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MEASUREMENT OF THE ENERGY SPECTRUM OF PRIMARY COSMIC RAYS IN THE ENERGY REGION FROM 10^{10} — 10^{14} EV WITH THE HELP OF AES "PROTON-1"

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SUMMARY

This experiment, carried out aboard the heavy AES Proton-1, was designed to measure the energy spectrum of primary cosmic rays in the high energy range. So far this could not be performed by direct measurements.

The measurements were conducted with the aid of a type SEZ-14 ionization calorimeter. The results presented here cover only a part of the material collected during satellite's lifetime and are therefore preliminary.

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The energy spectrum of primary cosmic rays, encompassing nearly 10 orders, is presently studied by means of direct measurements only in the very narrow range of energies 10^9— 10^{10}ev.

The various indirect methods, applied for the study of the spectrum for greater energies, assume also a different treatment of the data obtained, as a function of *a priori* assumptions laid at the basis of spectrum computation, thereby rendering the conclusions about the primary spectrum of cosmic rays ambiguous. Moreover, different results are also obtained during measurements by a single method with an identical computation scheme (see, for example [1-3]).

Because of the importance of information relative to the spectrum of primary cosmic rays for their astrophysics, and also for the establishment of a series of characteristics of nuclear interactions at high energies, there arises the pressing requirement in conducting direct measurements of the energy spectrum in as great an energy range as possible. It is obvious that such measurements are possible only beyond the limits of the atmosphere. The experiment has been set up on the heavy AES PROTON-1.

* IZMERENIYE ENERGETICHESKOGO SPEKTRA PERVICHNYKH KOSMICHESKIKH LUCHEY V OBLASTI ENERGIY 10^{10} -- 10^{14} EV S POMOSHCH'YU ISZ "PROTON-1"

Measurements were conducted by the ionization calorimeter method with the aid of the SEZ-14 device [4]. Proton spectra were measured in the energy range $5 \cdot 10^{9} - 10^{12}$ ev and those of all particles (protons and heavier nuclei) in the $2 \cdot 10^{10} - 10^{14}$ev energy range without determination of the charge.

The measurement of the spectrum of protons took place under fulfillment of the following conditions:

1) a singly-charged particle passed through the proportional counter;
2) a singly-charged particle passed through the interaction detector;
3) if only one particle emerged downward from the calorimeter (energy detector) and was registered by the lower scintillation counter;
4) the energy liberation in the calorimeter was sufficient for the operation of at least the first disciminator having minimum threshold.

Under such conditions the average thickness of the calorimeter constituted ~ 400 g cm^{-2}Fe.* With such a comparatively small thickness of the calorimeter (250 and 400 g cm^{-2}) the measured spectrum of all particles and protons are undistorted only in the case when the interaction characteristics are not dependent on energy in the entire measured band.

It was shown in [5] that in the $3 \cdot 10^{11} - 2 \cdot 10^{12}$ ev energy range the spectrum of nucleoactive particle impulses under the layer of the matter in a single nuclear range coincided with the spectrum of nucleoactive particles obtained in the whole calorimeter. An analogous conclusion was derived for energies $2 \cdot 10^{11} - 2 \cdot 10^{12}$ ev in the work [6]. Analysis of the data obtained during operation of a large calorimeter on Aragats also show that in the energy range $5 \cdot 10^{11} - 3 \cdot 10^{12}$ ev there is liberated in the layer of matter 260 g$\cdot$cm^{-2} ~ 50 percent of the whole energy and this quantity is not dependent on the energy of primary particles in the indicated range (Fig.1). An analogous result was obtained also with the small Aragatsk calorimeter for energies $2 \cdot 10^{11} - 5 \cdot 10^{11}$ ev in a 230 g$\cdot$cm^{-2} matter layer; extrapolation to 260 g cm^{-2} gives the same fraction of energy within the bounds of error.

