLUENCE OF AN UNFOCUSED LASER BEAM

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In this article we describe the results of an investigation of current pulses produced when an unfocused laser beam strikes a metallic electrode or a post that serves as an antenna, on which a negative potential is applied.

An ordinary Q-switched ruby laser was used, whose beam was aimed onto an antenna post located several meters away and under a negative voltage $U \approx 0 - 3$ kV. The antenna post was connected to the ground through a capacitor of $\approx 10^4$ pF (to block the dc current) and through a resistor of ≈ 100 ohms (to pick off the pulse). The pulse from the resistor was fed through a capacitance ($C \simeq 10^4$ pF) and amplifiers (UR-3 and UR-4) to an oscilloscope (S1-10).

Fig. 1

Figure 1 (0.3 μsec sweep) shows the characteristic pulse produced by the laser beam. The pulse duration is ~50 nsec, commensurate with the duration of the laser flash.

Figure 2 shows the dependence of the pulse amplitude on the potential applied to