III-4-3. High Energy Nuclear-Active Particles and the Extensive Air Showers Which Accompany Them

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In connection with a large role which high energy nucleons play in production and development of extensive air showers (EAS) in the depth of atmosphere, the spectra of high energy nuclear active particles and EAS which accompany them were measured. Measuring was carried out in 1959 at the Pamirs (650 g/cm²) with the help of the set described in paper (1).

The curve 1 of Fig. 1 shows a spectrum of ionization bursts which were initiated by nuclear interactions of high energy particles in a large block of carbon (200 g/cm²).

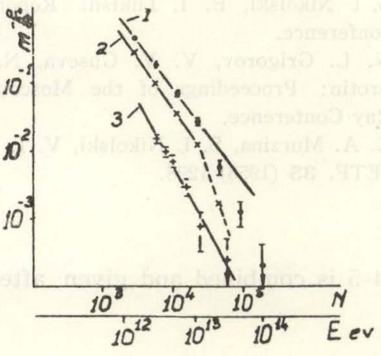

Fig. 1.

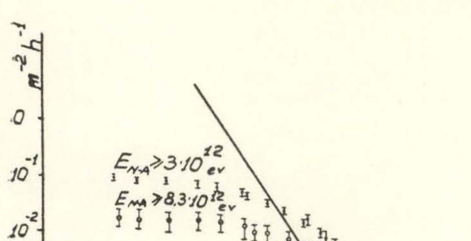

Fig. 2.

* This paper was combined with III-4-4 and III-4-5 and presented by G. T. Zatsepin.

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The absciss a presents the magnitude of bursts in the relativistic particle numbers N, and also the supposed value of the particle energy which caused this event.

An estimate of the energy of nuclear active particles which underwent a nuclear interaction in carbon is carried out taking into account of the absorption of electron-photon components in carbon.

The integral spectrum of EAS accompanying nuclear active particles with the energy $E \geq 3.10^{12}$ev and spectrum of showers accompanying particles with $E \geq 8.3.10^{12}$ev are given in Fig. 2. One can see from comparison of these spectra with the size spectrum (straight line in Fig. 2) that the value of the nuclear-active component in the EAS core in the showers with particle number $<10^5$ undergoes large fluctuations. These fluctuations are the results of a large role of energetically distinct particles in the development of EAS with the number of particles $<10^5$. It is even reflected with a constant inelasticity coefficient in the nucleon interaction as confirmed by the calculations which were carried out. Fig. 3 shows the results of calculations of spectra EAS which accompany nucleons the energy of which at the observation level is equal to 3.10^{12}ev. Different numbers of nucleon interactions with nuclei of air atoms were taken into account and average range for nuclear interaction in air $\lambda = 75$ g/cm² was

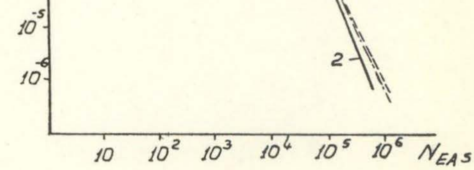

Fig. 3.

proposed. The distribution of depth of interactions and inelasticity coefficients was carried out by the Monte-Carlo method.

The curve 1 of Fig. 3 represents the results of calculation for the constant inelasticity coefficient (K=0.4) and curve 2 represents the event when the inelasticity coefficient distribution is the same as in the paper (2). The EAS produced by primary nuclei were taken into account for the constant inelasticity coefficient (curve 3). It is necessary to note that at a certain difference between the calculations and experiment: a change of the spectrum slope takes place at a smaller number of particles in a shower than it was observed in the experiment. As an analysis of the experimental data has shown the main reason of such difference is that some nuclear-active particles simultaneously impinge on the detector.

The calculations allow to determine more accurately the expected number of nucleons not accompanied by EAS.

The experimental data on events not accompanied by EAS are shown by curve 3 in Fig. 1. Here the events are included which are accompanied by shower with a number of particles <500.

As an analysis of the ionization distribution of chambers of the lower tray has shown the radiative shower share is less than 5%. At an isotropic angular distribution of muons these results and our calculations correspond to the range for nuclear interaction in air $\lambda=82\,\mathrm{g/cm^2}$ at absorption range equal to $120\,\mathrm{g/cm^2}$.

In conclusion it is necessary to note that the result of paper (3) on increase of the slope of the energy spectrum of nuclear-active particles at the ionization $>5.10^4$ relativistic particles was repeated in the present experiment.

This increase of spectrum slope becomes more noticeable, if one excludes groups of nuclear active particles or EAS cores with the number of particles $>10^5$ (curve 2 of Fig. 1).

References

1) S. I Nikolski, E. I. Tukish: Report on this conference.
2) N. L. Grigorov, V. V. Guseva, N. A. Dobrotin: Proceedings of the Moscow Cosmic Ray Conference.
3) E. A. Murzina, S. I. Nikolski, V. I. Yakovlev JETF, **35** (1958) 1298.

Discussion

Discussion for papers III-4-3, III-4-4 and III-4-5 is combined and given after the Paper III-4-5.