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INVESTIGATION OF NUCLEAR DISINTEGRATIONS PRODUCED BY THE CHARGED COMPONENT OF COSMIC RADIATION

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The momentum spectrum of negative π mesons from stars produced by charged cosmic ray particles of ~ 30 Bev has been measured. The power exponent of the spectrum is $\gamma = 1.46 \pm 0.2$. The ratio of positive to negative π mesons is $N_{\pi^+}/N_{\pi^-} = 1.67^{+0.81}_{-0.53}$ and the protons are found to constitute $\sim 30\%$ of all particles with momentum $p \geq 10^9$ ev/c.

THE products of nuclear disintegrations induced by fast charged particles of cosmic radiation in lead were investigated at 3200 m above sea level (Mt. Aragats) by means of the magnetic mass-spectrometer of Alikhanian and Alikhanov using a field of 6850 oersted. The schematic cross-sections of the instrument in two perpendicular planes are shown in Fig. 1.

The hodoscope placed above the spectrometer made it possible to select nuclear disintegrations produced by charged particles in the lead blocks ABCDEF, situated between the counter trays. Secondary products of the disintegrations were studied by means of the mass-spectrometer. The particle trajectory was determined in the plane of magnetic deviation by the coordinate trays 9, 12, 14, 16, 18, 20, 23, and in the plane perpendicular to it by the trays 5 — 8, 10, 11, 13, 15, 17, 19, 21, 22, 24 — 27. Each of the trays 6, 8, 10, 24 — 27 consisted of two layers of counters. The counters of the top layer covered the gaps between the coordinate counters and were connected in parallel. The side trays B_1, B_2, T_1, T_2 excluded particles entering the hodoscope from the sides and responded to particles produced in the stars.

The triggering system of the arrangement was so altered that all cases of star production were recorded, both when the secondary particles were stopped in the absorbers of the lower detecting array and when they succeeded in traversing them.

The mean square error of the momentum measurement amounted to 3, 13 and 65%, for particles of 2×10^8, 10^9, and 5×10^9 ev/c respectively.

Only the stars produced by a single charged particle entering the hodoscope at an angle smaller than 35° to the vertical in the plane perpendicular to the plane of magnetic deviation were selected. In order to exclude completely any cases of electromagnetic interaction of μ mesons with subsequent shower production we considered only the stars which had not less than five prongs, at least two of which penetrated the next absorber, i.e., produced discharges in the tray of counters below (cf. Fig. 1). From stars selected in the above manner only those were studied in which a secondary particle traversing the telescope satisfied the following conditions: (a) produced at least four discharges in the plane of magnetic deviation, the coordinates of which had to lie on a circle, and (b) produced at least three points laying on a straight line not passing through the pole pieces in the plane perpendicular to the plane of magnetic deviation.

The data were reduced by comparison of all actually observed events with master diagrams.

