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Dependence of the Absorption Coefficient of Cosmic Rays on the Thickness of the Air Layer of the Atmosphere

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Abstract. According to the results of the experiment, the value of the total absorption coefficient of the soft-hard component of cosmic rays decreases with an increase in the length of the layer in atmospheric air, u. gradual increase in density. At the same time, its numerical value decreases by about five times, that is, $\mu_1 = 7{,}1 \cdot 10^{-5}$ m^{-1} up to value $\mu_4 = 1{,}5 \cdot 10^{-5}$ m^{-1}, with an increase in the length of the air layer from 25 km to 156.7 km This absorption phenomenon is due to the high absorption coefficient of the soft component, as a result of which their relative amount decreases and the amount of the hard component decreases slightly, since they have a lower absorption coefficient.

Keywords: absorption; cosmic rays; air layer; atmosphere

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1. Introduction

Cosmic Rays (CR) coming from space are divided into two groups: primary and secondary. Both groups have high energies and are able to reach the surface of the Earth and penetrate into its depths. The Universe is filled with primary cosmic rays, their distribution in space is isotropic [1-3]. At an altitude of 15÷20 km above sea level, they collide with the nuclei of atoms of air molecules, forming a large number of new particles of soft and hard species. [4]. Solid nuclear-active particles are mainly mesons (positive, negative - neutral pions). Positive and negatively charged ions have a mass of 273 electrons and are the smallest particles in the group of nuclear active hadrons [5]. Peonies, being unstable and having a short lifespan, immediately break apart. For example, a negative pion decays into a non-nuclear active particle, a negative pion decays into a μ^-–meson (muon or "heavy electron") and a neutrino [6].

In the conditions of the city of Yerevan, the dependence of the intensity of cosmic rays on the polar angle or on the length of the length of the air layer was studied.

2. Experimental part

The FPK-01 space telescope hes been used to register the rays. The telescope consists of two Geiger measuring systems located at a distance of 40 cm from each other. The working electronic circuit operates in a coinciding mode. The ability of a telescope to register only a parallel flow of particles and which allows the application of Bouguer's law of particle absorption.

The polar angle was changed by moving from 0 to 90 degrees in increments of 15 degrees each. The results are shown in Table 1, and the average values of the number of particles are given in the last column of the table, from the data of which it can be said that the dependence of the CR intensity on the polar-angle from 0 to 30 degrees occurs as a function of the cosine, and from 30 and 45 degrees to 90 degrees it decreases according to the exponential Bouguer's law

$$I_n = I_0 e^{-\mu_n L_n},$$

where μ_n-is the total absorption coefficient of hard and soft particles, and L_n-n is the n-number distance traveled by the particles for all angles θ_n (for example, $n = 1$, $\theta_1 = 0^0$,$L_n = L_1 = 15$ km, $n = 2$, $\theta_2 = 15^0$, $L_n = L_2 = 16{,}7$ km, etc., the results are shown in Table 2.

Table 1: Intensity dependence of soft and hard CR components in unit of time from the polar angle.

θ	N_1	N_2	N_3	N_4	N_5	Ncp.
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

Table 2. Dependences of the absorption coefficient of the soft and hard components on the path length in the atmospheric air.

θ^0	$L_n(10^3)$km	θ^0	$L_n(10^3)$km	$\Delta L_{n1}(10^3)$m	$\mu \cdot 10^5$ m
$1. -0^0$	$L_1 15{,}0$	$4. -45^0$	$L_4 = 25{,}0$	10,0	7,1
$2. -15^0$	$L_2 = 16{,}7$	$5. -60^0$	$L_4 = 35{,}0$	20,0	6,4
$3. -30^0$	$L_3 = 20{,}0$	$6. -75^0$	$L_5 = 56{,}7$	41,7	4,6
		$7. -90^0$	$L_7 = 156{,}7$	141,7	1,5

Regardless of the latitudinal belt of the Earth, except for the north-south poles, the same is formed in the air layer, the initial constant number of particles moving down and reaching the FPC-01 recording device.

Table 1 data make it possible to determine the absorption coefficients (CR) in layers of different thicknesses of the terrestrial atmospheric air, for the measurement of which a model of the terrestrial air layer with a thickness of 15 km was used. The calculation data are given in the second and fourth columns of Table 2.

