first forbidden of the first type; but this indication is not quite peculiar to our theory. The above argument concerning the spectrum suggests that the same conclusion would be reached in any choice of invariants except, perhaps, in certain special cases. This general result may be interpreted to mean that the long-lived elements are not long-lived for the most part because of forbidden spin or parity change, or it may mean that the application of beta-decay theory must be further refined.

Second forbidden transitions in this theory show no change of parity and $\Delta i = \pm 2, \pm 3$. The shape of these Kurie plots is concave to the axis at high energy for all matrix elements.

We are indebted to Professors Konopinski and Uhlenbeck for helpful discussions of this subject at the Washington Conference and to the former for access to his review article on beta-decay before publication.

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The Second Maximum of the Rossi Curve

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August 11, 1941

SINCE Schmeiser and Bothe[1] reported that the second maximum in the Rossi transition curve at about 17 cm of lead is due to small angle showers a number of investigations have been made on this maximum. The results have been somewhat contradictory as to the height of the maximum and angular divergence of showers responsible for the maximum. In view of this contradiction in data taken mainly with counters, it was thought worth while to investigate this problem with a cloud chamber. This method would eliminate the uncertainty in angle inherent in counter measurements as well as the masking effect of counter background.

The apparatus used consisted of a vertical, counter-controlled, cloud chamber and a vacuum tube time delay control circuit. By means of a mirror system a camera took two pictures 54° apart. All lead was placed above the top counter so that non-ionizing particles as well as ionizing particles might cause an expansion.

The results obtained are shown in Fig. 1. More than 200 showers were recorded for each point near the maximum so that the probable error for these points is less than 5 percent. The Rossi curve for the total showers recorded has a definite maximum at about 17 cm of lead. The rise in the curve (nearly 30 percent) is well above the probable error as computed from the number of showers. The second curve is for two-particle showers with angular divergence greater than 20°. The similarity of the two curves suggests that the maximum is mainly due to this component. So few narrow angle showers were obtained that it was impossible to construct a similar curve for them or to draw any conclusions as to whether or not they exhibit a different behavior in the neighborhood of the maximum. A curve of

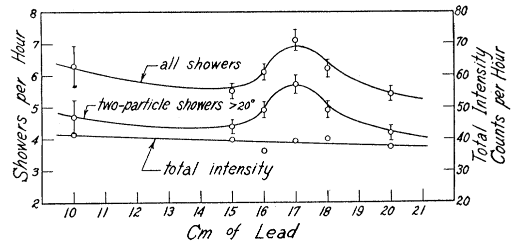

FIG. 1. Total intensity and shower intensity of cosmic rays.

total intensity on a different scale is included for purposes of comparison. It was obtained from the photographs used in obtaining the shower curves.

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Production of Mesotrons by Ionizing Radiation

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IN a series of 3881 random expansions of a large Wilson cloud chamber containing five horizontal lead plates each 1 cm thick one photograph was obtained which can be interpreted as the production by a heavy particle of a shower containing at least four heavy particles and possibly more. (Fig. 1).

The incoming particle must pass through a half-inch of cold rolled steel to enter the chamber. If it were an electron it is extremely unlikely that it would be unaccompanied by shower particles. The energy of the incoming particle must be quite great to produce such a shower, and this would almost insure the presence of shower particles if it were an electron.

The short heavy track appearing directly under the top plate is either a mesotron or a proton. The track which

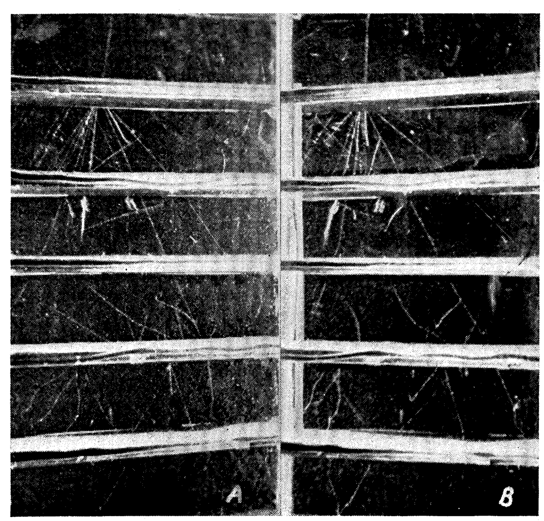

FIG. 1. Wilson cloud-chamber photograph. Each lead plate is 1 cm thick. Figures *A* and *B* were taken at 30° to the left and right of normal.

penetrates the second lead plate and then becomes very thick and passes out of the front of the chamber may be a proton. The upper part of the track appears slightly brighter than the neighboring rays. This would indicate that the particle was a proton. On the other hand the ray is coming towards the cameras and is the only one which is in the very front of the chamber, and the brightness of the upper part of the track may be due to these two conditions. If this is true the particle is a mesotron. The great increase in ionization in passing through the plate is a little larger than that usually observed for a proton.

A ray on the left-hand side passes through two plates without producing secondaries and then disappears in the back of the chamber. This particle is either a mesotron or a proton. A ray to the right passes through three lead plates without producing secondaries and is either a mesotron or a proton. It passes out of the back of the chamber. The ray bounding the right-hand edge of the shower passes through one lead plate without producing secondaries and passes out of the back of the chamber. This might be an electron but is more likely to be a heavy particle.

