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# 3 STUDY OF THE NUCLEAR COMPONENT OF PRIMARY COSMIC RAYS ABOARD AES "PROTON-2" 5 1

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# STUDY OF THE NUCLEAR COMPONENT OF PRIMARY COSMIC RAYS ABOARD AES "PROTON-2"

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## SUMMARY

The results of measurements are described of the nuclear component of primary cosmic rays. These measurements have been carried out aboard AES Proton-2 with the aid of a Cerenkov spectrometer CEZ-1 during the 105 to 113 orbits of the satellite.

* * *

The study of the nuclear component of primary cosmic rays aboard the AES Proton-2 was performed with the help of the Cerenkov spectrometer CEZ-1, of which the description is given in ref. [1].

During the active lifetime of Proton-2, which was of about three months, broad information was obtained on the composition of the nuclear component through nuclei with a charge $Z \simeq 40 \div 50$. Proton-2 did not have any specific orientation in space, and this is why such a detailed analysis of the results of measurements (kind of energy spectrum of particles with different charges) could be completed only after very cumbersome computations of satellite orientation. At present the computed orientation corresponds to a small part of trajectory, allowing to ascertain the mode of satellite rotation over the 105-113 convolutions and understand the character of intensity variation of nuclear fluxes measured by CEZ-1.

In this current note we shall limit ourselves to the examination of the results of measurements over trajectory convolutions 105 to 113.

The dependence of the measurement time $t$ of the number of various nuclei with kinetic energy $E \geqslant 400$ Mev/nucleon is plotted in Fig.1. It may be seen from these diagrams that the intensities of nuclei with different Z vary identically with time, attaining maxima and minima at time intervals $\sim 15\Delta t$.

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(*) IZUCHENIYE YADERNOY KOMPONENTY PERVICHNYKH KOSMICHESKIKH LUCHEY NA ISZ " PROTON-2".