To calculate the total absorption coefficient of particles in atmospheric air, it is necessary to calculate the lengths of additional paths traversed by particles, starting from a layer 15 km high, i.e. particle path minus 15 km, the values of which are given in the fifth column of Table 2. In this case, we write the Bouguer's law:

$$N = N_0 e^{-\mu \Delta L_{n1}},$$

where $\Delta L_{n1} = L_n - L_1$, and $L_1 = 15$ km corresponding to the angle $\theta_1 = 0^0$ is subtracted from the n-th measurement of the length L_n of the path traveled by the particles, corresponding to the angle θ_n.

Calculations of the values of the total absorption coefficient of the soft and hard components of CR are given below, and the data obtained are presented in column 6 of Table 2. The results show that with an increase in the length of the layer of atmospheric air, the value of the absorption coefficient of soft-hard decreases by 45^0 degrees ($L_4 = 25$ km) from $\mu_1 = 7{,}1 \cdot 10^{-5}$ m^{-1} to $\mu_4 = 1{,}5 \cdot 10^{-5}$ m^{-1} values for an angle of 90^0 degrees ($L_7 = 156{,}7$ km).

1. $\theta = 45^0 \; \mu_1 = \frac{ln\frac{N_1}{N_4}}{L_4 - L_1} = \frac{ln\frac{83,2}{40,8}}{25,0-15,0} 10^{-3} = \frac{ln\, 2.039}{10} 10^{-3} = \frac{0,71}{10} 10^{-3} = 7,1 \cdot 10^{-5}$ m^{-1}

2. $\theta = 60^0 \; \mu_2 = \frac{ln\frac{N_1}{N_5}}{L_5 - L_1} = \frac{ln\frac{83,2}{23,0,}}{35,0-15,0} 10^{-3} = \frac{ln\, 3.617}{20} 10^{-3} = \frac{1,28}{20} 10^{-3} = 6,4 \cdot 10^{-5}$ m^{-1}

3. $\theta = 75^0 \; \mu_3 = \frac{ln\frac{N_1}{N_5}}{L_5 - L_1} = \frac{ln\frac{83,2}{12,2}}{56,66-15,0} 10^{-3} = \frac{ln\, 6{,}82}{41,7} 10^{-3} = \frac{1,92}{41,7} 10^{-3} = 4,6 \cdot 10^{-5}$ m^{-1}

4. $\theta = 90^0 \; \mu_4 = \frac{ln\frac{N_1}{N_6}}{L_6 - L_1} = \frac{ln\frac{83,2}{9,8}}{156,66-15,0} 10^{-3} = \frac{ln\, 8.49}{141,66} 10^{-3} = \frac{2,14}{141,66} 10^{-3} = 1,5 \cdot 10^{-5}$ m^{-1}

It follows from the results obtained that the value of the absorption coefficient of soft-hard CR decreases by a factor of seven with an increase in the distance traveled in atmospheric air from 10 km to 150 km.

According to the results of the experiment, the average value of the absorption coefficient of CR in atmospheric air is $\overline{\mu} = 4{,}9 \cdot 10^{-5}$ m^{-1}, which is three orders of magnitude less than the absorption coefficient of the soft component in lead [7].

3. Conclusions

Thus, about the process of absorption of soft and hard components in the atmospheric air of the CR we can say:

1. The soft component of CR is noticeably absorbed by the surrounding air.
2. If the process of absorption of the solid component of CR is not noticeable in an 18-cm layer of lead, then absorption is noticeable in a long thick layer of atmospheric air at $\theta = 90^0$, and the intensity remains nonzero. At an altitude of 1000 m above sea level, the thickness of such a layer of air is less than at sea level. Significant absorption of the solid component can occur at sea level, which can only be confirmed by the results of the experiment.
3. The value of the absorption coefficient decreases with increasing length of the atmospheric air layer. This phenomenon is associated with an increase in the path length of particles, and due to the large value of the absorption coefficient of the soft component and their relative amount in the CR flow decreases, and the relative amount of hard components increases, since the absorption coefficient of which has a smaller value, since the loss of their energy per unit the length of the path is negligible.

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