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Abstract

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Measurements of Radiation During the Flight of the Third Cosmic Rocket

On board the third cosmic rocket, launched on 4 X 1959, apparatus was installed for recording fast charged particles and photons. The apparatus consisted of a scintillation counter and three gas-discharge counters. All the gas-discharge counters (working dimensions 1×5 cm^2) had a wall thickness of ~ 50 mg/cm^2 of steel and were surrounded by additional shields of various thickness and composition. Counter I was placed in a shield 3 mm of lead + 1 mm of aluminum thick, with a window of 0.28 cm^2 covered by 0.2 mm of aluminum; counter II was placed in the same kind of shield, but without a window; counter III was placed inside a shell 2.5 mm of aluminum thick. The scintillation counter (the detector was a cylindrical crystal of sodium iodide measuring 39.5×40 mm, surrounded by a layer of aluminum 1 g/cm^2 thick) recorded the total ionization produced by radiation in the crystal, and the counting rate of pulses corresponding to an energy release in the crystal greater than 45 keV (1st threshold) and greater than 3.6 MeV (2nd threshold).

Pulses from the outputs of the scintillation and self-quenching counters were fed to scaling circuits, the contents of which were transmitted by radio. The readings of the instruments were transmitted on average once per day over the course of an hour, which made it possible to determine the radiation intensity during the transmission with good accuracy both during the rocket' s flight in the radiation belts and during its flight outside the limits of the Earth' s magnetic field. In the intervals between sessions, all the counters of the third rocket, except counter III, remained switched on and continued to register radiation. The large capacity of the scaling circuits* made it possible to determine with high accuracy the total dose recorded by the instruments during the time between sessions.

The accuracy of recording the total dose and, correspondingly, the average intensity depends on the interval of time between sessions and becomes better the larger this interval is. With good reception quality and with an interruption in transmission of 1 day, the accuracy of measuring the average intensity was 0.1%. However, at large distances from the Earth the reception quality was not always high because of the small magnitude of the received signal. Therefore, in some cases the accuracy of the results obtained was not maximal, and for calculating the average intensity not all sessions were used, but only the most reliable ones.

In the present work preliminary results are given for the processing of the instrument readings during the period from 4 X 1959 to 18 X 1959. The first radio transmission was carried out for 20 min. at the rocket' s departure. During this time the rocket rose from 7500 to 14 000 km**. The next radio transmission was pro–

* Complete filling of the scaling circuit of counter I at a radiation intensity corresponding to cosmic rays occurred in 4 days, of counter II in a day, of the scaling circuit of the 1st threshold of the scintillation counter in 4 days, of the 2nd threshold in a day, and of the scaling circuit for measuring ionization in 100 days.

** Distances are measured from the center of the Earth.

was introduced after 10 hours and continued for about an hour. During this time the rocket reached an altitude of 130,000 km, i.e., it was outside the Earth' s radiation belts.

Table 1 gives the radiation doses recorded by some instruments of the third rocket during the entire time the rocket was in the outer radiation belt. For comparison, radiation doses recorded by analogous instruments of the first and second space rockets are also given.*

Table 1

Date	Intensity according to gas-discharge counters (particles/cm^2), inside the container*	Intensity according to gas-discharge counters (particles/cm^2), outside the container	Total ionization in a crystal weighing 180 g (ev), inside the container*	Total ionization in a crystal weighing 180 g (ev), outside the container
2 I 1959			$9.4 \cdot 10^{14}$	
12 IX 1959	$3.74 \cdot 10^{5}$**		$13.4 \cdot 10^{14}$	$3.83 \cdot 10^{15}$
12 IX 1959	$2.37 \cdot 10^{5}$***			
4 X 1959		$2.65 \cdot 10^{5}$***	$8.4 \cdot 10^{14}$	

Figure 1

Figure 1: Figure 1

* The walls of the containers of the first, second, and third space rockets had a thickness of 1 g/cm^2.
** Counter under a shield of 1.5 mm of copper.
*** Counter under a shield of 3 mm of lead + 1 mm of aluminum.

The flight trajectories and velocities of the first, second, and third rockets differed little from one another. Therefore the doses given in Table 1 reflect the true values of the intensity of particle fluxes in the outer zone during the passage of this zone by the rockets.