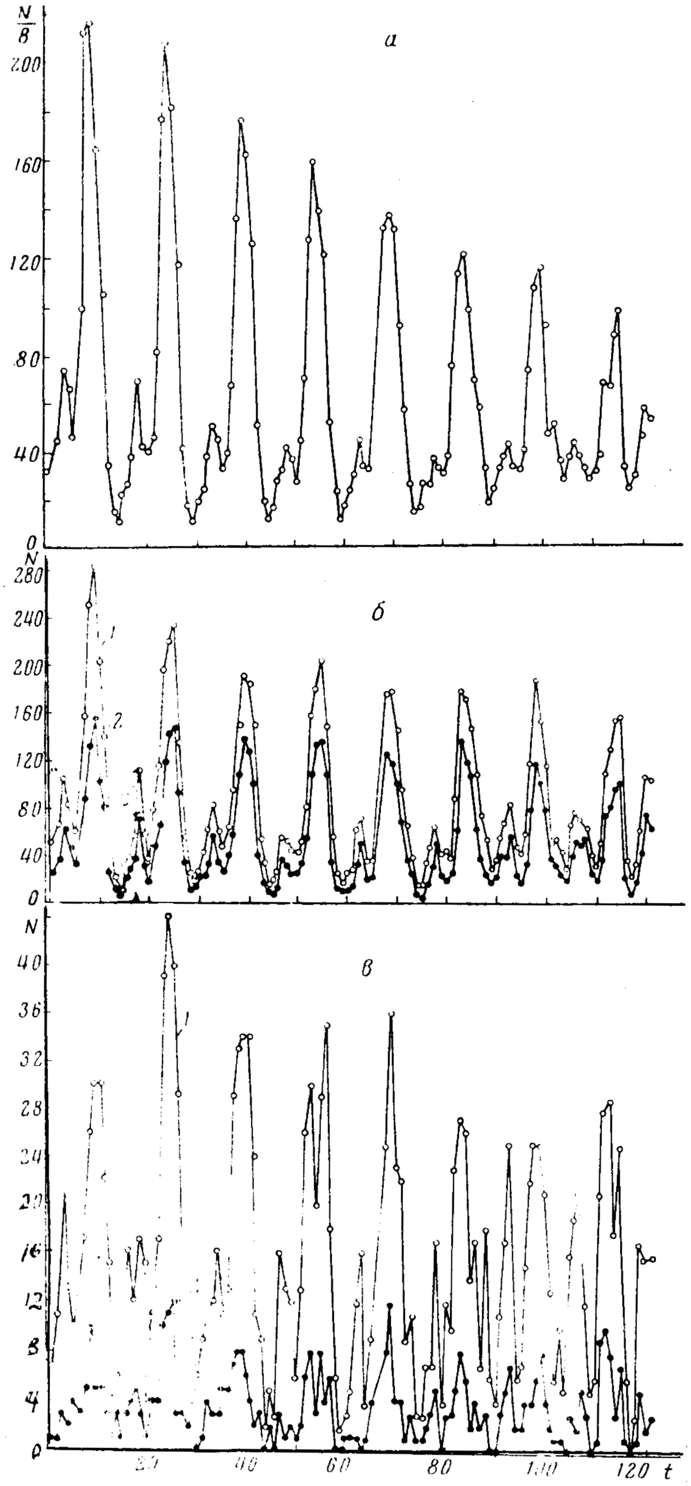

Fig.1. Dependence of the number N of nuclei with kinetic energy $E \geqslant 400$ Mev/nucleon, registered for the (unitary) time interval $\Delta t = 387$ sec on the measurement t for various groups of charge groups. a) for $Z \geqslant 2$, b) for $z \geqslant 4$ (curve 1) and $Z \geqslant 6$ (curve 2), c) for $Z \geqslant 10$ (curve 1) and $Z \geqslant 21$ (curve 2)

The intensity maxima correspond to satellite flight through high latitudes, and the intensity minima — to flight across the equator, i. e., the periodical intensity variation with period 15$\Delta t$, equal to the time of satellite revolution around the Earth, is conditioned by the latitude effect of cosmic rays.

Attention is drawn to the fact that following the large maximum (high latitude flight in the Southern Hemisphere) comes a small minimum (high latitude flight in the Northern Hemisphere). An analogous pattern is observed with intensity minima: one minimum is "deeper" than the neighboring minimum. At the same time there is a tendency of maximum height decrease (in the Southern Hemisphere) and intensity leveling in minima.

Such a character of intensity variation is determined by the fact that during averaging time of 387 seconds, Proton-2 effected several convolutions around its axis of own rotation, whereupon the axis of rotation succeeded during that time to modify essentially its position relative to the vertical. As a result of this, the CEZ-1 device registering the directed radiation was found to be shielded by the Earth.

Analysis of the character of rotation has shown that at the outset, during the flight through high latitudes of the Southern Hemisphere over the considered portion of the trajectory, there was no shielding by the Earth, for the device was "looking" upward. However, as the time went on, it began to fall within the Earth's shadow in the Southern hemisphere, and the darkening time gradually rose.

During the flight through high latitudes in the Northern Hemisphere, the device "looked" most of the time downward, that is, it was ed by the Earth. The different depth of minima is explained by the different degree of darkening by the Earth of the input device of CEZ-1 in the equtorial regions as the satellite moved from South to North and from North to South.

Therefore, the different degree of apparatus' darkening by the Earth over various parts of satellite trajectory is equivalent to variation with the time <u>t</u> of the effective angular aperture of the device. Since different groups of nuclei are registered simultaneously, the variation of the measured intensity, conditioned by the rotation of the AES, is manifest identically on all nuclei outside the dependence on Z. This is why the effect in question can not change the group ratio of nuclei with various Z.

In order to be convinced of the above, we determined the ratios of the various groups $N(Z \geq 2, t) / N(Z \geq 4, t)$, $N(Z \geq 4, t) / N(Z \geq 6, t)$ and so forth, for each of the 15 time intervals constituting the total period of satellite's revolution, tying to them the values of the ranges of vertical magnetic hardness determined after J. Quenby and Wenk [2]. The ratios are averaged by 8 periods. The results are compiled in Table 1.

It may be seen from Table 1 that the group ratios of various nuclei are not dependent upon the values of magnetic hardness and device orientation relative to the Earth, i. e., by hardness all the spectra from those of helium to those with $Z \gtrsim 21$ are similar.

This is why we utilized with the view of improving the statistics for the determination of the chemical composition of the nuclear component, all particles with different Z, registered by the device for the entire flight time in the interval 103 - 113 convolutions.

