instant of their $\pi\mu$ decays. The kinetic energy of the π mesons was estimated to be several tens of Kev[1]. Because of the extremely small stopping time of such π mesons, the author[1] concludes that the observed $\pi\mu$-decay events did not take place "in flight", but after formation of mesonic atoms. If this conclusion is correct, then some very interesting deductions follow from it, to which we wish to draw attention in this note.

2. The energy distribution of μ mesons, produced during the π-meson decays which become part of the mesonic atoms, can be calculated with sufficient accuracy by the method analogous to that used by Podgoretskii and Rosental[2]. This distribution for the K-shells of light nuclei which are a part of the emulsion (C,N,O) agrees within the limits of statistical error with the experimental results. One cannot exclude also the decay of the π meson while it is on the L and M shells of these nuclei. However, while it is on these shells, the π meson must make a transition to the K-shell. The duration of the transition to the K shell does not exceed $\sim 10^{-13}$ sec even for the N-shell of C,N,O. The probability of the π-μ decay during this time is only 5×10^{-6}. If one assumes that the decay of π mesons takes place in the mesonic atoms of the heavy emulsion components (Ag, Br), then the observed energy distribution of μ mesons corresponds to μ meson decays on shells with a principal quantum number $n = 10-15$. Simple calculations show that in this case also the duration of transitions to the K shells does not exceed $\sim 10^{-13}$sec. It is necessary to conclude that the observed[1] π-μ decay of negative π mesons took place in the K-shell of the light mesonic atom of (C,N,O) nuclei, which is clear from the known energy distribution of μ-mesons on the K- shell of mesonic atoms with light nuclei.

3. Such a conclusion strongly contradicts modern conceptions about the properties of π mesons. Since about one half of the π mesons which stop in the emulsion are captured by the coulomb field of light nuclei, then it follows from reference 1 that the probability of a π meson decay is $\sim 10^{-3}$. Beginning with the generally accepted value of the π meson lifetime ($\sim 10^{-8}$ sec), we get a value of $\tau \sim 10^{-11}$ sec for the lifetime in relation to the nuclear capture of a π meson from the K shell of light nuclei. Meanwhile, theoretical estimates of τ, even for hydrogen and deuterium, give $\sim 10^{-15} - 10^{-16}$ sec (see, for example, reference 3), whereas for C,N,O one can expect a decrease in τ by several orders of magnitude[4,5].

Thus, the problem of verifying and refining the observations[1] becomes interesting in order to ascertain whether or not the above mentioned contradiction might not be explained by incorrect experimental data.

Note added in proof: Investigations appeared very recently[6] which reveal the shift of π meson K-levels in light mesonic atoms, indicating an effective repulsion of π mesons by nuclei. The connection between these facts and the results in reference 1 are not excluded.

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Measurement of the Absorption Coefficient of High Energy Nuclear Interacting Particles

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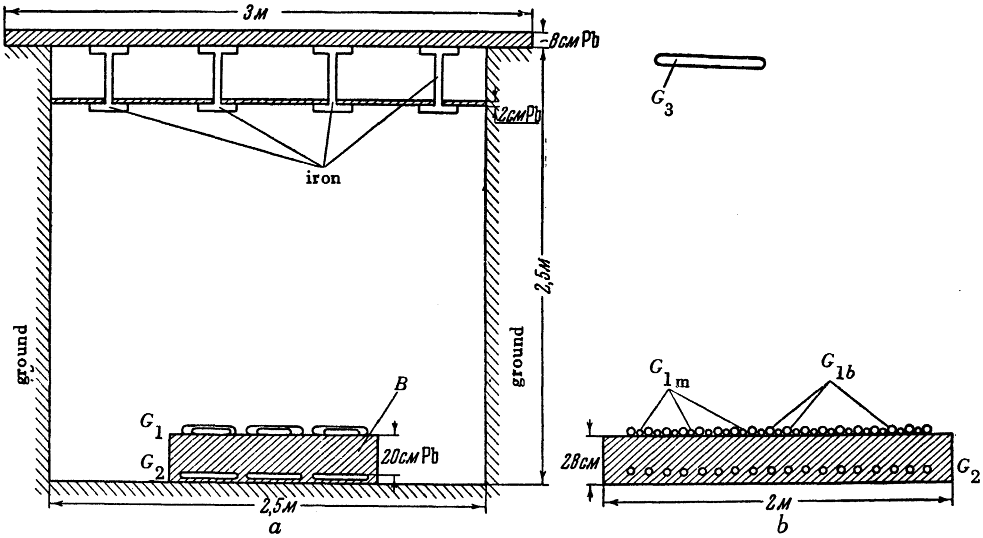
At the present time the problem of the collision mechanism of high energy nuclear interacting particles is of considerable interest. The data on the elementary act of high energy particle interactions can be obtained by investigating the dependence of the absorption coefficient of such particles on their energy[1]. The pertinent measurements were made by us during fall of 1952 at two elevations: 3860 m (Pamir) and at sea level (Moscow) with identical hodoscopic setups.

