fitted to a theoretical relation.[16] It contains an outer Coulomb correction using $r_0=\lambda\!\!\!^{-}_c$. This value for α_3/η and the present experimental a give $\alpha_1/\eta=0.184$. The same α_3/η and a, except using $r_0=0.5\lambda\!\!\!^{-}_c$, give $\alpha_1/\eta=0.174$. If we now apply the inner Coulomb correction as well, we get $\alpha_1/\eta=0.170$ and 0.172 using $r_0=\lambda\!\!\!^{-}_c$ and $0.5\lambda\!\!\!^{-}_c$, respectively.

The Hamilton and Woolcock analysis gives $\alpha_1/\eta=0.178\pm0.005$ with outer Coulomb correction using $r_0=\lambda\!\!\!^{-}_c$. The comparable value found from this experiment is $\alpha_1/\eta=0.184$ using the α_3/η of Hamilton and Woolcock. The present experiment is therefore not in disagreement with the consistent low-energy pion parameters of Hamilton and Woolcock.

[16] The value of α_3/η preferred by Hamilton and Woolcock is not directly comparable with that reported by Fischer and Jenkins. When the Fischer and Jenkins result is corrected using $r_0=\lambda\!\!\!^{-}_c$, it becomes $\alpha_3/\eta=-0.108$. Furthermore, the Fischer and Jenkins amplitude fell off at low energies by $1\frac{1}{2}$ standard deviations.

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Probable Example of the Decay $\Sigma^0\rightarrow\Lambda+e^++e^-$ in Nuclear Emulsion

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An event has been observed in nuclear emulsion which is attributed to the production of a Σ^0 hyperon and its subsequent decays via the mode $\Sigma^0\rightarrow\Lambda+e^++e^-$. From the apparent concurrence of the tracks involved in the disintegrations, it has been deduced that the Σ^0 lifetime for this event is $<10^{-14}$ sec.

THE lifetime of the Σ^0 hyperon is expected to be within the range 10^{-18}–10^{-20} sec,[1,2] and possible methods for its determination have been recently discussed by Dreitlein and Primakoff.[3] Until now the sole experimental value reported[4] was obtained from the observation of Σ^0 hyperon decay events in a hydrogen bubble chamber by Alvarez *et al.*[5] The Σ^0 hyperon lifetime was quoted to be less than 10^{-11} sec. During the systematic scanning for K^- meson captures at rest in an Ilford $K5$ emulsion stack an event has been found which is attributed to the decay of a Σ^0 hyperon via the Dalitz mode, i.e.,

$$\Sigma^0\rightarrow\Lambda^0+e^++e^-. \quad (1)$$

This decay mode was first observed by Eisler *et al.*[6] in a hydrogen bubble chamber. The high spatial resolution of the emulsion technique has enabled a much more precise experimental upper limit to be placed upon the decay length and hence the lifetime of the Σ^0 hyperon.

A photograph of the event to be described is shown in Fig. 1 and the measurements made on it are summarized in Table I. A K^- meson is captured at point O and three fast charged particles are seen to be emitted from the resulting nuclear disintegration. One is due to a charged π meson, probably negative, because it interacts in flight after a path length of 9.1 mm to form a star from which no charged secondaries are emitted. The energy of this π meson, as determined by ionization and scatter-

TABLE I. Summary of the measurements.

Track	φ (deg)	λ (deg)	Observed length (μ)	g^*	$p\beta$ MeV/c	Kinetic energy (MeV)
e_1	184.8	+10.6	2200	0.96±.04	28± 9	28± 9
e_2	187.7	+ 5.7	3300	1.07±.03	48±10	48±10
$\pi^\pm$	45.3	+16.2	9100	1.28±.02	90±17	57± 4

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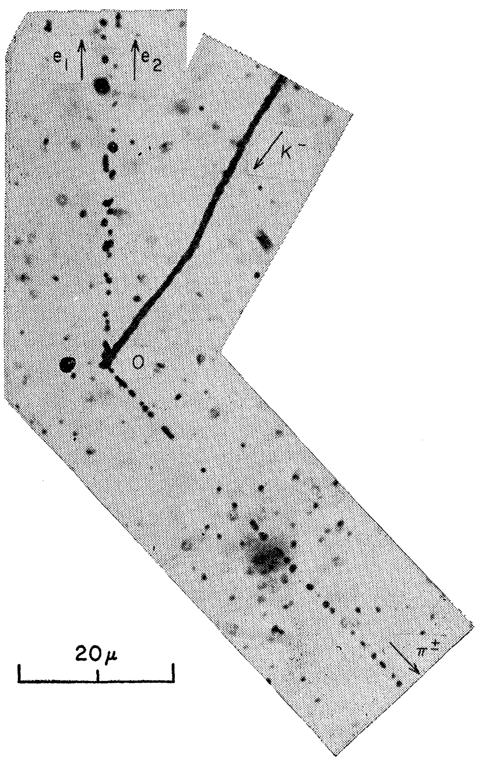

