lines of C IV (1548·2, 1550·8 Å), show considerable brightening at their ends, while the nearby C I multiplet at 1560 Å does not. The He II line at 1640·5 Å shows some limb brightening compared to the C I multiplet near 1657 Å. The same was observed in the 1955 spectrum, but not as clearly. In the 1955 spectrum the O VI resonance line 1031·9 Å is definitely limb-brightened by comparison to Lyman-β at 1025·7 Å. This would, of course, be expected for a line that must originate in the top of the chromosphere, or bottom of the corona.

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5. STUDY OF COSMIC RAYS BY ROCKETS AND SPUTNIKS IN THE U.S.S.R.

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In the U.S.S.R. the study of cosmic rays by rockets was started in 1947.

In the beginning, with the help of Geiger counters the number of charged particles was measured, and the formation of the electron-photon component in the interaction of primary particles of cosmic rays with nuclei of light elements was investigated.

It was shown that in 1947, 1948, 1949 and 1951 the intensity of cosmic rays at altitudes up to 75 km was the same and did not change more than by 5%. In 1949 the data on the photon intensities outside the atmosphere were obtained. In order to measure the number of high-energy photons, one of us (A. E. Chudakov) proposed a method permitting these measurements to be made with a strong background of charged particles.

It was found, with the help of this apparatus, that at altitudes exceeding 50 km, the flux of photons with energy of the order of 10^7 eV and more is 0·25 photons/cm^{-2} sec. The same apparatus was used for measuring photons in the stratosphere at various heights, and it was shown that at the heights of 20 km, a maximum intensity is 0·7 photons/cm^{-2} sec.

Ionization produced by cosmic rays up to altitudes of 100 km was measured in 1951. Measurements were carried out with absorbers of various thicknesses: 1 g/cm^2 of steel, 15 cm of aluminium, 1 cm of lead.

Surrounding the ionization chamber with lead 1 cm thick leads to an increase of ionization by a factor of 2·06 ± 0·003; with 15 cm of aluminium the increase is 1·92 ± 0·02; and with 15 cm of aluminium and 1 cm of lead the increase is 3·26 ± 0·03. The difference in the values of ionization obtained during three rocket flights does not exceed 2 or 3%.

Comparison of ionization and the number of particles in the stratosphere with those above the atmosphere shows that an average specific ionization of cosmic ray particles considerably exceeds ionization of the relativistic particle.

Relation of the average specific ionization to ionization of the relativistic particle is as follows:

20 km	– 1·59 ± 0·06	Without absorber
50 km	– 2·16 ± 0·07	
50 km	– 1·68 ± 0·06	Under the layer of aluminium 15 cm thick.

The high value of the specific ionization in the stratosphere can be explained by the existence of secondary heavy (sufficiently slow) particles.

Outside the atmosphere the number of such secondary particles is sufficiently small. As one can see from the above-mentioned data, when the ionization chamber is placed under the layer of aluminium 15 cm thick, the average specific ionization corresponds approximately to the results expected on the basis of experiments at the height of 20 km. The large value (2·16) of the average ionization of the primary cosmic particles is due to the α-particles and more heavy nuclei available in the primary radiation.

This conclusion about a large average specific ionization of primary cosmic particles has been further supported by measuring bursts in the pulse-type ionization chambers on rockets.

These studies on cosmic rays were carried out by one of us (A. E. Chudakov).

In the preparation of electronics and the radio-emission system P. V. Vakulov and B. A. Khvoless took part. M. I. Fradkin helped in the measurements of the number of charged particles and bursts, and V. I. Solovjova in the photon measurement.

On the basis of the experiments on cosmic rays carried out by rockets, new measurements were prepared, some of which were confirmed during flights of the second and third sputniks. New possibilities developed from these sputniks permit us to find a new method to solve the following problems.

First of all, it is possible to obtain the cosmic ray distribution over the globe, and consequently to study the magnetic field of the Earth.

Due to the long duration of observations from the sputnik, one may hope to find new components of cosmic radiation. In this connexion particular attention must be drawn to the search for photons in cosmic radiation. If the photon component is found in cosmic rays, a new possibility for the study of outer space arises.

The study of the composition of primary cosmic rays and the determination of the nuclei of various elements among particles of this radiation also plays an essential role.

Sufficiently long measurements from the sputniks permit us to compare the changes in the intensity of these rays with those processes on the Earth and in the cosmos which caused these variations.

In order to measure cosmic rays two identical instruments were placed in the second sputnik. Both instruments were absolutely independent from each other. Therefore the coincidence of the results of these instruments permits us to be sure of the normal behaviour of the apparatus during the flight.

