It can be concluded that the obtained experimental results on the radiation produced by electrons in thin aluminum films agree on the whole with the theory of transition radiation.

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POSSIBLE EXISTENCE OF A PASSIVE BARYON STATE

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Submitted 2 January 1966
ZhETF Pis'ma 3, No. 5, 197-201, 1 March 1966

A group of physicists from the Tokyo Institute of Nuclear Research reported at the London Conference of 1965 [1] that they observed an extensive air shower with approximately 10^5 particles, falling at a zenith angle of 86 ± 1/2 deg. This shower was extremely interesting, since it was observed under a layer of atmosphere approximately 12,000 g/cm^2 thick. The authors have shown that this shower, with energy [3-5] 10^{14} eV, accompanies a nuclear interaction occurring under the installation in a layer 200 - 400 g/cm^2 thick.

The authors indicate that an array of area $S = 100$ m^2 and solid angle $\Omega = 1$ will record such events produced by exponentially absorbed nucleons once every 10^{36} years. Showers due to bremsstrahlung of muons should be registered once every 10^5 years. One can likewise not exclude the possibility of interpreting such an event as being a nuclear interaction between muons of energy $\sim 5 \times 10^{14}$ eV, but then the estimated observation frequency is at best once every 10 years, whereas the duration of the experiment was only 3500 hours.

The experimental situation becomes quite natural if one admits of the possibility that the nucleon goes over into a passive state after the interaction [2]. It is easy to calculate the angular distribution of the nucleons from this point of view. By considering a flux of particles traveling in the atmosphere at a zenith angle ϑ, we can, neglecting the fluctuations of the inelasticity coefficient K for the interaction of the first-generation nucleons with flux N_1, write equations for the variation with depth (x) of the flux S_1 of first-generation baryons and the flux N_2 of second-generation nucleons

$$\frac{\partial^2 S_1}{\partial x \partial E}(E, x, \vartheta) = \frac{1}{1 - K}\frac{\partial N_1}{\partial E}\left(\frac{E}{1 - K}, 0\right)^{e^{-x}} - \frac{\partial S_1}{\partial E}(E, x, \vartheta)\frac{\beta}{x}, \quad (1)$$

$$\frac{\partial^2 N_2}{\partial x \partial E}(E, x, \vartheta) = \frac{\partial S_1}{\partial E}(E, x, \vartheta)\frac{\beta}{x} - \frac{\partial N_2}{\partial E}(E, x, \vartheta), \quad (2)$$

where

$$\beta = 1/\rho_0 c\tau_0 \cos\vartheta (E/Mc^2). \quad (3)$$

In agreement with [2], we assume henceforth that the passive baryon has a lifetime $\tau = 2 \times 10^{-10}$ sec and a mass $Mc^2 = 10^9$ eV, and that the density of the atmosphere at an altide corresponding to one nuclear range is $\rho_0 = 1.2 \times 10^{-6}$ nuclear ranges in a 1-cm path.

For sea level, where $x > 1$, the solution for S_1 is given by the equation

$$\frac{\partial S_1}{\partial E}(E, x, \vartheta) = \frac{1}{1 - K} \frac{\partial N_1}{dE}\left(\frac{E}{1 - K}, 0\right) \beta! \, x^{-\beta}. \qquad (4)$$

The sphericity of the atmosphere was taken into account in the calculation in accordance with [3]. The following values were chosen for x (in nuclear ranges) and for the effective value of $\cos\vartheta_{eff}$:

$\vartheta°$	0	53	66	72	78	84	87	90
$\cos\vartheta$	1.0	0.60	0.40	0.30	0.20	0.10	0.05	0.00
$\cos\vartheta_{eff}$	1.0	0.60	0.41	0.32	0.23	0.15	0.13	0.12
x	10.5	17.5	26.2	35.0	51.5	97.0	160.0	370.0