FIG. 1. Photomicrograph of the event.

ing measurements along its track, is (57±4) MeV. Tracks e_1 and e_2 are due to an electron pair of opening angle 5.1°. The energies of the electrons, as measured from multiple Coulomb scattering, are (48±10) MeV and (28±9) MeV, respectively. The energy of the pair is thus (76±14) MeV. At the vertex of the capture star there is also a small blob, which is probably either the track of a heavy recoiling nucleus or of a slow electron. A mass measurement of the primary particle, which entered the stack in the direction of the beam, was made using the constant sagitta scattering method. The value obtained, (0.8±0.2) m_K, clearly indicates that the event is indeed due to a K^- meson capture.

By far the most likely interpretation of this event is that the K^- meson is captured on a bound neutron to form a Σ^0 hyperon

$$K^- + n \rightarrow \Sigma^0 + \pi^-, \quad (2)$$

and that the Σ^0 hyperon subsequently decayed via the Dalitz mode. This mode is expected to occur with a frequency of once for every 160–180 normal radiative Σ^0 hyperon decays[7,8]. It can be shown that alternative interpretations of this event, viz., the decay of a K^- meson almost at rest, via the mode $K^- \rightarrow \pi^- + \pi^0 + \pi^0$, and the π^0 decay of an unobserved hyperfragment, are extremely improbable.

The upper limit of the decay length of the Σ^0 hyperon was measured in a way similar to that used by other emulsion workers[9–11] when estimating the π^0 meson lifetime. The direction of the resultant of the electron pair momenta was found to be concurrent with the intersection of the π meson and K^- meson tracks, to within (0.1±0.3) μ in the emulsion plane, and to within (0.4±0.5) μ in the vertical plane. In this emulsion, Ilford K5, the mean diameter of the developed grains is (0.55±0.03) μ, whereas in Ilford L4 fine grain emulsion (used for the π^0 meson lifetime estimates by Glasser *et al.*[10]) the mean diameter of the developed grains is about 0.35 μ. Furthermore, whilst the velocity of the π^0 meson from $K_{\pi 2}^+$ meson decays at rest is precisely known, that of the Σ^0 hyperon in this case is much lower and less well determined. Both of these factors render one unable to measure the decay length of the Σ^0 hyperon with the same precision as can be achieved for individual π^0 mesons. However, Gilbert *et al.*[12] and the European K^- Collaboration[13] have shown that for K^--meson captures on bound protons in which a Σ hyperon and a π meson are the sole charged particles emitted, the sum of their kinetic energies is usually some 15 MeV less than the Q value for the reaction on a free proton. For a π meson energy of about 57 MeV, the most likely value for the Σ^0 hyperon energy is about 30 MeV, corresponding to a $\beta = 0.22$. The upper limit of the decay time of the Σ^0 hyperon is then $\sim 4 \times 10^{-15}$ sec. Even if the energy of the Σ^0 hyperon is assumed to be as low as 6 MeV, β_{Σ^0} would become 0.1 and the upper limit of the decay time can still be set at $\sim 1 \times 10^{-14}$ sec.

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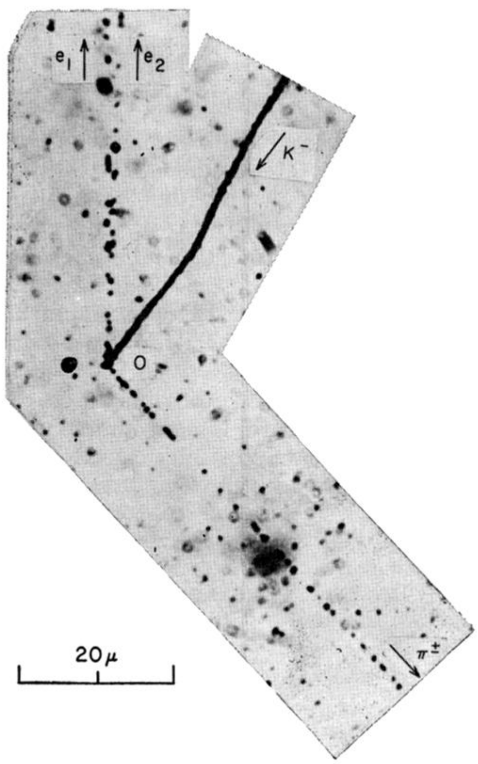

FIG. 1. Photomicrograph of the event.