Search for Heavy Cosmic-Ray Particles with a Cloud Chamber

Beacuse of the relativistic increase of masses with velocity, the determination of the rest mass of charged particles with a cloud chamber becomes impossible if their energies are very large. To investigate the nature of cosmic-ray particles a special anticoincidence amplifying set was used to trip the cloud chamber only by those cosmic-ray particles whose further path lies below a given range. By this method one makes sure to investigate only those particles which are of low energy and in which differences of mass can be detected by the ionization produced in a cloud chamber.

With a big rectangular Wilson chamber of 12 by 24 inches area and a magnetic field of 2000 gauss, 118 successful photographs have been taken. In 104 expansions the particles traversing the cloud chamber had a range less than 5 mm of lead. In five pictures this range was less than 17 mm. Nine additional expansions were taken with 15 cm of lead above the whole arrangement to count only the penetrating component.

No case was found which showed any observable difference of ionization from fast electrons. This result is in qualitative agreement with similar experiments published in the meantime by Street and Stevenson,[1] and emphasizes the rarity of occurrence of the terminal portion of a mesotron track.

The experiments were performed at the Swiss Institute of Technology in Zurich, and I would like to acknowledge the support and many discussions by Dr. P. Scherrer.

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May 18, 1939.

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[1] J. C. Street and E. C. Stevenson, Phys. Rev. 52, 1003 (1937).

Zenith Angle Distribution of the Hard Component of Cosmic Rays and the Mass of the Mesotron

In a recent publication,[1] a formula was derived for the relation between the path of decay L of mesotrons and the vertical angle distribution of the hard component of cosmic radiation which is supposed to consist of mesotrons. Regarding both, radioactive decay and absorption due to ionization, we get

$$-d \ln N/d \sec \vartheta = \mu_h(H+H_p)+H_f/L, \tag{1}$$

where N is the intensity of the radiation, H the mass of the earth atmosphere, H_p the additional mass of the absorber, H_f[2] the height of formation of mesotrons and μ_h the absorption coefficient of the hard component.

Measurements of Brackertz[3] on the zenith angle distribution behind different thicknesses of absorber were used to draw new conclusions on the energy and mass of the hard component.

The difference in value of the absorption coefficient behind different thicknesses of absorber has to be considered. Introducing the relation

$$\mu_h \approx 1/\text{thickness of absorber}_{(\text{m H}_2\text{O})} \tag{1a}$$

found by Auger for the first few meters of water equivalent of absorber, and taking into consideration the inclination, we have

$$\mu_h \approx 1/(H+H_p) \sec \vartheta.$$

With formula (1) this gives

$$-d \ln N/d \sec \vartheta \approx \cos \vartheta + H_f/L.$$

This formula means that the distribution of the hard component can be found without any assumption about the absorption coefficient if L and H_f are known, since μ_h does not appear in it.

Since L is proportional to the energy according to the law

$$L = E\tau_0/mc,$$

and as the height of formation H_f can be found[4] from $\cos \vartheta/10 = \exp(-H_f/H)$ and is

$$H_f = H(2.3+\ln \sec \vartheta),$$

the general formula

$$-d \ln N/d \sec \vartheta \approx \cos \vartheta + (1/E)H(2.3+\ln \sec \vartheta)mc/\tau_0$$

is obtained, or

$$E \approx mc/\tau_0 H(2.3+\ln \sec \vartheta)/(-d \ln N/d \sec \vartheta - \cos \vartheta), \tag{2}$$

which gives the energy distribution of the penetrating rays. The data given by Brackertz for $(H+H_p)=19.4$ m may be used to investigate the energy distribution by applying formula (2) (Table I). As a simplification $\ln \sec \vartheta$ will be taken as constant, and the difference quotient will be used in place of the more accurate differential quotient. This shows an increase of the energy with greater angle of inclination as was to be expected.

As Brackertz gives as data on the inclination effect behind different thicknesses of absorber, we may also apply formula (2) to find the energy curve for different thicknesses of dense absorber for a constant angle of inclination as for example the vertical rays ($\vartheta=0°$). Then $(-d \ln N/d \sec \vartheta)$ may be found by extrapolation of the values found for $-\Delta \ln N/\Delta \sec \vartheta$ for $\Delta\vartheta = 30° \rightarrow 0°$, $20° \rightarrow 0°$, $10° \rightarrow 0°$ toward $0° \rightarrow 0°$. This was done in the first publication[1] on this subject.

This result (Table II) is in absolute disagreement with the well-known fact that the mean energy of the cosmic radiation increases with the mass of absorber.

The simple law for the vertical angle distribution as represented by formula (1) has been found experimentally to be correct especially near $\vartheta=0°$. The formula (1a) has

TABLE I. *Energy distribution calculated from Eq. (2).*

ϑ	N	$-\dfrac{\Delta \ln N}{\Delta \sec \vartheta}$	$\cos \vartheta$	DENOMINATOR	INCREASE OF E BY FORMULA (2)
	283				
0–10°		2.079	0.996	1.083	——
	274				
10–20°		2.055	0.966	1.089	—— (−0.4)
	248				
20–30°		1.996	0.906	1.090	—— (−0.4)
	207				
30–40°		1.796	0.819	0.977	10%
	158				
40–50°		1.631	0.707	0.924	17%
	105				
50–60°		1.418	0.574	0.844	30%
	56				