TABLE 1

| Interval number | Interval of vertical magnetic hardness Bv | $\frac{N(Z \geq 2,\ t)}{N(Z \geq 4,\ t)}$ | $\frac{N(Z \geq 4,\ t)}{N(Z \geq 6,\ t)}$ | $\frac{N(Z \geq 6,\ t)}{N(Z \geq 10,\ t)}$ | $\frac{N(Z \geq 10,\ t)}{N(Z \geq 21,\ t)}$ |
|---|---|---|---|---|---|
| 1 | 3 – 1 | 6.8±0,4 | 1.6±0.1 | 2.3±0.3 | 7,5±2.2 |
| 2 | 1 – 3 | 4,8±0.2 | 1.6±0.1 | 1.9±0.2 | 6.1±1,3 |
| 3 | 3 – 6 | 5.0±0.2 | 1.5±0.1 | 3.9±0.4 | 4.2±0,9 |
| 4 | 6 – 13 | 6.3±0,3 | 1.8±0.2 | 2.7±0.3 | 6.5±1.9 |
| 5 | 13 – 15 | 6.6±0.4 | 1.8±0.2 | 3.0±0,4 | 2.9±0,7 |
| 6 | 15 – 12 | 5,8±0.3 | 1.6±0.1 | 2.9±0.4 | 2.8±0.6 |
| 7 | 12 – 6 | 5,6±0.2 | 1.6±0,1 | 2.3±0.2 | 5.5±1.0 |
| 8 | 6 – 3 | 6,0±0.2 | 1.5±0.1 | 2.6±0.2 | 5.9±0.8 |
| 9 | 3 – 1 | 6,4±0,2 | 1.5±0.1 | 2.3±0.1 | 7,2±1,0 |
| 10 | 1 – 3 | 6.2±0.2 | 1.5±0.1 | 2.3±0.1 | 8.2±1.3 |
| 11 | 3 – 6 | 6.6±0.2 | 1.5±0.1 | 2,4±0.2 | 8.7±1.8 |
| 12 | 6 – 13 | 6,7±0.3 | 1.8±0.1 | 2,9±0.4 | 4.7±1,2 |
| 13 | 13 – 15 | 6.0±0.4 | 1.9±0.2 | 2.5±0.4 | 4.2±1,3 |
| 14 | 15 – 9 | 6.3±0.4 | 1.5±0.2 | 2.6±0.4 | 3,6±1,1 |
| 15 | 9 – 3 | 5.2±0.3 | 1.7±0.2 | 3.2±0,5 | 6.1±2.1 |

During that time 60,350 nuclei with $Z \geq 2$, 9,886 nuclei with $Z \geq 4$, 6,280 nuclei with $Z \geq 6$, 1,836 nuclei with $Z \geq 10$ and 422 nuclei with $Z \geq 21$ have been registered. In order to obtain the real number of nuclei with the indicated values of Z, the following corrections were introduced into the results of measurements, these being conditioned by the apparatus' specifications.

1. The threshold of the amplitude discriminator, separating protons from α-particles, was installed at the magnitude corresponding to $3V_p$, where $V_p$ is the most probable pulse amplitude induced by a particle with Z = 1. Starting from the experimentally determined in laboratory width of pulses induced at Cerenkov counter output by μ-mesons of cosmic rays, we computed the fraction of α-particles that would be susceptible of inducing pulses $V < 3V_p$. It was found to be equal to 32 percent. In other words, the device's efficiency for the registration of He nuclei is 68 percent.

2. When registering nuclei with $Z \geq 10$ at a time interval of ~9 sec., the trigger position was interrogated, "memorizing" the fact of registration by the apparatus of nuclei with $Z \geq 10$. Thus, if for the time of 9 sec., 2, 3, 4 etc. particles with $Z \geq 10$ hit the device, such cases were miscounted. This kind of calculation was subject to corrections.

The group of light nuclei (L-group) encompasses nuclei with charges Z = 3 : 5, the group VH — nuclei with $Z \geq 20$. In our device light nuclei separated, with Z = 4 : 6, and in the group VH — nuclei with $Z \geq 21$. Taking into account the distribution by Z after the data of reference [3] and the above indicated corrections, we obtained that for the measurement time of ∿ 775 min., 74,200 He nuclei, 2790 nuclei with $3 \leqslant Z \leqslant 5$ (L-group), 5800 nuclei with $6 \leqslant Z \leqslant 9$ (M-group), 2100 nuclei with $Z \gtrsim 10$ (H-group) and 474 nuclei with $Z \gtrsim 20$ (VH-group) were registered. Hence the He nuclei ratio to the S-group ($Z \gtrsim 6$) is

$$He/S = 9.4 \pm 2.0;$$

and

$$L/S = 0.35 \pm 0.04,$$
$$H/M = 0.36 \pm 0.08,$$
$$VH/H = 0.23 \pm 0.04.$$

The errors in the ratios are fundamentally determined by way of accounting for the possible variation of amplitude discriminators' thresholds, which does not exceed 10 percent.

We disregarded here the group of particles with $Z = 1$, for there is included in it, besides primary protons, a significant admixture of secondary particles, of which the share is function of the latitude of the place of observation and of device's orientation [4].

*** THE END ***

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