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II-2-5. Observation of the Radiation Anomalies at the Altitudes of 200-300 km*

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On the board the second and third Soviet space ships Sputnik V (1960 λ) and Sputnik VI (1960 ρ) there was a number of radiation detectors. One of such devices was a telescope, consisting of the two sets of gas-discharge counters. There was an absorber (five g. cm^{-2}) inside the solid angle of the telescope. The geometrical factor of the telescope was equal to 2.5 cm^2 ster (for the radiation distributed isotropically over the hemisphere). The resolving time of the circuit was equal to 20 microseconds.

The measurements, carried out at the altitudes 310-330 km (the second ship) and 190-260 km (the third ship) all over the globe (in the latitude range from minus 65° to plus 65°) gave the possibility to draw the lines of the equal counting rates. Such lines for the second space ship are shown in Fig. 1. The dash lines correspond to that cases, when the measured values were not trustworthy enough; the figures near the lines give the corresponding counting rate (counts per second). One observes lines of equal intensity have a trend to stretch in the latitude direction. But one can easily see a number of peculiarities in the line distribution or as we named them radiation anomalies or simply anomalies. The most prominent anomalies are placed in the South hemisphere in the Atlantic area. They are South Atlantic and South anomalies. The counting rates in this anomalies were about two orders greater the mean counting rates in neighbouring regions at the corresponding latitudes. An example of the counting rate changes during the passage of the third ship through the anomaly region is shown in Fig.

Fig. 1.

* This paper was read by N. A. Dobrotin, at the session of "Solar Radiation".

2; we give Universal Time along the x-axis and the counting rate (counts per second) along the y-axis. This peak just corresponds to the moment when the ship was in the centre of the South anomaly.

The intensity distribution over the globe obtained by measurements on the third space ship is shown in Fig. 3. Roughly it is like the distribution in Fig. 1, but they are different in some details. The most important difference is the absence of the similarity in the character of the anomalies. Both anomalies are clearly separated from each other in the first case but in the second case the South Atlantic anomaly is expressed more weakly and is not separated from the South anomaly so sharply. This difference may be connected with the difference in the altitude of the flight or with the temporal changes. It seems to us the cause of the difference is the change of the altitude: in the second experiment device cross the anomalies at the altitude being 100 km lower than that in the experiment on the 20-th of August.

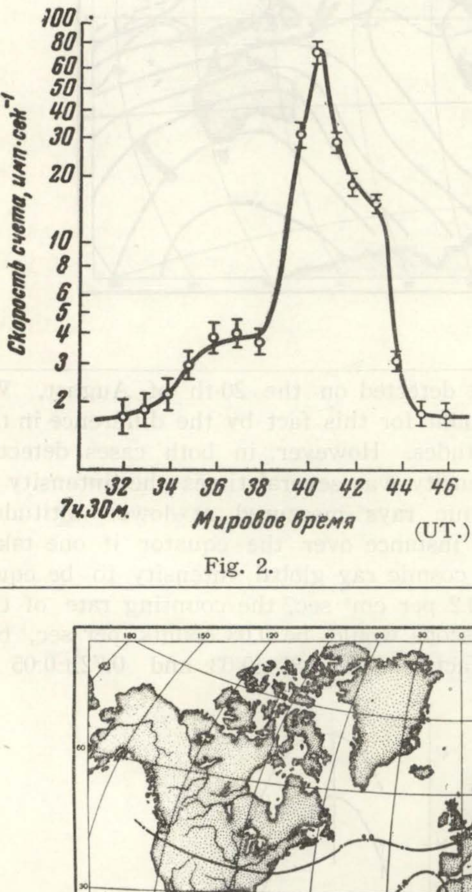

Fig. 2.

One considers very naturally the presence of these anomalies being connected with the existence of the radiation belts and the anomalies of the Earth magnetic field in the South part of the Atlantic Ocean. For comparison we show in Fig. 4 the distribution of the lines of the equal absolute values of the magnetic field vector over the globe. It is evident that the South Atlantic anomaly correlates well with the area of the minimum values of the magnetic field vector and the South anomaly is situated in the region where the absolute value of the magnetic field vector has a minimum in the given geomagnetic latitude. The mirror

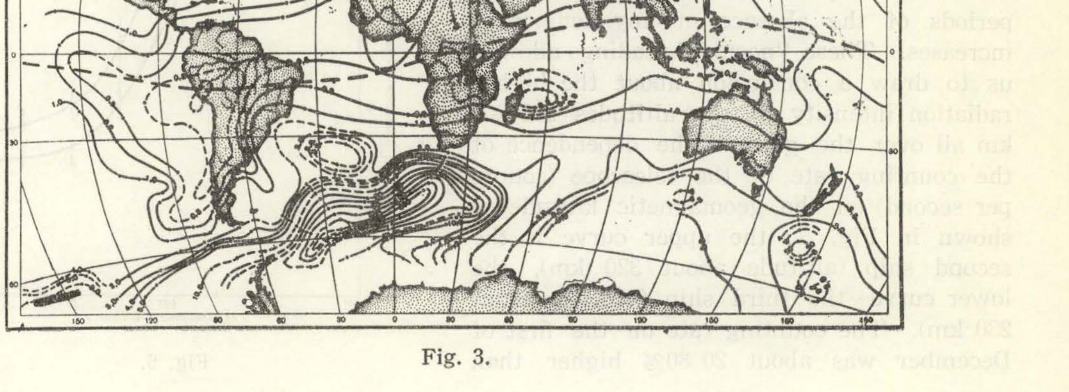

Fig. 3.

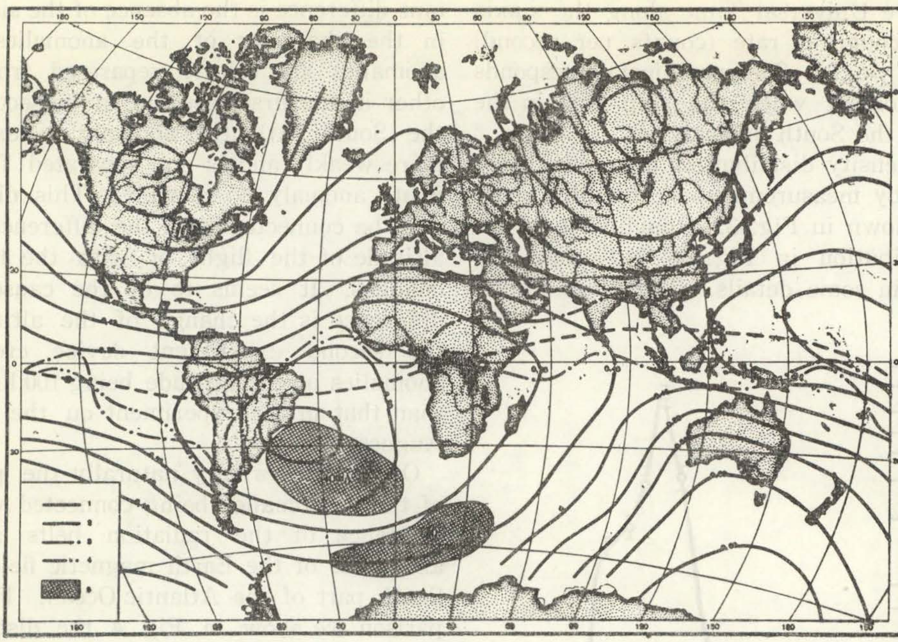

Fig. 4.

points of the particles, trapped in the radiation belts, appear to come down to the 200–300 km in these regions and give rise to such effects.

Apart from the two stationary anomalies discribed above we detected some increases of the counting rates of the telescope, which had a temporal character: they were observed at definite place over the globe only once. Such event (at 7.40 on the 20-th of August) was shown in Fig. 1 as a shaded strip in the North-East. These increases were connected either with the direct arrival of the charged particles from the Sun or with the temporary capture of these particles by magnetic traps.

The telescope gave stable readings in the areas far away the anomalies and at the periods of the absence of any temporary increases. These "normal" readings allowed us to draw a conclusion about the higher radiation intensity at the altitudes 200–300 km all over the globe. The dependence of the counting rate of the telescope (counts per second) on the geomagnetic latitude is shown in Fig. 5: the upper curve is the second ship (altitude about 320 km), the lower curve—the third ship (altitude about 230 km). The counting rate on the first of December was about 20–30% higher than that detected on the 20-th of August. We account for this fact by the difference in the altitudes. However, in both cases detected intensity was several times the intensity of cosmic rays measured at lower altitudes. For instance over the equator if one takes the cosmic ray global intensity to be equal to 0.2 per cm^2 sec, the counting rate of the telescope would be 0.08 counts per sec, but in fact it was 0.83 ± 0.03 and 0.72 ± 0.05 in

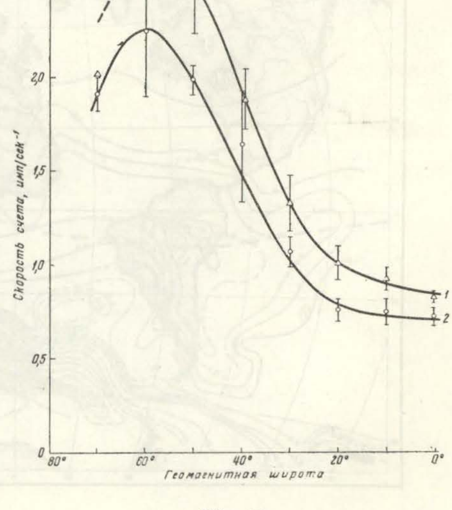

Fig. 5,

the first and second experiments correspondingly. At the latitude 50° cosmic rays would give a counting rate 0.5 counts per sec, but our data are 2.5±0.2 and 2.0±0.1.

Such a great effect can not be explained in our opinion by the secondary processes of cosmic rays (such as atmospheric albedo or multiplication and shower production in the body of ship). We are prone to think in this case we deal with the edge effects of the inner and at the high latitudes also of the outer radiation belts. Presence of the absorber (5 g. cm^{-2}) inside the solid angle of the telescope limits the energy of the detected particles: for protons $E_{kin}>60$ Mev and for electrons $E_{kin}>8$ Mev. If one supposes this increase is due to such particles, the particle intensity corresponding to the data of the second ship would be 1.36±0.03 particles per cm^2 per sec at the equator, 2.6±0.2 and 3.3±0.1 at the 40 and 60 degree accordingly in comparison with the cosmic ray intensity 0.2, 0.5 and 1 particles per cm^2 per sec at the corresponding latitudes.

The fact, that radiation intensity at the altitudes 400-800 km surpasses appreciably the cosmic ray intensity was mentioned by Y. Miyazaki and H. Takeuchi at the Moscow Cosmic Ray Conference. These data are in full accordance with the more complete data published in J. Geophys. Research by Yoshida, Ludwig and Van Allen. Our measurements show that the region of the higher intensity reaches down the altitudes of 200-300 km.

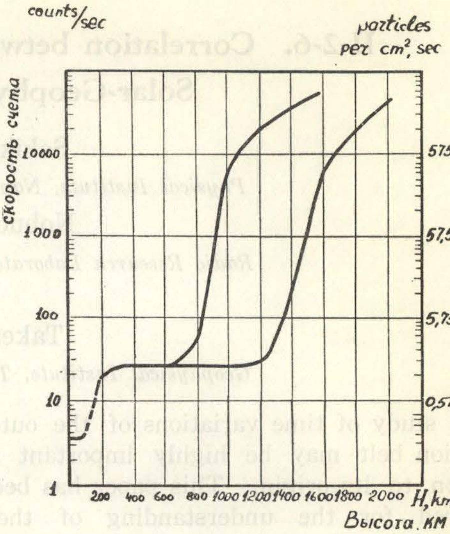

Fig. 6.

So the curve of the altitude dependence of the radiation intensity has the following shape (Fig. 6): at the comparatively great distances from the Earth we observe high intensity (inner radiation belt), which drops as the altitude decreases; then we have a plateau, extending from 1000-800 km down to 300-200 km and finally we see a rapid intensity decrease to cosmic ray level in the altitude interval from 200 km to 100-150 km.

The nature of such a plateau is not yet clear, but we believe that important role in the formation of this plateau is played by the particle diffusion across the Earth magnetic field.

Discussion

Roederer, J. G.: Which was the energy threshold for the detector in the space ship which detected the increase in the South Atlantic anomaly?

Dobrotin, N. A.: >8 Mev for electrons and>60 Mev for protons. But it is possible that part of the telescope rate was caused by accidental coincidences.