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Phenomena of Absorption of Soft and Hard Components of Space Rays in the Atmosphere in Yerevan Conditions

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Abstract. The article examines the angular distribution of cosmic ray intensity and identifies the triads using two different empirical formulas for their distribution. The total absorption coefficient of soft and hard components was measured.

Keywords: cosmic rays, radiation flux intensity, angular distribution, absorption study

1. Introduction

The high energy rays (from 10^6 to 10^{20} eV) coming from space to Earth are mainly stable particles called primary cosmic rays. Entering the Earth's atmosphere, և interacting with the nuclei of atoms of atmospheric molecules, they form new elementary particles called secondary cosmic rays. Primary cosmic rays (mostly protons) do not have a specific, unique point source of delivery other than the Sun. Proof of this is the fact that the intensity of cosmic rays arriving at the Earth does not change during the daily rotation of the planet Earth. The overwhelming majority of primary cosmic rays, high−energy rays, come to Earth from the Metagalaxy, and a small part of them is associated with the activity of the Sun. Primary galactic cosmic rays are invariable in time and isotropic in space. It mainly consists of protons, which make up 90% of all primary particles և nuclei − particles make up about 7%, and the remaining 3% are atomic nuclei, down to the heaviest nuclei such as a small number of electrons, positrons and neutrons.

Primary cosmic rays from space (such as a proton or an alpha particle), which have a relatively large mass − a high energy reserve (on the order of 10^{15} eV), at an altitude of 15−20 km above sea level, collide with the nuclei of atoms of air molecules, causing a large number of predominantly active particles − Mesons: positive, negative և neutral (pions). Positively and negatively charged ions have a mass of 273 electrons, the smallest particles in the group of nucleoactive hadrons. The charged pions, in turn, collide with the nuclei of air atoms to form secondary pions, which, in turn, form third−generation pions, etc. However, peonies, being unstable and having a short lifetime, split immediately. For example, a negative pion splits into an inactive nuclear particle, a negative meson (muon or "heavy electron") and a neutrino. A negatively charged muon is close to an electron in its properties, having a mass of 207 electrons and a relatively long lifetime, it is non−nuclearactive. Passing through the atmosphere, it spends its energy only on the ionization of air atoms − molecules, carries relatively small energy losses and is able to reach the surface of the Earth, penetrate into its depths.

In the work under the conditions of Yerevan, the dependence of the intensity of cosmic rays on the polar angle was studied, for which the FPK−01 space telescope was used to register the rays.

The viewing angle during measurements was changed from 0 to 90 degrees with a step of 15 degrees, the results of which are shown in Table 1, the average values of which are given in the last column of Table 1.

Graph plotted by data of Table 1 is presented in Fig. 1.

Table 1.

Θ	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**	**$N_{ave.}$**
0^0	87	91	72	81	85	83,2
15^0	79	68	67	103	79	79,2
30^0	54	79	65	76	71	69
45^0	34	44	43	39	44	40,8
60^0	17	25	21	22	30	23
75^0	10	13	9	15	14	12,2
90^0	10	7	14	4	14	9,8

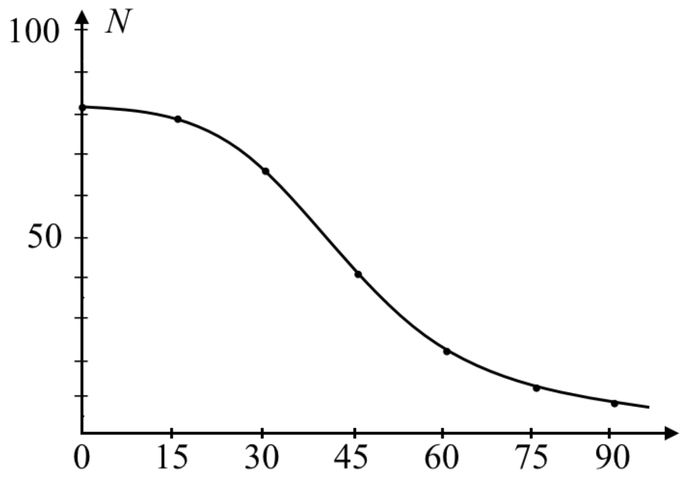

Fig. 1. Dependence of the number of soft և hard cosmic rays per unit time on the polar angle.