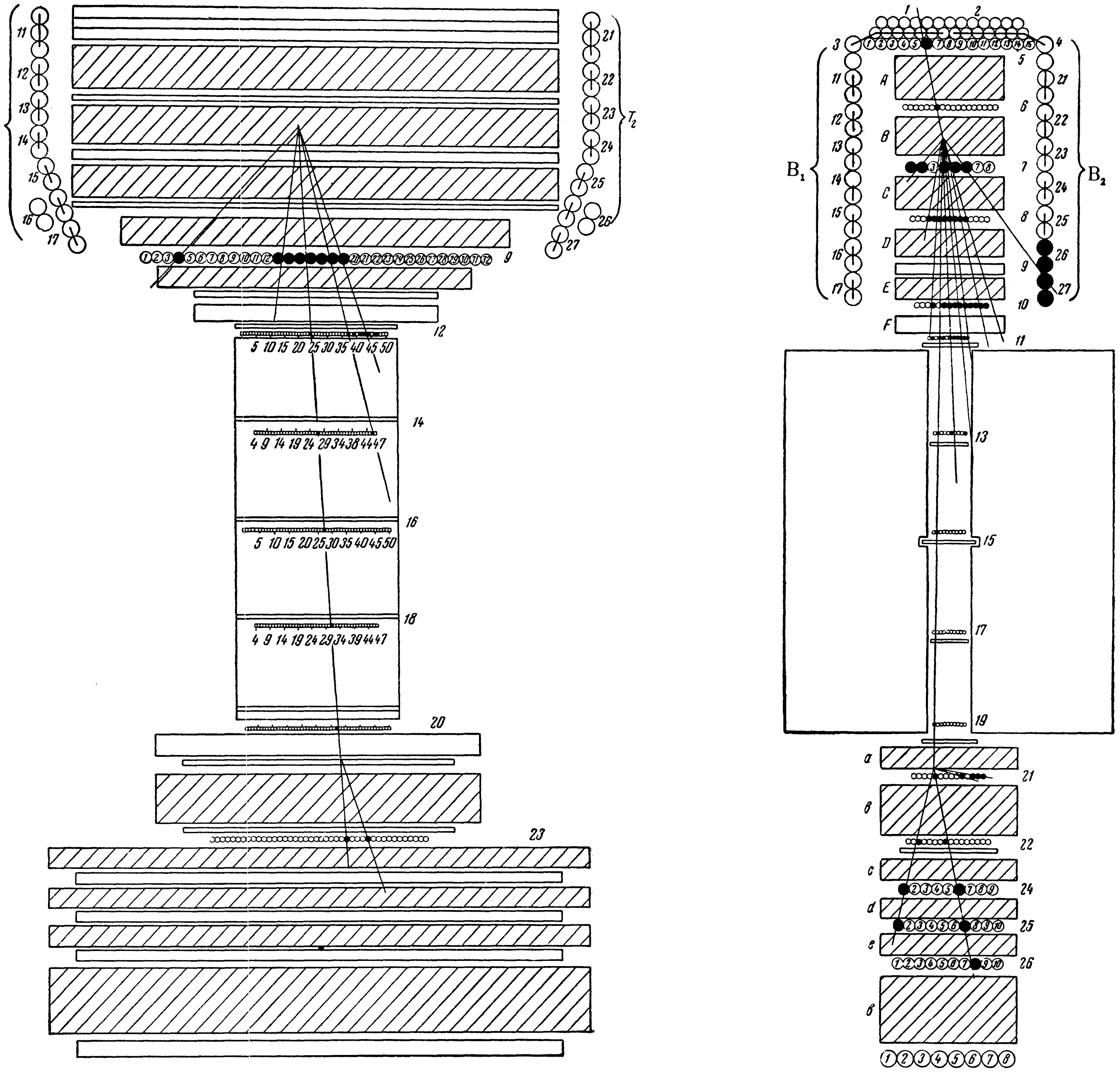

FIG. 1. Diagram of apparatus.

Series	Thickness of lead absorbers in the upper hodoscope (cm)						Thickness of absorbers in the lower detector (cm)					
	A	B	C	D	E	F	a	b	c	d	e	f
										Graphite		
1	0	7	6	5	4	3	4	9	4	3.6	3.6	1 Pb+9 Cu
2	0	7	6	0	0	0	4	9	4	2	2	1 Pb+9 Cu
										Copper		
3	8	7	6	5	4	3	3.6	8.26	4.26	3.1	2.66+1 Pb	9.25 +1Pb

In the present article we report the results of three series of observations, which differed in the various disposition and thickness of the lead plates in which the stars were produced in the upper hodoscope and of the absorbers in the lower detecting arrangement (see table).

In the course of experiment we determined the momenta of 316 particles originating in stars. Of these, 231 were found to be positive and 85 negative. The differential momentum spectrum of these particles is shown in Fig. 2.