Each instrument consisted of a counter of charged particles with a length of 100 mm and diameter of 18 mm. The counters were surrounded on the average by 10 g/cm^2 of matter. The operating voltage of the counter (400 V) was provided with the help of a semi-conducting transformer supplied by the battery of 6·5 V. Both instruments included semi-conducting scalers. Each of these instruments required a power of 0·1 watt. The total power supply was 0·15 watt; the stored power was sufficient for 200 hr of continuous work. The weight of one instrument including the batteries was 2·5 kg. The scheme of the instrument was described in [1].

During the sputnik flight the records of both instruments coincided with each other within the limits of statistical accuracy in nearly every case.

When the sputnik flew over the U.S.S.R. by 'direct path' (motion from south to north), the altitude of its flight was nearly constant. During motion on the 'opposite path' the altitude continuously increased from approximately 350 to 700 km. The relation of the intensity of cosmic rays on the 'opposite paths' to the intensity on the 'direct paths' in the same geographic points gives the relative increase of intensity due to the difference in altitudes.

This dependence of cosmic ray intensity on altitudes must be caused, in any case, by the following:

1. Increases of intensity due to a decrease of the Earth's screening.
2. Increase of intensity due to decrease of the Earth's magnetic field that leads to decrease of a threshold energy of particles which are able to penetrate through the Earth's magnetic field.

The altitude dependence found can be explained by taking into account only these two effects.

The measurements of cosmic ray intensity during the sputnik's motion on many 'direct paths' permit us to plot the lines of equal intensity of this radiation ('isocosms').

Isocosms for three values of the counting rate, 18, 27 and 36 particles per sec, were obtained.

The best fit of the experimental data gives the isocosms which coincide with geographic parallels. In the equatorial region, Sympson[2] discovered that the line of minimum intensity of cosmic rays ('cosmic equator') does not coincide with the geomagnetic equator. In this connexion, it is of great interest to obtain the data on distribution of cosmic ray intensity over the globe.

The spread of points relative to the appropriate isocosms exceeds by 2–3 times that to be expected on the basis of the statistical errors only. Apparently, this phenomenon is connected with the variation of cosmic ray intensity. Analysis of the data obtained shows that, in some cases, considerable increases of cosmic ray intensity were observed.

Thus, on 1957 November 7, in the time-interval from 4.36 a.m. to 4.49 a.m., Moscow time, in the latitudes above 58°, an increase of cosmic radiation of approximately 50% was recorded. This increase was simultaneously recorded by two instruments. Both instruments gave identical dependences on time.

It is of interest that large fluctuations of intensity are observable during the 'burst'.

This 'burst' was not recorded at sea level. At present it is difficult to determine the source of this increase of intensity. The possibility is not excluded that this phenomenon is caused by an increase in the density of the electron flux with a relatively small energy, of the order of hundreds of KeV, which can be recorded with a rather small efficiency by a Geiger counter due to the Bramsstrahlung (but not caused by increase of intensity of primary cosmic rays).

The possibility of such an interpretation is based on the analysis of data of the third sputnik. A scintillation counter having a high efficiency for photon recording was mounted on this sputnik. In this case, a rather large intensity of photons was observed. In the latitude region where this burst was observed, the intensity of photons increased and had strong fluctuations.

It is possible to explain the origin of these photons by the Bramsstrahlung radiation of electrons with the energy of 10^5 eV. Thus, variations in cosmic ray intensity observed from the second sputnik differ from the variations observed at sea level and in the stratosphere (at altitudes of 20–30 km).

Apparently, two types of variations occur. A part of the variations is caused by cosmic rays, and therefore it must correspond to a change in the number of primary cosmic rays. Another part of the variations does not deal with cosmic rays. Apparently, a new radiation, and a variation in the intensity of charged particles and photons caused by this radiation, were recorded on the sputniks with the help of apparatus constructed for the study of cosmic rays. These variations are caused by the radiation, which can be called the 'Earth radiation', i.e. the particles of high energy originating near the Earth and rotating around the Earth.

A. I. Lebedinsky and one of us (S. N. Vernov) considered the possibility of storing a large number of secondary particles near the Earth. These particles are able to move quasi-periodically from one hemisphere to another. In the first approximation, the motion of the particle in the magnetic field must take place in such a way that the magnetic moment of the particle will be constant. Therefore, a charged particle is 'closed' in the region of a relatively weak magnetic field. This particle is able to make a great number of oscillations and their intensity must be very large. One of the sources of particles is the decay products of neutrons emitted by the Earth under the action of cosmic rays. On the other hand, particles of corpuscular streams emitted by the Sun can be such a source.

This 'halo' of substance and high energy electrons can also exist around the other planets having magnetic fields.

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