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STUDY OF HIGH ENERGY γ-QUANTA BEYOND THE ATMOSPHERE

by

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(USSR)

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SUMMARY

The results of measurements are illustrated of primary cosmic radiation's γ-quanta, carried out from the space stations PROTON-1 and PROTON-2, designed for energies exceeding 50 Mev. The translated version includes the additional results published in a later work [9].

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* *

Work on measurement of γ-quanta of sufficiently high energies in the composition of primary cosmic radiation began to develop in the course of the last few years. By the same token a substantial broadening in the frequency band of registered electromagnetic radiation has been attained. One may anticipate that new data will be at the same time obtained on the galactic and intergalactic space, and also on local emission sources [1, 2].

Estimates of flux of primary γ-quanta with energies $E_\gamma > 50$ Mev come up with a magnitude $\sim 10^{-4}$ $cm^{-2} \cdot ster^{-1} \cdot sec^{-1}$ [1 - 3], which constitutes a small fraction of the flux of charged particles. The greatest number of works on γ-ray measurements in the indicated energy range was completed during raising of instrumentations on balloons. The magnitudes of the fluxes obtained upon extrapolation of data to atmosphere boundary constitute $\sim 10^{-3}$ $cm^{-2} \cdot ster^{-1}$ [4-6]. Apparently, accountable factors are included in these experiments, which are linked with the presence of notable amount of matter ($\sim 3 - 5$ $g \cdot cm^{-2}$), distributed over a significant height above detectors. The corresponding value obtained in the Kraushaar and Clark experiment carried out aboard Explorer-11 was found to be equal to $3 \cdot 10^{-4}$ $cm^{-2} \cdot ster^{-1} \cdot sec^{-1}$ [7, 8]. However, the statistical precision of the results obtained in this work is insufficient and the data require refinement.

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* [IZUCHENIYE γ-KVANTOV VYSOKOY ENERGII ZA PREDELAMI ATMOSFERY]

A device was installed aboard AES Proton-1 and Proton-2 with the view of registering γ-quanta with energies exceeding 50 Mev. The variant, referred to in the work [7], was laid at the basis of its construction so as to make the comparison of results most reliable. At the same time improvements were introduced, of which the most substantial consists in that the apparatus is adjusted for measurements of γ-ray spectra.

The device constitutes a telescope formed by a γ-quantum converter, which consists of layers of plastic scintillator and caesium iodide disposed in sequence, and of a Cerenkov counter with radiator made of lead glass, which functions as detector of energy and propagation direction of γ-rays. The telescope's detectors are placed inside a hood made of scintillating plastic material, shielding the telescope from the background of charged particles when sorting the anticoinicidences (Fig.1). Besides γ-rays the device is used for spectra of pulses from other electrical neutral particles (for example, neutrons), and also the fluxes of charged particles, of which the energy exceeds the threshold of luminance in the radiatior of the Cerenkov counter. The details concerning this device and the characteristics of its operation are presented in the work [9].*

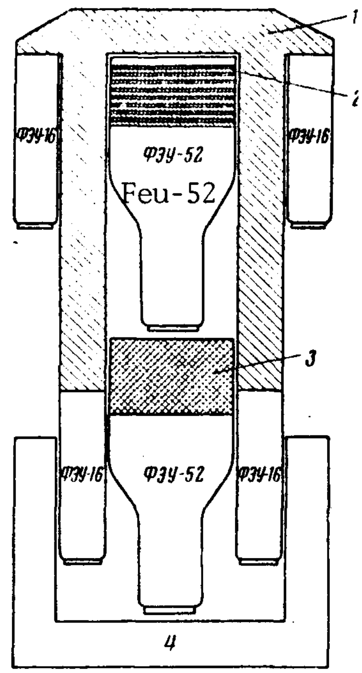

Fig.1. Block-scheme of the device: 1) plastic scintillator ("hood"); 2) laminar crystal; 3) Cerenkov counter (Lead glass); 4) electronic circuits.