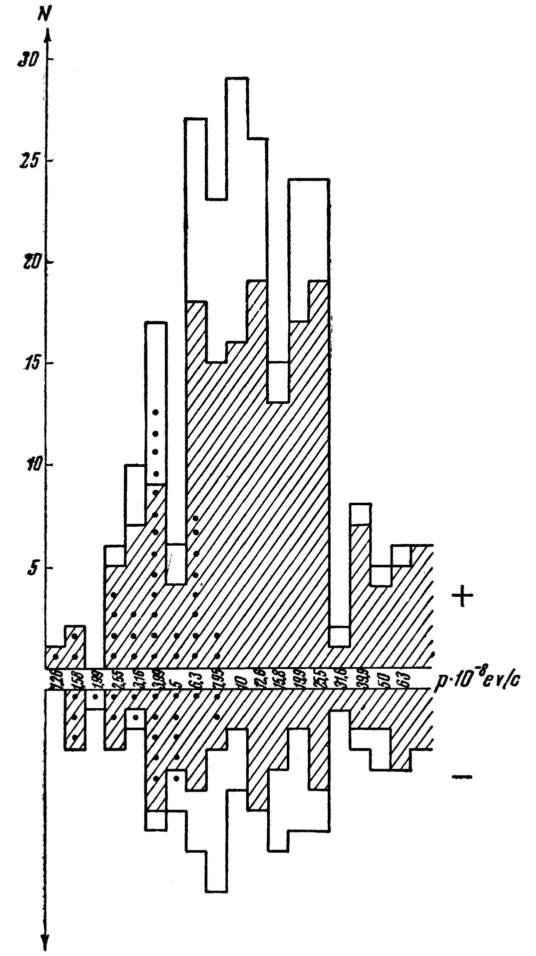

FIG. 2. Differential momentum spectrum of secondary particles: + — positive particles, — — negative particles. Dashed region — first and third measurement series, undashed — second series.

We sought to determine the ratio of positive to negative mesons $N^{+}_{\pi,K}/N^{-}_{\pi,K}$. The upper mass limit for particles in the momentum range $1.2-9 \times 10^8$ ev/c was found for this purpose from their momentum and their minimum range (cf. Ref. 1). The minimum range was taken as the absorber thickness traversed by the particle without apparent interaction.

The upper mass limit was taken as 1300 m_e to ensure a good differentiation between mesons and protons. This selection yielded 35 positive and 21 negative mesons (these particles are represented in Fig. 2 by dots).

The following value was obtained for the ratio of positive to negative mesons:

$$N^+/N^- = 1.67 {+0.81 \atop -0.53}$$

Unfortunately, it was impossible to differentiate between π mesons and K particles. If we note, however, that the K mesons constitute only a few percent as compared with π mesons, one can regard the above ratio as N_{π^+}/N_{π^-}. It can be seen from Fig. 2 that, for $p \geq 10^9$ ev/c the ratio of the positive to negative particles is 110:40. If the ratio N_{π^+}/N_{π^-} does not vary considerably for $p > 10^9$ ev/c, then the number of protons with momentum $p > 10^9$ ev/c constitutes 0.3 of the number of star particles in lead. The results obtained are, within the limits of the errors, in agreement with the data of Refs. 2 – 6.

The momentum spectrum of secondary particles in the range $2 \times 10^8 - 10^9$ ev/c is considerably distorted due to ionization losses. The production spectrum of π mesons in this range can be obtained introducing corrections for ionization losses in lead. We have then the following value for the exponent of the momentum spectrum of negative particles (Fig. 3):

$$\gamma = 1.46 \pm 0.2.$$

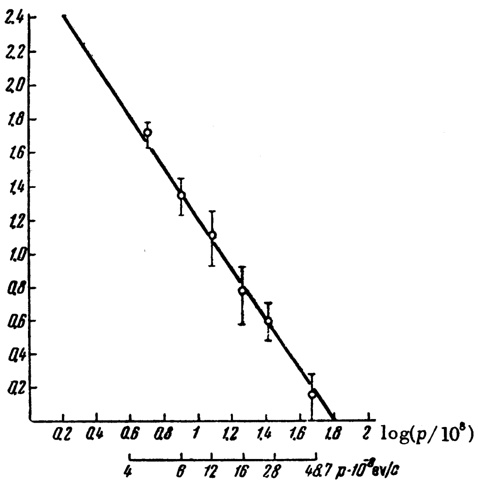

FIG. 3. Differential momentum spectrum of negative particles.