The shower might be interpreted as a nuclear disintegration where all the fragments were protons of high energy. On the other hand most disintegrations of this type send particles equally in all directions. The most likely interpretation seems to be that the incoming particle is a proton of high energy and the shower consists of mesotrons.

This work is supported by the Rumford Fund for the Study of Radiation of the American Academy of Arts and Sciences, the Penrose Fund of the American Philosophical Society, the Fund for Astrophysical Research, and the John Simon Guggenheim Memorial Foundation.

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Cloud-Chamber Photograph of Slow Mesotron Pair

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August 10, 1941

During July, some 5000 photographs have been taken with a cloud chamber in a field of 1165 gauss at an altitude of 15,500 feet at San Cristobal mine, Peru. As a complete discussion of the results obtained may not appear for some time, it seems desirable to report now on one picture of some interest. The numerical results given here are those reported at the cosmic-ray symposium in Rio de Janeiro, August 3–9, and are admittedly rough, there having been no opportunity as yet for precise measurement of the film.

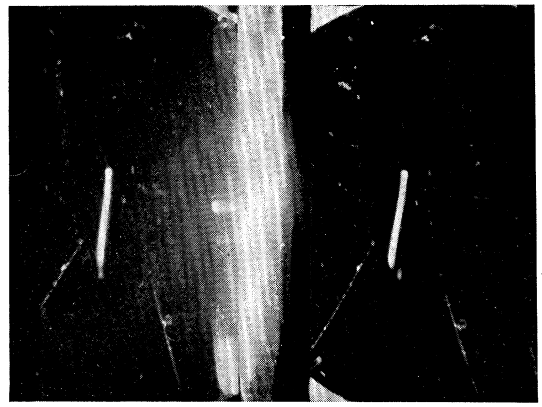

Fig. 1. Slow mesotron pair.

Figure 1 shows several shower electrons, a contamination α-particle and a positive-negative pair of heavily ionizing particles. Stereoscopic examination shows the pair to be in the same plane, which is not the plane of the other tracks, and proceeding from a point in or near the front glass plate of the chamber.

The right-hand particle (negative) has an $H\rho$ value of 1.03×10^5 gauss cm. Its ionization (estimated from the original negative) is about 4 to 6 times the electronic minimum. Corresponding to this variation, the calculated mesotron mass will range from 160 to 196 electron masses. The ionization density can also be estimated from the fact that it is very nearly equal to that of the knock-on electron. The known range of the latter (hence its velocity) gives an ionization value of 4.5. A value equal to this for the mesotron results in a mass of 170. The particle cannot be a proton, for with the $H\rho$ value observed it would have a range of only 1.2 cm in the chamber.

The energy and angle of ejection of the knock-on furnishes an additional independent mass determination. As it ends in the chamber its range, and hence its energy, can be easily obtained, the latter being 34 kev. The angle of ejection is estimated as lying in the range 50°–60°, which gives a mesotron mass of 189 ± 24. If the incident particle were electronic, the knock-on energy would be 320 kev at 60° and even more for smaller angles—an impossible value.

The mass of the left-hand (positive) particle cannot be fixed as accurately as the other for there is no knock-on and the curvature is not as constant. For the present it must suffice to say that the ionization and $H\rho$ values are very close to those of the negative particle and the mass is of the same order of magnitude—about 180 electron masses.

Though later calculations will probably change to some extent the quantitative results, it seems reasonable to conclude that we have here observed the creation of a pair of slow mesotrons ($KE\approx5$ Mev) either in the gas or glass wall of the cloud chamber. The production of mesotrons at this altitude has also been shown by the occurrence of related penetrating, non-multiplying rays in cloud chambers. Dr. Wollan has observed several such cases during the present experiments. The results with the magnetic field, however, furnish in addition information on the mass and energy of the particles. About sixteen heavy tracks with measurable curvature have been obtained and will be reported on later.

We wish to thank the Cerro de Pasco Corporation for their hospitality and the use of many facilities during these observations. The Academy of Science of Brazil and the faculty of Sao Paulo University have rendered great assistance to us during our stay in Brazil for which we are deeply grateful.

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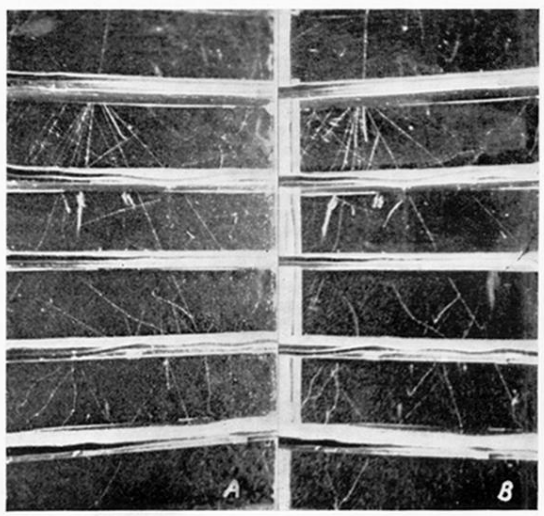

FIG. 1. Wilson cloud-chamber photograph. Each lead plate is 1 cm thick. Figures *A* and *B* were taken at 30° to the left and right of normal.