In order to obtain a sufficient amount of statistical data for the registration of high energy nuclear interacting particles a detector of large area was used. Its cross section is shown in the Figure. A layer of lead 3×2.5 m^2 in area and 8 cm thick, supported on flooring covered with iron (total thickness ~ 7 gm/cm^2), was placed over a rectangular pit with a 2.5×2 m^2 bottom area and 2.5 m deep. Under this lead layer and at 30 cm from its lower surface another 2 cm lead layer was placed. These lead filters absorbed the electron-photon component of cosmic radiation incident on the apparatus from



the atmosphere; in them electron-nuclear showers were produced by the nuclear interacting particles. In the center of the pit's bottom a lead block B (see drawing b) with a 2×1.2 m^2 base was located, with three layers of counters spaced uniformly over the entire surface; the area of each counter was 100 cm^2 (54 counters labeled G_{1b}) and 24 cm^2 (54 counters labeled G_{1m}). Inside of this lead block there were narrow cylindrical channels into which were placed counters G_2 of 100 cm^2 in area; their arrangement was similar to that of counters G_{1b} . The lead thickness between two adjacent counters was 4 cm, 20 cm above the counters and 4 cm below them. At the ground level at a distance of 1 m from the lead's edge there was placed a box G_3 with 10 counters each 330 cm^2 in area. All the mentioned counters were connected in the hodoscope according to Korablev's scheme[2]

Thus we had essentially three different groups of counters G_1 , G_2, G_3 . The counters of group G_1 (G_{1b} and G_{1m}) registered the intensity of the electronic component of the showers, generated by the nuclear interacting particles in the lead above the pit. Counters G_2 registered the penetrating particles in the showers. The counter G_3 gave information about the passage of a wide atmospheric shower. The operation of the hodoscope was effected by the coincidence of not less than three counters of group G_{1b} and two counters of group G_2 . Thus, the registered shower consists of at least three particles, two of which had to be of the penetrating type.

All the recorded showers were subdivided into various energy groups according to the number of strongly penetrating and strongly absorbed particles. The results shown in Table 1 refer to the selection of showers according to the number of penetrating particles. Showers with a greater number of penetrating particles also had the greater intensity of strongly absorbed particles. Consequently, the distribution of showers according to the number of strongly absorbed particles gave the same results as the subdivision in relation to the number of penetrating particles.

If one takes as a value $\gamma = 1.6$ for the index of the energy spectrum of nuclear interacting particles which produce recorded showers, then it follows from the data of Table 1 that the relationship of the number of recorded events pertaining to the extreme energy groups corresponds, to at least a ten-fold difference in the energy of particles producing these showers.

The absolute values of the energies of shower-producing particles were calculated by two independent methods: (1) by extrapolating the number of nuclear interacting particles from 3860 m to the top of the atmosphere and making a comparison with the intensity of the primary component of the cosmic radiation, and (2) according to the number of strongly absorbed particles, apparently electrons, in electron-nuclear showers. Both methods gave the same order of magnitude for the energy of generating particles. Thus, the energies for the nuclear interacting particles producing showers, when referred by us to the extreme energy groups, were $E_{\mathrm{I}} \sim 10^{11}$ eV and $E_{\mathrm{V}} \sim 10^{12}$ eV respectively.

Assuming that the flux of nuclear interacting particles is absorbed with atmospheric depth x according to the law $I_2 = I_1 \exp \{ -x/\lambda_{\mathrm{exp}} \}$ we determined from the data of Table 1 the absorption mean free path of these particles $\lambda_{\mathrm{exp}} = x / \ln$

TABLE I

No. of the energy group	No. of coincidence counters in group G_2	At sea level: Time of operation (hours)	At sea level: Total number of events	At sea level: Number of events per hour	3860 m: Time of operation (hours)	3860 m: Total number of events	3860 m: Number of events per hour
I	2; 3	217.8	389	1.79 ± 0.09	156.6	6823	43.57 ± 0.53
II	4; 5		171	0.79 ± 0.06		3169	20.24 ± 0.36
III	6; 7		102	0.26 ± 0.03		1061	6.78 ± 0.21
IV	8; 9	389.6	26	0.067 ± 0.013		327	2.09 ± 0.12
V	$\geqslant 10$		18	0.049 ± 0.011		269	1.72 ± 0.11
VI	$\geqslant 10 + \gtrless 20 \text{ в } G_{1m}$		10	0.026 ± 0.009		153	0.977 ± 0.08

TABLE II

No. of energy groups	I	II	III	IV	V	VI
$\lambda_{exper.}$	115 ± 2	113 ± 3	113 ± 3	107 ± 6	109 ± 7	100 ± 9
λ_1	131 ± 3	128 ± 4	128 ± 4	120 ± 7	116 ± 9	112 ± 11

where I_1 is the intensity at 3860 m, I_2 that at sea level, and x the air depth in gm/cm² between these altitudes. The results are shown in Table 2 .

In the second line of Table 2 are shown the values of the absorption mean free paths of nuclear interacting particles coming in vertically, corrected for the geometry of the apparatus. Our values for the absorption mean free path in air of nuclear interacting particles of 10^{12} eV energy agree well with the data of reference 3, in which for particles of the same energy in the upper half of the atmosphere the obtained value was $\lambda \sim 120$ gm/cm^2.

From our data and the data of other writers it is seen that absorption mean free path of the nuclear interacting flux with an energy interval $10^{10} - 10^{12}$ eV does not vary significantly, exceeding by about a factor of two the value of the interaction path which corresponds to the geometrical nuclear cross section for particles of such energies. Using the relationship of reference 1, $\lambda_0 = \lambda(1 - \Delta)$, where λ_0 is the mean free path of the interaction of nuclear particles and Δ is the effective number of secondary nuclear interacting particles, it is possible to conclude that, in collisions of nucleons with the nuclei of light elements, the energy of the incident nucleon is distributed non-uniformly among the secondary nucleons. Apparently the mechanism of collision is such that more than half of this energy is concentrated in one of these particles.

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