The processing of information arrived after the launching of Proton-1 allowed us to obtain preliminary data on radiation intensities beyond the limits of the atmosphere. The device's spectra from γ-quanta and neutral particles, measured for 40 hours of flight are plotted in Fig.2. The inclinations of these spectra are different, which is evidence of the different nature of radiations connected with them. The same figure shows the spectrum of γ-rays after correction for accounting of the effective registration and of device's geometric factor ($\varepsilon = \bar{\varepsilon}_1 \varepsilon_2 \approx 0.3$); here $\bar{\varepsilon}_1 \approx 0.43$ is the probability of γ-ray conversion; $\bar{\varepsilon}_2 \approx 0.7$ is the probability determined by the effectiveness of neutron and γ-ray fission; $\Gamma_{ef} \approx 7$ $cm^2 \cdot ster$ [9]. The flux of γ-quanta with energies $E \geqslant 50$ Mev, equal to $\sim 2 \cdot 10^{-3}$ $cm^{-2} \cdot ster^{-1} \cdot sec^{-1}$, agrees well with the data obtained in measurements on balloons, and also with those of Kraushaar and Clark for the case when the device's orientation in space is not taken into account [8]. The basic contribution to the intensity thus determined is conditioned by γ-rays of albedo from the atmosphere. This conclusion is corroborated by the close correlation in the variation of the counting rate of charged particles on account of latitude effect with the counting rate of neutral particles (γ-quanta, as well as neutrons). The value of the characteristic index of the γ-ray spectrum $\gamma = 1.6$ is also not in contradiction with the assumption, that the γ-quanta registered by the device are fundamentally conditioned by by decay of neutral π^0-mesons formed in the atmosphere matter by primary cosmic rays.

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* [Some of the data from this work and Figs.1,4* and 5* were borrowed from this later work]

The orientation magnitude of the flux of primary γ-quanta may be determined by introduction of data on satellite orientation obtained on the basis of readings of the SEZ-device entering into the complex of scientific apparatus of Proton-1 [10].

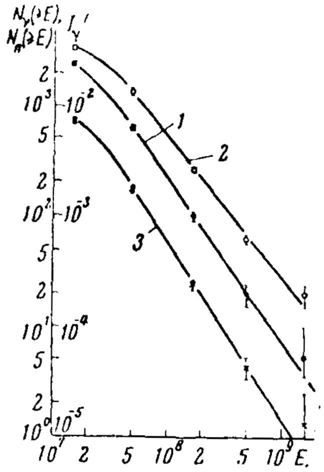

Fig.2. Integral spectra of radiations beyond the atmosphere: 1) device's spectrum of pulses from γ-quanta, $\gamma' = 1.5$; 2) same from neutral particles, $\gamma_n' = 1.3$; 3) normalized spectrum of γ-rays $\gamma' = 1.6$

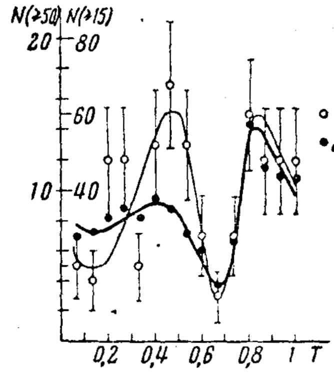

Fig.3. Counting rates of γ-quanta with energies $E_\gamma > 15$ and > 50 Mev, averaged for eight satellite revolutions (T = 1 corresponds to the revolution period; the time of measurement at each point is $\Delta t \approx 48$ min): 1)- N (>50 Mev) 2) N (>15 Mev)

According to these data it was found to be possible to choose the time interval when the angle between the axis of the telescope, measuring quanta and the direction toward the center of the Earth was sufficiently great. The counting rate of γ-quanta with energies E > 15 Mev and > 50 Mev, including the indicated time intervals, is shown in Fig.3. In the region 0.6 - 0.8T sharp minima were observed on the curves of Fig.3 (rise to the left and to the right explainable by the fact that in respective regions the device begins to register mainly γ-rays of albedo [8]). In the interval corresponding to the minimum, three γ-quanta were registered for the 48 minutes, of which the energies exceeded 50 Mev. The magnitude of the flux, estimated on the basis of these data, was found to be $(5 \pm 3) \cdot 10^{-4} cm^{-2} ster^{-1} sec^{-1}$, and agreeing well with [7, 8] within the limits of measurement errors. The precision of this result may be considered only as tentative. It is hoped that further processing will allow more substantial conclusions on the fluxes and also on spatial and energetic distribution of primary γ-rays.