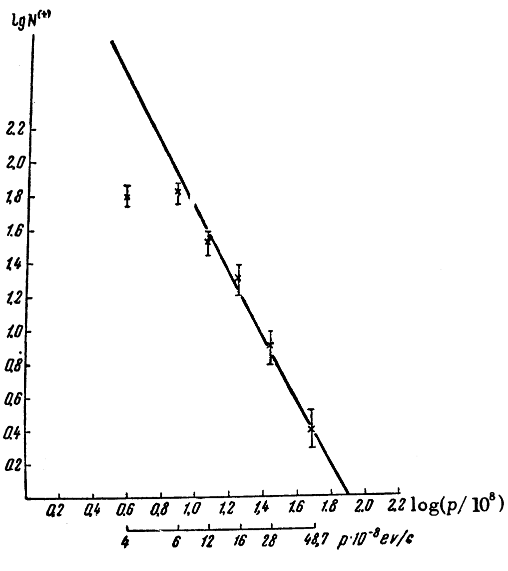

FIG. 4. Differential momentum spectrum of positive particles with momentum $p \geq 10^9$ ev/c (without ionization corrections).

We estimated the value of γ for the momentum spectrum of positive particles with $p \geq 10^9$ ev/c. This value, neglecting ionization corrections, was found to be of the order of 2.0 (Fig. 4).

In the third series of measurements, the interaction of secondary particles in the lower detecting arrangement, in which the observation conditions for stars were almost identical to the upper hodoscope, was studied for an estimate of the minimum energy of the star-producing primary particles. Not a single case, however, of a similar star was observed in the lower detector. It follows that the energy of primary particles should be > 6×10^9 ev.

By the method described in Ref. 7, using our data on the number of penetrating particles and their angular distribution, we obtained a value of the order of 30 Bev for the mean energy of the star-producing particles. The mean number of prongs was found to be 7.6, the mean number of secondary particles capable of penetrating 10 and 20 cm of lead is 5.6 and 2.7 respectively. The above results, however, are not very accurate because of the limitations of the hodoscope and the value obtained for the mean energy of the primary particles is only approximate. In addition, this value would be correct only for isotropic distribution of secondary particles in the center-of-mass system.

In conclusion, the authors wish to express their gratitude to A. I. Alikhanian and A. V. Khrimian for their help and discussion, to V. Sh. Kamalian and A. M. Gal'per for taking part in the measurements and to V. M. Krishchian for help in reducing data.

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ON THE HALL EFFECT IN FERROMAGNETICS

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The Hall effect has been studied in Fe — Ni alloys of the invar group near the Curie temperature. It has been established that in ferromagnetics above technical saturation, the Hall emf continues to increase linearly with increasing true magnetization; this confirms the validity of formula (2), which was proposed by Volkov for describing the Hall effect in ferromagnetics. A relation between the Hall emf and the magnetic field, obtained on the basis of Ginzburg's equation for the true magnetization of ferromagnetics near the Curie temperature, is satisfactorily confirmed by experiment.

NUMEROUS studies of the Hall effect in ferromagnetic materials have led to the establishment of a number of laws. Basic among these—as has been shown by the systematic investigations of Kundt,[1] Pugh,[2] and Kikoin[3]—is a linear relation between the Hall electromotive force and the magnetization of the material in the region of technical magnetization of ferromagnetics. As is shown by experiment, after a ferromagnetic has attained magnetic saturation, the Hall effect in it continues to increase with increase of the magnetic field.

On this basis, Pugh and his coworkers[2,4] proposed the following formula for describing the Hall effect in ferromagnetics: