Letters to the Editor

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Cloud-Chamber Track of a Decaying Mesotron

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IN a previous letter[1] we described a track of what was evidently a negative mesotron at the end of its range in the gas of the cloud chamber. As with most of the other five or six published photographs showing mesotron stoppage in the gas there was no evidence in our picture that the mesotron had disintegrated and until now a single photograph by E. J. Williams[2] has constituted the only indisputable cloud chamber evidence for mesotron decay. It is therefore of interest to put on record another track of a mesotron disintegration recently obtained during first tests of a high pressure cloud chamber.

The details of the chamber will be described in another article and it will suffice to state that the chamber is cylindrical, 30 cm in diameter and 10 cm deep. It is designed to operate at an internal pressure of 200 atmospheres but the present photograph was obtained at a pressure of 70 atmospheres in a mixture of argon, *n*-propyl alcohol, and water vapor, without magnetic field or counter control. The expansion ratio decreases as the pressure is increased and at 70 atmospheres good tracks were obtained at a volume ratio of 1.05.

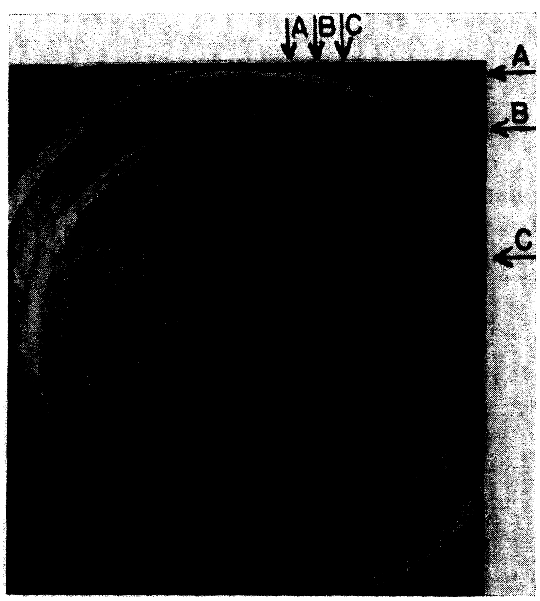

FIG. 1. Photograph of a mesotron disintegrating at *C*.

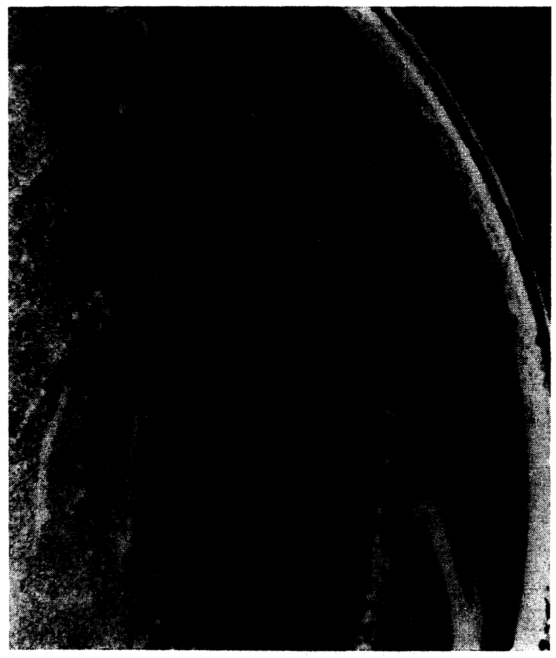

FIG. 2. Decaying mesotron of Fig. 1, enlarged.

Figure 1 shows the entire field of the chamber, and Fig. 2 is an enlarged view of the track of particular interest. What is evidently a mesotron enters the chamber at *A*, at *B* the track is definitely heavy, and at *C* a conversion takes place in which the mass of the mesotron disappears and a lightly ionizing particle of high energy, presumably an electron, flies off at an angle of 85° with the direction of the primary mesotron track.

