Shower Producing Cosmic-Ray Primaries

In a previous paper[1] the writer suggested that cosmic-ray showers, produced in heavy materials, are tertiary particles. These tertiary particles are ejected by light element secondaries and the secondaries are ejected by the primary rays. The absorption of these cosmic-ray primaries has now been measured.

In order to accomplish this the usual arrangement of three Geiger counters in a triangle with a lead scatterer beneath the top counter was used to detect the showers. A sufficient thickness of paraffin wax was placed over the counters to cut out the air secondaries and also to produce the equilibrium amount of paraffin secondaries. The paraffin secondaries then produced tertiary showers which were counted. Lead absorbers of different thicknesses were placed above the wax. These absorbers cut out the primary rays and lower the equilibrium amount of paraffin secondaries so that the number of tertiary showers is lowered.

The arrangement of Fig. 1 was used for this experiment.

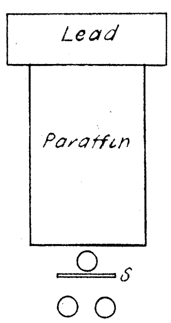

FIG. 1.

The Geiger counters were 20 cm long and 4.8 cm in diameter. The lead scatterer, S, was 0.85 cm thick, 10 cm wide and 30 cm long. The paraffin block was 33 cm thick, 32 cm long and 12 cm wide. The lead block was 18 cm wide, 48 cm long and its thickness was varied.

The counting rate with the arrangement of Fig. 1 with a lead absorber 5.3 cm thick was measured. Then the counting rate without the paraffin block was measured. It was found that taking out 33 cm of paraffin decreased the counting rate from 22.5 to 20.3 per hour. Evidently there was some secondary radiation from the paraffin which ejected tertiary showers from the lead scatterer.

The thickness of the wax was held constant and that of the lead absorber was varied. The counting rates were determined for each thickness of the lead and the results, after the subtraction of a constant, are plotted in the curve of Fig. 2. The corrected counting rate has been plotted on the logarithmic scale against the thickness of the absorber. The experimental points fall on a straight line within the statistical error. Therefore the absorption obeys the exponential law

$$I = I_0 e^{-\mu x}, \quad (1)$$

where I is the counting rate of showers at a thickness x, I_0 with thickness zero and μ is the absorption coefficient.

First, the constant which must be subtracted from the actual counting rates to give the curve was calculated. Three equations of the type (1) with different thicknesses were solved simultaneously for this constant. Its value was found to be 17.0 per hour which is almost exactly the chance count with no materials near the counters. Then, the slope of the curve of Fig. 2 gave the required absorption

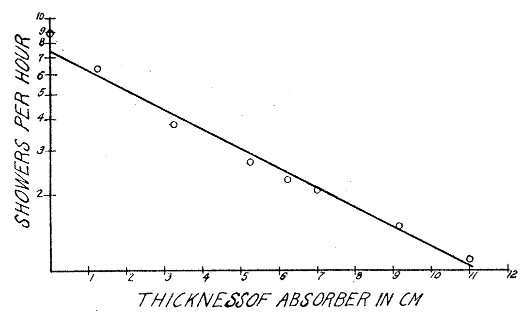

FIG. 2.

coefficient 0.50 cm^{-1} Pb. This is the absorption coefficient of the primaries which are causing the showers.

The absorption of the shower-producing radiation has been measured by several workers. Johnson[2] found the radiation had the same absorption coefficient as the corpuscular component, or about 0.50 m^{-1} H_2O. Then, Montgomery[3] found a value of 0.90 m^{-1} H_2O from measurements at different altitudes. Lastly, Pickering[4] has made three measurements beneath water which agree roughly with the results of Montgomery.

If we assume the absorption obeys a mass law the absorption coefficient is directly proportional to the desity. From this we find that Montgomery's data correspond to 0.10 cm^{-1} Pb. This is only one-fifth of our value for the absorption coefficient. So we checked the work of Montgomery and of Pickering. Using the arrangement of Fig. 1 we removed the lead absorber and replaced the paraffin block with an aluminum one. From values of the counting rate with three thicknesses of aluminum, we find an absorption coefficient of 0.022 cm^{-1} Al. This agrees very well with the results of the other workers, giving 0.82 m^{-1} H_2O to compare with their 0.90 m^{-1} H_2O. From these results we conclude that the absorption coefficient is not proportional to the density.

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J. H. SAWYER, JR.

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[1] J. H. Sawyer, Phys. Rev. **44**, 249 (1933).
[2] T. H. Johnson, Phys. Rev. **45**, 569 (1934).
[3] D. D. Montgomery and C. G. Montgomery, Phys. Rev. **47**, 339 (1935).
[4] W. H. Pickering, Phys. Rev. **47**, 423 (1935).