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(The following has been borrowed from the work ref. [9])

The spectrometric properties of the device have been made apparent in experiments at sea level by way of measurement of spectra of γ-quanta in the atmosphere matter. (Fig.4*). The experimental results were normalized, taking into account the geometrical characteristics of the device :

$$\Gamma_{eff} = 6\ cm^2\ .sterad, \vartheta_{eff} = 22$$

and the registration efficiency ε_γ.

Plotted in Fig.5* are the characteristic results of measurements of charged particle and of the electrically-neutral radiation (γ-quanta and neutons) as functions of time for the lowest energy threshold (measurements carried out on Proton-2). The periodicity of the curve a reflects the latitude effect of the dependence of particle intensity of primary cosmic rays. The asymmetry of the maxima 2 and 4 is due to the increased intensity in the region of the Brazilian anomaly. The correlation between the curves a and b is evidence

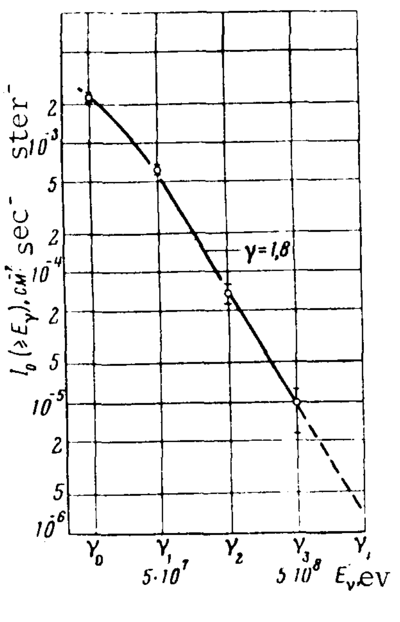

Fig.4* (fig.3 of [9])

Integral energy spectrum of the vertical flux of γ-quanta formed by cosmic rays in the atmosphere. Measurements at sea level; total measurement time 250 hours; the errors are statistical.

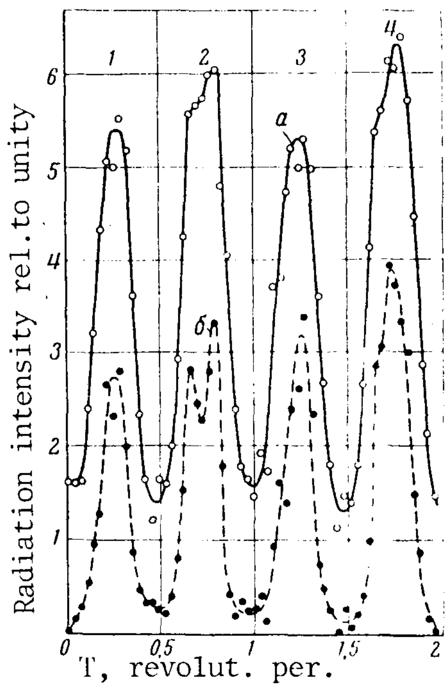

Fig.5* (Fig.4 of [9])

Intensity variation of charged particles (a), and of electrically-neutral radiation (b), that is γ-quanta and neutrons as functions of time. The scales of the curves a and b in ordinates are different.

of the chief contribution to the counting rate of γ-quanta and neutrons of electrically-neutral radiation of secondary origin (from satellite construction components and, principally from the atmosphere "albedo").

*** THE END ***

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