It is interesting to observe the apparent change in density of the mesotron track 5 cm from its end at *B*. According to the Bethe-Bloch formula the residual range of a mesotron of mass 180 m is 6 cm after the ion density in the track has become four times that of a ray of minimum ionization. Thus the apparent change in density occurring over a relatively short distance at this pressure is probably not an effect of uneven illumination. The curvature of the mesotron track is presumably caused by multiple scattering, and may be used for an estimate of the mass of the mesotron. According to Williams[3] $\rho_s/R \approx 1.3(m/Z)^{\frac{1}{2}}$, where ρ_s is the average radius of curvature of the track over the first half of its range R, m is the mass number of the particle, and Z the atomic number of the scattering gas. Examination of the track shows that ρ_s is between 2 and 6 times the residual range which places the mass of the particle between 40 and 400 electron masses.

The lightly ionized track of the disintegration particle shows no deflection, and taking into account the high pressure of the gas we may conclude that its energy exceeds 3×10^7 ev whereas the density of the mesotron track indicates that its final energy was less than 10^6 ev.

In conclusion the picture seems to represent a slow particle of intermediate mass converted into a fast particle of small mass, the type of disintegration which has been postulated to account for certain anomalies in the absorption of cosmic rays in the atmosphere. Since this is the first track found in our experiments out of a total 2×10^6 cm of mesotron tracks examined we have an estimate that the probability of disintegration is 5×10^{-7} per cm. In our high pressure chamber we can have an equivalent path length of 6000 cm for each ray and with the long time of sensitivity realized we may have several rays in each photograph. Thus we may expect to find events of this type occurring once in something of the order of every one hundred photographs at maximum pressure.

Acknowledgment is made of the generous support given for the high pressure cloud-chamber project by the Carnegie Institution of Washington.

[1] T. H. Johnson and R. P. Shutt, Phys. Rev. **61**, 380 (1942).
[2] E. J. Williams and G. E. Roberts, Nature **145**, 102 (1940).
[3] E. J. Williams, Phys. Rev. **58**, 292 (1940).

The Beta-Ray Spectrum of Antimony (124)

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DEUTERON bombardment of antimony gives rise to a large number of radioactive isotopes. Sb^{122} and Sb^{124} are formed from the two stable isotopes Sb^{121} (56 percent) and Sb^{123} (44 percent) by a (d, p) reaction. The periods associated with these two radioactive isotopes have been identified by producing them in a number of different ways.[1] The average of the values reported for the half-life of Sb^{122} is 61 hours, and that of Sb^{124} is 60 days. Both isotopes emit hard gamma-rays.

In addition to the radio-antimony isotopes, a number of tellurium isotopes are also formed by deuteron bombardment; Te^{121} is formed by a $(d, 2n)$ reaction, and has a half-life of 125 days.[2] There is some evidence[3] that it is a positron emitter giving rise to several gamma-rays.[2,3] Other tellurium isotopes which are probably formed at the same time are those having mass numbers 122, 124, and 123; the first two by a (d, n) reaction and the latter by a $(d, 2n)$ process. Although these isotopes occur as stable in nature, there is some evidence[3] that two of them, $Te^{122,124}$ are formed in excited states by the deuteron reaction, yielding gamma-rays having energies of 82.0 kev and 88.3 kev. Other gamma-rays which are emitted by the separated tellurium fraction and whose origins are not definitely known, have energies of 136,157.3, 210.8, and 615 kev.[3] A period of 30 days has been assigned to the composite gamma-ray activity.

The present investigation was undertaken in cooperation with Professor Goldhaber. A source produced by deuteron bombardment of antimony was prepared for him by Dr. Kamen of Berkeley. A fraction of this source, in the form of a powder scraped from the surface, was attached to a copper foil, 0.001″ thick, by pouring on a very small amount of Vinylite dissolved in methyl ethyl ketone. The surface density of the source, including all materials, was estimated to be 30 mg/cm²

More than seventy days after the sample was bombarded, measurements were started on the continuous (negative electron) spectrum of Sb^{124}. The beta-ray activity of Sb^{122} was, by this time, reduced to approximately one part in two hundred million. The only other long-lived activities present were those due to a 30-day gamma-ray[3] and to the 125-day Te^{121} activity. Since the latter decays either by K-electron capture or by positron emission, there were no beta-rays due to these activities except possibly those due to internally converted gamma-rays. In addition, measurements made at the momentum intervals specified by 3170 gauss-cm (0.57 Mev) and 5680 gauss-cm (1.26 Mev) gave half-lives of 59 days and $62\frac{1}{2}$ days, respectively.