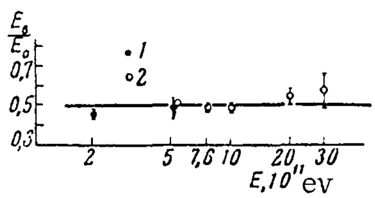

Fig.1 Mean share of energy liberated in a layer 260 g cm^{-2} thick, as a function of energy: 1) according to the small Argatsk calorimeter, 2) according to the large Argatsk calorimeter; thickness of the absorber 260 g cm^{-2}

The SEZ-14 device was tuned up at sea level by solitary μ-mesons, so calculated that the energy threshold correspond to the energy of a primary particle equal to $\sim 10^{10}$ ev. This value was refined in flight by the latitude effect of cosmic rays.

Presented in the current work are only the preliminary data, resulting from the processing of only part of the material collected during satellite's lifetime. Thus, for the construction of the proton spectrum data of 36 hr flight were utilized [7], whereas for the spectrum of all particles data of 50 hours were used, whereupon for the energy range $5 \cdot 10^{9} - 10^{12}$ ev, only data of 24 hours at the beginning of flight were utilized.

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* When measuring the spectrum of all particles, conditions 1-3 were not required. Then the thickness was 250 g$\cdot$cm^{-2}.

The results of measurements are plotted in Fig.2 in double logarithmic scale. The small inclination of the proton spectrum at low energies ($5 \cdot 10^9 - 5 \cdot 10^{10}$ ev) is caused by apparatus' effect, for at such energies a significant part of events is not registered, inasmuch as for the registration of protons the egress from the calorimeter downward of if only one particle is required. Consequently, all those cases, when the entire avalanche, including the primary particle, is absorbed in the calorimeter, are rejected. It is clear that such cases are most probable for protons with low energies. It is well apparent in Fig.2 that the spectrum of all particles does not show the "obstruction", inasmuch as at registration of all particles the fulfillment of the above-indicated conditions 1 - 3 is not prerequisite.

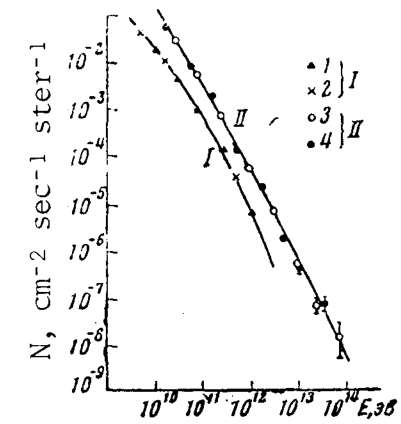

Fig.2. Spectrum of protons (I) and of all particles (II) of primary cosmic radiation: 1) & 3) first half of the device; 2, 4) second half of the device

The absolute values of intensities are plotted in the ordinate axis of Fig.2. The tying of the data obtained to the intensity was performed as follows. The hardness spectrum for protons' registered by SEZ-14 was constructed after one of the sessions. As a result it was established that the first threshold corresponds to energy ∿5 Bev (this quantity will be subsequently refined, after the statistical material has been increased and data on the orientation are obtained). After the indicated tying of device's energetic calibration to the point of proton spectrum corresponding to energy 10 Bev, the intensity was added, equal to $2 \cdot 10^{-2}$ $cm^{-2} \cdot sec^{-1} \cdot ster^{-1}$, that is, the value measured by a number of authors.

Analogously, ascribed to the point of spectrum of all particles at energy 10^{10} ev was the intensity $6.0 \cdot 10^{-2} cm^{-2} sec^{-1} \cdot ster^{-1}$. The ratio of the flux of nuclei and of protons to the proton flux at identical energy of nuclei and protons, the factor of 3.0, was obtained from estimates of fluxes of heavy nuclei at energies $\sim 10^{10}$ ev by the method described in [8].

It should be noted that the results obtained are preliminary, and that more specific conclusions may be made only after processing of a considerably larger experimental material.

Follows the vote of thanks for the numerous coworkers in this experiment.

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