one arrives at an upper limit for the width of the 665-kev excited state of Mo^{97}, $\Gamma \leq 5\times 10^{-4}$ ev, and at a lower limit for the lifetime of this state of 1.5×10^{-12} second. This lifetime is one order of magnitude longer than the one expected from the Weisskopf formula. Thus, the $M1$ transition in Mo^{97} shows the same behavior as the low-energy $M1$'s.

It should be mentioned that the Mo^{97} transition, as well as most of the low-energy transitions measured by the Canadian group, involve a change of two units of orbital angular momentum, whereas the Li^7 gamma ray presumably leads from a $p_{\frac{1}{2}}$ to a $p_{\frac{3}{2}}$ state.

† Assisted by the joint program of the U. S. Office of Naval Research and the U. S. Atomic Energy Commission.
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Production of $V_1{}^0$ Particles by Negative Pions in Hydrogen*

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THE photograph reproduced in Fig. 1 is one of two obtained in a hydrogen-filled diffusion cloud chamber exposed to a beam of 1.5-Bev negative pions (π^-) from the Cosmotron. The hydrogen was at a pressure of 18 atmospheres, and a field of 11 000 gauss was applied. The picture is believed to represent the production of a $V_1{}^0$ particle by a π^- interaction with a proton. Track a is the incident π^-, the end point of which is to be called A. Tracks b and c are the decay products of the $V_1{}^0$. A single neutral heavy meson also may have been produced at A, which would travel in the direction indicated by d.[1]

Since track a is short, its momentum can only be estimated to lie near the nominal π^- beam momentum of 1.63 Bev/c. This track is parallel to the other beam tracks and thus probably is not due to a secondary particle. The line connecting point A with the vertex of b and c, to be called G, forms an angle of 26° with a. The distance between A and G is 0.65 cm. Tracks a, b, and c are coplanar, while only coplanarity of A, b, and c is necessary for the tracks to be associated. In addition, the components of momentum of b and c perpendicular to line AG balance. Track b forms an angle of 16° with a; b is caused by a positive particle with a measured momentum of 480 ± 80 Mev/c and an estimated ionization density of $3\times$minimum. Thus b is identified as a proton track. The angle between b and c is 37°. Track c is negative, with a momentum of 210 ± 70 Mev/c and estimated ionization density of less than $1.5\times$minimum. An upper limit of 410 m_e is inferred for its mass, indicating a π^-. Assuming that b and c represent the decay of a $V_1{}^0(\rightarrow p+\pi^-+Q)$, one finds a Q-value of 51 Mev from these data.[2] Assuming the generally accepted Q of 37 Mev one would find that, for the given angles, the momenta should be 460 Mev/c for the proton and 180 Mev/c for the π^-. These values fall within the errors given for the measured values and have been used for the further computations. The lifetime of this $V_1{}^0$ is 4×10^{-11} sec.

The total energy of the $V_1{}^0$ is 1.26 Bev, and its momentum is 610 Mev/c. To conserve energy and momentum at least one other neutral particle must start at A. Assuming a single particle, its total energy would have to be 1.31 Bev and its momentum 1.11 Bev/c, leading to a mass of 1350 ± 70 m_e for a kinetic energy of 1.5 Bev for the incident π^-. For an energy of 1.2 Bev instead of 1.5 Bev one would obtain a value of 1150 m_e. However, such a low value for the incident energy is improbable. In any case, if only one other particle had been produced in addition to the $V_1{}^0$, this would have to be a heavy meson. Its direction of flight is indicated by d in Fig. 1, and its lifetime must have been longer than 4×10^{-10} sec since no decay was observed in a path of 23 cm in the chamber. A threshold energy of 870 Mev is necessary for the process discussed, while 1.06 Bev were available for a 1.5-Bev incident π^- (including the rest mass of the π^-).