All relative numbers of counts were reduced to a standard time on the assumption that the 60-day half-life given by Livingood and Seaborg is correct.

Figure 1 is a plot of the relative number of counts per momentum interval against the corresponding momenta specified in gauss-cm. The probable errors in the relative numbers are given approximately by the lines through the points. A greatly magnified drawing of the end-point region is shown in the upper right-hand corner. Figure 1 clearly indicates that the continuous spectrum consists of two components.

The end points were determined both by inspection and by the Fermi plots. The two sets of values are in good agreement. Allowance was made for the fact that the last beta-rays to enter the counter were grazing the inner slit jaw. The upper end point did not include a small tail on the observed curve. The end points assigned were 3800 ±100 gauss-cm and 9720 ± 200 gauss-cm. These probable errors are due largely to the magnetic field calibration. They would be about one-half as large on the basis of internal consistency alone. These end points correspond to energies of 0.74 ± 0.03 Mev and 2.45 ± 0.07 Mev.

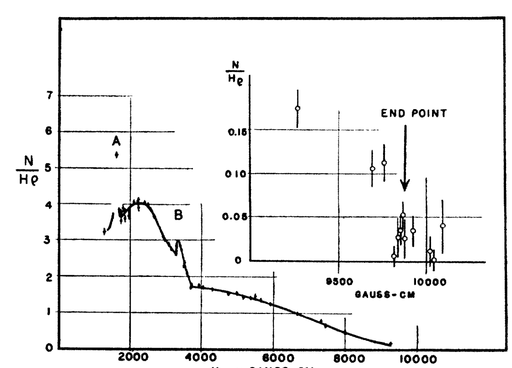

FIG. 1. The beta-ray spectrum of Sb^{124}. The curve is plotted with arbitrary ordinates.

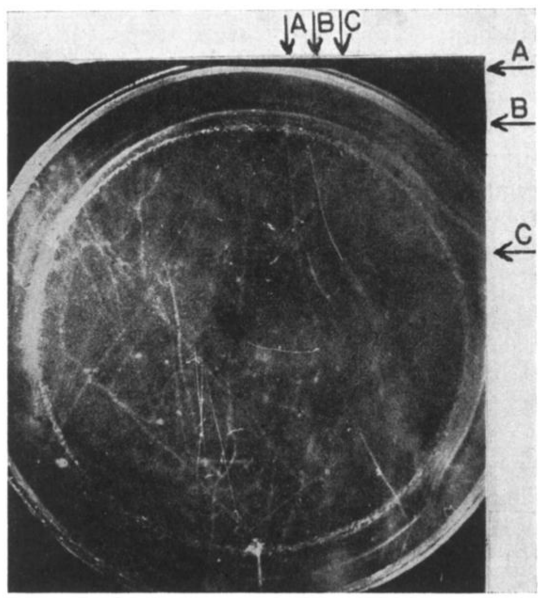

FIG. 1. Photograph of a mesotron disintegrating at C.

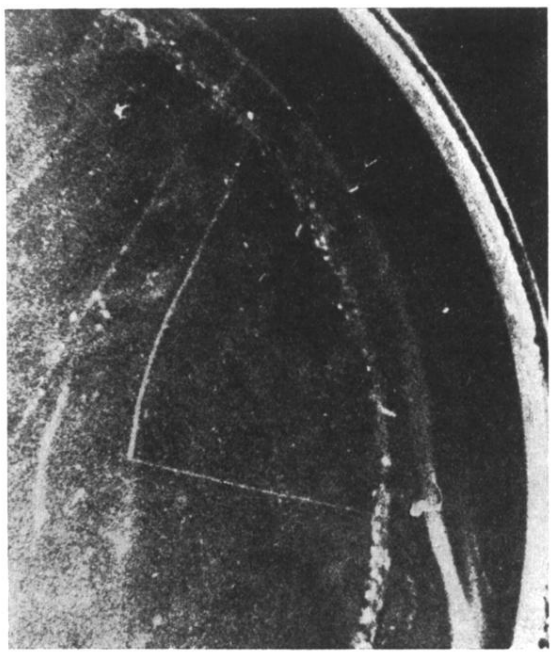

Fig. 2. Decaying mesotron of Fig. 1, enlarged.