Comparison of the values of total ionization given in Table 1 shows that the states of the outer zone on 2 I and 4 X differed little from one another. On 12 IX an increase in the total ionization in the crystal by about 1.5 times was recorded in comparison with 2 I and 4 X. From Table 1 it is evident that the intensity of the particles registered by the rockets' instruments depends on absorption in the walls of the container—this follows from a comparison of the readings of the scintillation counter inside and outside the container on 12 IX, and also from a comparison of the readings of the gas-discharge counters on 12 IX and 4 X.

Fig. 1. *I*— "mean daily" intensity according to the readings of the gas-discharge counter; *N*—two-hour readings of the standard neutron monitor, averaged over the time between sessions; *T*—date (October 1959). On the *T* axis the arrows indicate the times of the sessions used to determine the "mean daily" intensity.

Analysis of the operation of the instruments of the third space rocket from 4 X to 18 X, while the rocket was in interplanetary space, made it possible to determine the intensity of cosmic rays, not distorted by the influence of the magnetic field and atmosphere

* The accuracy of the dose values and mean intensities given in the article corresponds to the accuracy of decoding the instrument readings. Because of inaccuracies in the calibration of the instruments, the true values cannot differ from those given in the article by more than 5%; the doses in Table 1 are given after subtraction of the cosmic-ray background.

Earth. The intensity, averaged over the time from 4 X to 18 X, as measured by counter I, proved to be 2.12 particles/cm^2 · sec; by counter II—2.12 particles/cm^2 · sec; the mean pulse count rate with a threshold energy of 45 keV was 6.79 pulses/cm^2 · sec, and with a threshold energy of 3.6 MeV, 2.15 pulses/cm^2 · sec. The mean ionization over the entire crystal during the indicated interval proved to be $1.56 \cdot 10^9$ eV/sec. The average intensity values obtained in the present work agree with the data obtained during the flight of the first and second space rockets ([1]).

The accuracy of the instrument readings made it possible to establish that beyond the Earth's magnetic field the radiation intensity was quite constant during the first 14 days of the rocket' s flight. Only in isolated cases were small changes in the "mean daily" intensity (the intensity averaged over the time between sessions) recorded.

As an example, Fig. 1a shows the "mean daily" intensity according to the readings of gas-discharge counter II. For comparison of the readings of counter II with the intensity of cosmic rays, Fig. 1b shows the readings of a neutron monitor ([2]), averaged over the time between the sessions used to determine the "mean daily" intensity (2-hour averages are used and corrected for the barometric effect; the monitor was located at sea level at latitude 55.5° N and longitude 37.3° E).

It follows from Figs. 1a and 1b that all changes in intensity recorded by the instruments of the third rocket are in qualitative agreement with the monitor readings. Exact correspondence between measurements of cosmic-ray intensity by the instruments of the third rocket and by the monitor cannot exist, since the averaging intervals for the counter on the rocket and for the monitor did not coincide completely. A comparison of Figs. 1a and 1b shows that the changes in cosmic-ray intensity recorded by the rocket counter do not exceed 10%, while the changes recorded by the monitor do not exceed 2%. Since the readings of the neutron monitor are sensitive to primary particles with energies 10^9 eV (the critical energy determined by the magnetic field), and counter II records protons with energies of 50 MeV, it may be concluded that, when the energy changes from $5 \cdot 10^7$ to 10^9 eV, the intensity of the particles causing the variations changes by a factor of 5. The relative short duration of the intensity changes recorded on 7 X and 18 X indicates a connection of these phenomena with solar activity. In this case the observed intensity changes may be explained both by a change in the intensity of cosmic rays generated on the Sun ([3]), and by the action, on cosmic rays arriving not from the Sun, of magnetic fields ejected by the Sun. In view of the fact that the particle spectrum in the observed variations is substantially harder than in the case of cosmic-ray emission during flares on the Sun, it seems unlikely that the observed variations are connected with particle generation on the Sun. Apparently, if conditions for the generation of high-energy particles arise on the Sun, their intensity is very great and in most cases exceeds the intensity of cosmic radiation. The weak variations observed during the period from 4 X to 18 X are most likely connected with variations of the magnetic fields in the solar system and with the action of these fields on the intensity of cosmic rays arriving from outside.

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Note: Figure translations are in progress. See original paper for figures.