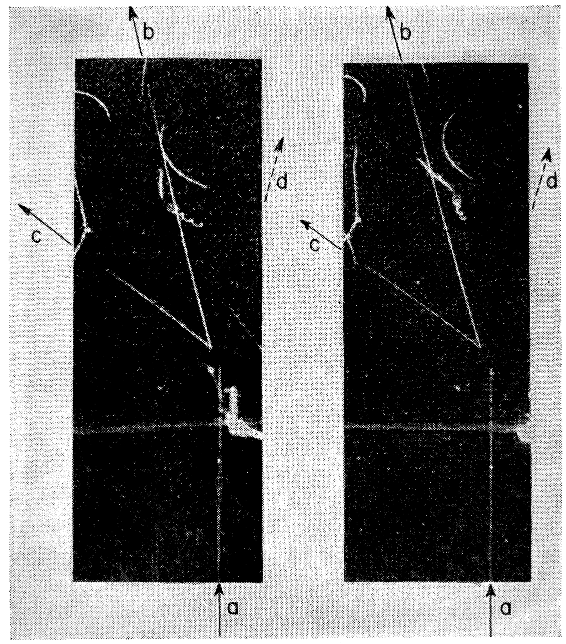

FIG. 1. Stereoscopic photograph of a $V_1{}^0$ (tracks b and c) produced in hydrogen by a negative pion (track a) of an energy of 1.5 Bev. If one heavy meson of a mass of about $1350m_e$ has been produced in addition, its line of flight is indicated by d.

The other photograph is quite similar to the one described, except that no momentum measurements can be obtained. However, the measured angles and estimated ionization densities are quite consistent with a $V_1{}^0$. Its direction of flight forms an angle of 30° with the incident π^-. If it is assumed to be a $V_1{}^0$ one calculates that its total energy is 1.33 Bev, its momentum 745 Mev/c, and is lifetime 3×10^{-11} sec. Assuming again that only one other neutral particle leaves the event, its mass would be 1280 ± 80 m_e (for a 1.5-Bev incident π^-) and its lifetime longer than 3×10^{-10} sec.

Of course, instead of one heavy particle several lighter ones (for instance two π^0's, or a π^0 and a $V_2{}^0$) could originate from the events in addition to the $V_1{}^0$. However, the present results are consistent with the possibility of production of $V_1{}^0$ together with one other heavy unstable particle.[3]

* Work performed under the auspices of the U. S. Atomic Energy Commission.
1 It is not likely that the interaction of the π^- at A involved carbon or oxygen in the alcohol rather than H_2, since (1) there is at most one molecule of alcohol per 800 molecules of H_2 and (2) an interaction with C or O would most probably give rise to charged prongs.
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Effect of the Electric Quadrupole Interaction on the $\gamma-\gamma$ Directional Correlation in Cd^{111}. III

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IN previous letters[1,2] we showed the effect of an interaction between the nuclear electric quadrupole moment of the intermediate state and an extranuclear inhomogenous electric field on

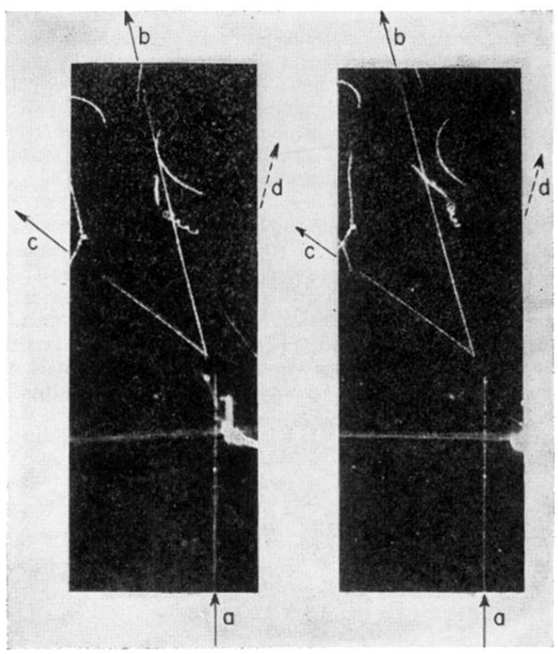

FIG. 1. Stereoscopic photograph of a V_1^0 (tracks *b* and *c*) produced in hydrogen by a negative pion (track *a*) of an energy of 1.5 Bev. If one heavy meson of a mass of about $1350m_e$ has been produced in addition, its line of flight is indicated by *d*.