In accordance with [4], we put $1 - K = 0.44$, and in accordance with [5,6] we took the primary spectrum of the nucleons in the form

$$\frac{\partial N_1}{\partial E}(E, 0) = 1.0 \times 10^{-10}\left(\frac{E}{10^{15}\ \text{eV}} \right)^{-2.8} \text{nucleons/cm}^2\text{sec-sr}\cdot 10^{15}\ \text{eV}$$

In the case when $\beta/x < 1$, i.e., when the fluxes S_1 and N_1 are in equilibrium, we have:

$$\frac{\partial N_2}{\partial E}(E, x, \vartheta) = \frac{\partial S_1}{\partial E}(E, x, \vartheta)\, \frac{\beta}{x}. \qquad (5)$$

It was assumed in the calculations that the ratio of the geometric range corresponding to the nuclear range to the range of the baryon in the passive state is $\beta/x = 1.2 \times 10^{-2}$ (10^{15} eV/E), for in this case the processes proceed in air under normal conditions.

It is easy to verify that for angles $\gtrsim 70°$ the nucleon flux is limited with good accuracy to the second-generation nucleons N_2. For smaller angles, in the energy region where the transition takes place from the exponential nucleon absorption (dashed curves of Fig. 1) to the law described by formula (5), it is necessary to take into consideration the contribution from succeeding nucleon generations. Such an account was taken for the vertical nucleon flux shown in Fig. 1.

It is seen from Fig. 2 that the differential spectra of the nucleons at 86 - 87° have a sharp maximum in the energy region $\sim 10^{15}$ eV. This circumstance can explain the absence from the experiments reported in [1] of events with lower energy. In accordance with Fig. 1, the total flux of nucleons at 86° is $\sim 5 \times 10^{-15}$/cm^{2}sec-sr. If we recognize that the observed showers are produced in a layer 5 nuclear ranges thick, then the number of events expected for the Tokyo experiments is

$$h = 5N_2\Omega St = 0.25.$$

We emphasize that from the point of view developed here both experimentally-observed

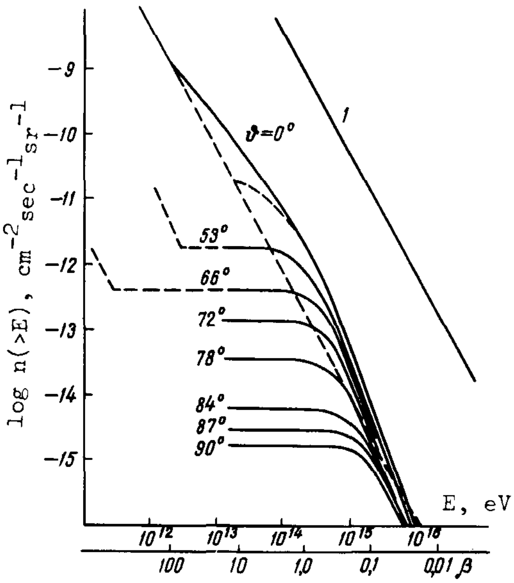

Fig. 1. Integral nucleon fluxes at sea level for different zenith angles. 1 - Spectrum of primary cosmic-ray nucleons.

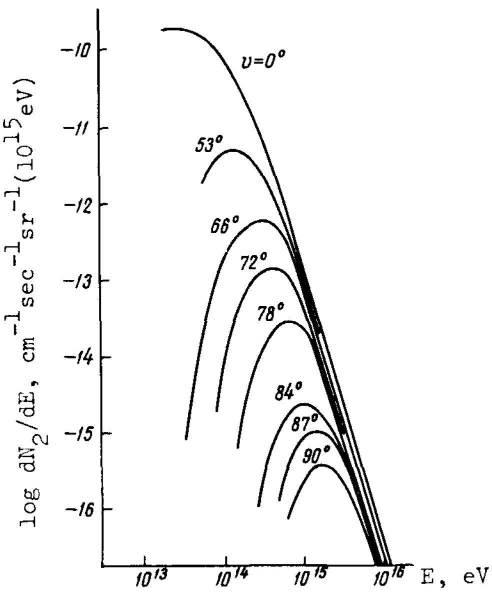

Fig. 2. Differential energy spectrum of sea-level nucleons at different zenith angles.

uantities - the nucleon energy and their flux - are determined by the value of τ_0 - the life-ime of the baryon in the passive state.