Until now, it was assumed that the intensity of cosmic rays changes in direct proportion to the square of the cosine of the polar angle. However, according to the results of our experiment from Fig. 1, it can be seen that such a change can occur only in the range of polar angle values from 0 to 30 degrees, and in the range from 30 և 45 degrees to 90 degrees decreases exponentially.

The result of the experiment may be important for its use in scientific journals as well as in textbooks, since it is assumed that the change in intensity is directly proportional to the square of the cosine of the polar angle from 0 to 90 degrees[1], [4].

Despite the dependence of the number of soft and hard cosmic rays on the polar angle, their change obeys two different laws, and since the FPK−01 space telescope used in the experiment registers only parallel particle fluxes, measured in the range from 0 to 90 degrees (Table 1), these the data allow determining their absorption coefficient in the atmosphere.

2. Calculation of the path lengths of space particles in the atmosphere at different polar angles

Primary cosmic rays from space at an altitude of 15–20 km above sea level collide with the nuclei of atoms of air molecules, forming secondary cosmic rays, and about 15 km above sea level this process ends and, therefore, the value of this intensity at all latitudes can be taken as a constant value ($I_0 \square N_0\ s^{-1}$).

As already mentioned, the function of the FPK−01 space telescope allows us to use

Bouguer's law $N_n = N_0 e^{-\mu_n L_n}$ to calculate the total absorption coefficient of soft and hard cosmic particles in the atmosphere.

$$\mu_n = \frac{\ln \frac{N_0}{N_n}}{L_n} \qquad (1)$$

As can be seen from formula (1), to determine the absorption coefficient, it is necessary to know other physical quantities N_0, N_n and L_n in equation (1) that must be measured. The measurement results for different polar $\theta-$angles are shown in Table 1.

In Table 1, the value of N_0 is 83.3 s^{-1}, and the N_n values are shown below for each value of each angle.

Since no mathematical formula can be used to calculate the L_n values, the L_n values for various angles are calculated below, where these numerical values are taken from measurements taken on a proportional model. The model is built for the air basin of the earth.

1. 0 = 90^o $\quad L_6.....42 \Rightarrow L_6 = \frac{15\cdot 42}{4} = \frac{630}{4} = 157; L_6 = 157km$
   $15.....4$
2. 0 = 75^o $\quad L_5.....5 \Rightarrow L_5 = \frac{15\cdot 25}{4} = \frac{375}{4} = 94; L_5 = 94km$
   $15.....4$
3. 0 = 60^o $\quad L_4.....16 \Rightarrow L_4 = \frac{15\cdot 16}{4} = \frac{240}{4} = 60; L_4 = 60km$
   $15.....4$
4. 0 = 45^o $\quad L_3.....9 \Rightarrow L_3 = \frac{15\cdot 9}{4} = \frac{135}{4} = 34; L_3 = 34km$
   $15.....4$
5. 0 = 30^o $\quad L_2.....6,5 \Rightarrow L_2 = \frac{15\cdot 6,5}{4} = \frac{97,5}{4} = 24,4; L_2 = 24,4km$
   $15.....4$
6. 0 = 15^o $\quad L_1.....5 \Rightarrow L_1 = \frac{15\cdot 5}{4} = \frac{75}{4} = 19; L_1 = 19km$
   $15.....4$
7. 0 = 0^o $\quad L_0 = 15km$

3. Calculation of absorption coefficients for soft and hard components

Using the numerical values of the above calculations, and according to the data in Table 1, the values of the absorption coefficient of soft and hard cosmic rays in the atmospheric air are calculated for different polar angles.

From the results obtained, we obtain the following value for the average value of the absorption coefficient of soft–hard cosmic rays in atmospheric air:

$$\bar{\mu} = 2,5 \cdot 10^{-5} m^{-1} \tag{2}$$

This value of the absorption coefficient, as we see, is three orders of magnitude less than the numerical value of the absorption coefficient of the soft component in lead.

Comparing the absorption of soft and hard components of cosmic rays in atmospheric air with their absorption, we can say:

1. The soft component of cosmic rays is noticeably absorbed by lead and atmospheric air.
2. If the absorption rate of the solid component of cosmic rays is imperceptible in an 18 cm layer of lead, then it is significant in a long thick layer of atmospheric air, because the total intensity of soft and hard components tends to asymptotically tend to zero.

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