It follows from the obtained results that the cross section for the nuclear interaction f the baryon in the passive state does not exceed, in order of magnitude, 10^{-2} of the normal alue.

An important factor in the foregoing calculation is that at energies $\geq 10^{14}$ eV the prob-bility of transition of a nucleon into the passive state after interaction is close to unity. ata presented in [2] indicate that this probability remains appreciable when the energy de-reases to 10^{11} eV. At the present time we cannot exclude the possibility that at 30 GeV nergy, which is attainable with accelerators, some small fraction of passive baryons may be-ome observable.

We can predict in conclusion that "horizontal" showers will be observed and furthermore ith like probability. The frequency of shower observation at smaller zenith angles will in-rease, in accord with Fig. 1.

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CONTRIBUTION TO THE THEORY OF QUANTUM OSCILLATIONS OF SURFACE IMPEDANCE

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ZhETF Pis'ma 3, No. 5, 201-205, 1 March 1966

It is well known that diamagnetic Ladau-level quantization of the electron energies at temperatures that are low compared with the Fermi degeneracy temperature leads to quantum oscillations of both thermodynamic and kinetic quantities. In sufficiently strong magnetic fields ($\hbar\Omega > 2\pi^2 kT$, $\Omega\tau > 1$) these oscillations are not exponentially small. (This is the only case discussed here.) In the static case, when the electrostatic and electromagnetic effects separate, there is also separation of the oscillations of the thermodynamic quantity - the magnetic moment (Shubnikov - van Alphen effect) - and of the kinetic quantity - the resistance (Shubnikov - de Haas effect). The relative amplitude of the quantum oscillations of the conductivity is then proportional to the "quasiclassic parameter" $\kappa = (e\hbar H_0/cS)^{\frac{1}{2}}$ (H_0 = constant magnetic field, S = area of extremal section of the Fermi surface) and is of the order $\Delta \sim \Delta\sigma_{qu}/\sigma_{cl} \sim \kappa p$, where $p \sim \sigma_{cl}^{anom}/\sigma_{cl}^{main}$. The factor p is the result of the fact that the quantum oscillations are connected with anomalously small groups of electrons, whereas the classical conductivity is due to the main electron groups, which are absent only from the metals of the bismuth group. The amplitude of the oscillations of the magnetic susceptibility $\chi_{ik} \equiv \partial\mathcal{M}_{st}^{i}/\partial n_{st}^{k}$ ($\mathcal{M}$ - magnetic moment, an expression for which is given in [3]) is determined at low temperature both by the "quasiclassic parameter" and by the "relativistic parameter" $\rho = v_0/c$ (v_0 = Fermi velocity of the electrons) and is of the order of $\chi_{st} \sim \rho^2\kappa^3$. In an alternating electromagnetic field (and of course in a quantizing constant magnetic field) it is meaningful to speak of oscillations of a single quantity, the total surface impedance. These oscillations are connected both with nonrelativistic oscillations of the conduction current and with the relativistic oscillations of the magnetic moment, which are essentially of a different order of magnitude. It is of interest to estimate the contribution of each of these quantities to the impedance and to determine the relative magnitude of the quantum oscillations of the impedance in different cases.

This is simplest to do in the low-frequency region, when $\omega\tau \ll 1$, so that the system "manages" to follow the frequency (ω = frequency of the alternating field, τ = mean free path time), and $\delta_{eff} \gg r, l$ (r = Larmor radius of the electrons, $l \sim v_0\tau$ = mean free path, δ_{eff} = effective thickness of the skin layer), so that at microscopic distances r or l the fields can be regarded as homogeneous, and all the relations can be regarded as local. In the main approximation it is then possible to use the formulas derived for the static case [1-3], and the magnetic susceptibility can be regarded as static. It is easy to obtain the surface impedance Z from Maxwell's equations, by means of the obvious calculations. It turns out that