either helium or carbon polarization data should be viewed as exemplifications of that part of the nucleon-nucleon scattering that involves no change in spin state of the target nucleons.

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Energetic Disintegration of a Heavy Nuclear Fragment*

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SEVERAL events[1–11] have been observed in photographic emulsion where a nuclear fragment stopped and subsequently disintegrated. In some of these events a π meson was emitted, while in other events, only nuclear particles were observed. The energy release from the disintegration of the nuclear fragment has been measured quite accurately in a few cases[6,7,9] and found to be consistent with the assumption that a Λ^0 particle was loosely bound in the nuclear fragment.

An energetic disintegration of a nuclear fragment was found in a 1000-micron glass-backed plate which had been exposed to cosmic rays in a sky-hook balloon flight. A photograph of the event is shown in Fig. 1. The primary star is of the type $(22+9p)$. The track of the nuclear fragment F, is 192 microns long. The thindown along the track F and the multiple scattering near the end of the track show that the fragment stopped before producing the secondary star. From a comparison of the thindown characteristics along track F with other tracks of known Z, the charge of the fragment is found to be greater than $2e$ and definitely less than $5e$. The secondary star has four prongs. The characteristics of the tracks from the secondary star are given in Table I.

If track 4 is assumed to be a π meson, the residual momentum of the charged particles from the secondary star is 342 Mev/c; if track 4 is assumed to be a proton, the residual momentum is 680 Mev/c. If the residual momentum is carried away by two neutrons traveling together in the direction to conserve the residual momentum, the energy of the two neutrons is found to be 28 Mev if track 4 is assumed to be a π meson, and 116 Mev if track 4 is assumed to be a proton. If track 4 is ascribed to a π meson, the minimum energy release from the secondary star is $2.7+14+20+(45-18)+28 \cong 92$ Mev. If track 4 is due to a proton, the minimum

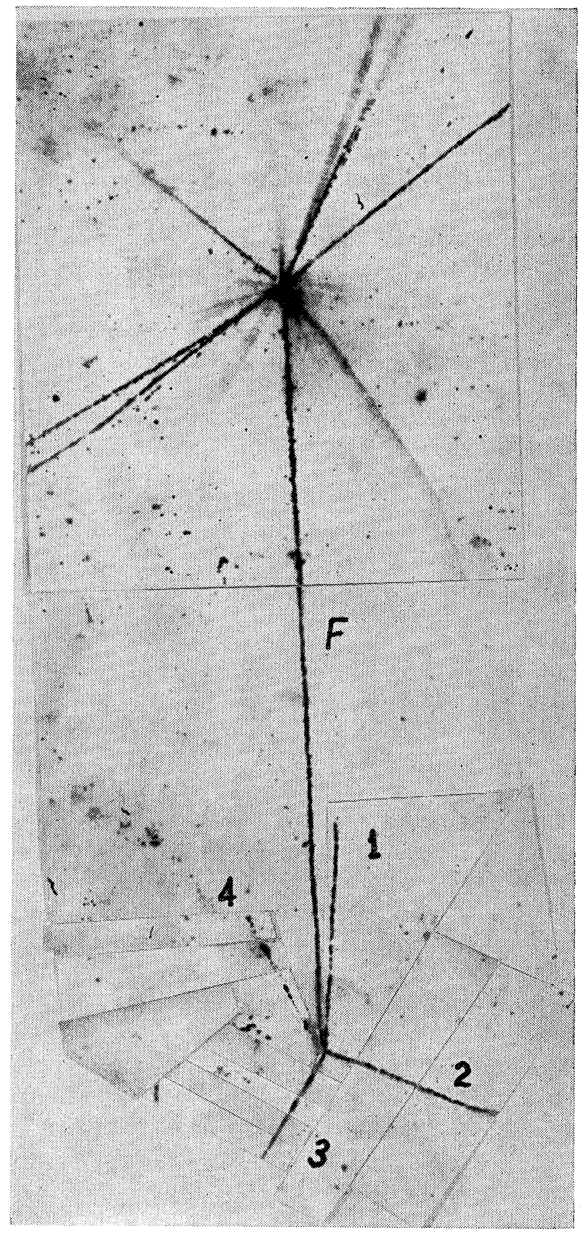

Fig. 1. A nuclear fragment F from a cosmic-ray star stops in the emulsion and produces a secondary star which has four prongs. Tracks 1 and 3 were produced by a proton or deuteron or triton; and track 2 by an α particle. Track 4 is most likely due to a negative π meson. (Observer: J. Slowey.)

energy release is $2.7+14+20+(300-125)+116 \cong 328$ Mev. If only one neutron was emitted from the star, the total energy of the secondary star would be greater than the above estimates. If it is assumed that more than two neutrons were ejected, the total estimated energy is not appreciably decreased. If track 4 is assumed to be a proton, the Z of the fragment would have to be 5 which is inconsistent with the observations, therefore it seems reasonable to assume that it was produced by a negative π meson and that the energy release from the secondary star is about $2.7+14+20+45+28 \cong 110$ Mev. Of course the energy could be considerably larger because two neutrons were assumed to be emitted in the same direction.

In any case the energy release is much greater than the expected value from the decay of a Λ^0 particle bound in the nuclear fragment (37 Mev for the mesonic decay and 176 Mev for the nonmesonic decay).

TABLE I. Characteristics of tracks from the secondary star.

Track	Range microns	Ionization	Identity	Energy in Mev
1	62	black	p,d,t	2.7 if p
2	109	black	α	14
3	>2000[a]	black	p,d,t	$20<E<24$ if p
4	>300[b]	gray	π or p	45 ± 18 if π 300 ± 125 if p

[a] The track left the emulsion after a range of 2000 microns. The total range is estimated to be less than 2500 microns.
[b] The track dips steeply and leaves the emulsion after 300 microns. The energy was determined from a comparison of the blob density along track 4 with minimum ionizing tracks of the same dip. The blob density is 1.5 ± 0.12 times minimum. The track is too straight for an electron with the observed ionization.

The high-energy release may be explained by assuming that a hyperon other than a Λ^0 was bound in the nuclear fragment. The decay energy from a bound[12] Y^+ would be about 117 Mev.[13] The observed energy release is somewhat higher than would be expected from a bound cascade hyperon $Y^-(Q_{Y^-} \cong 67$ Mev).[14] It is also possible that a θ^0 was bound in the fragment and decayed with the absorption of one of the π mesons. The expected decay energy is 360 Mev if only one π meson is emitted.[15] The possibility can not be excluded that a negative K meson was bound in a mesonic orbit around the fragment and absorbed after the fragment stopped.

The one unusual disintegration was found among 7000 cosmic-ray stars and 15 000 stars produced by 3-Bev protons. Among these stars 15 additional cases of the disintegration of a nuclear fragment have been observed which are consistent with the interpretation of a bound Λ^0 particle.

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Neutron-Proton Mass Difference*

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It has recently been suggested[1] that the nucleon may be treated as a structured system having varying numbers of pions in bound states centered on a core particle of spin and isotopic spin $\frac{1}{2}$. An interesting question concerning this model is whether or not it is capable of accounting for the sign and order of magnitude of the neutron-proton mass difference on the basis of electromagnetic interactions alone.[2] The purpose of this note is to point out that the model does indeed account for the mass difference. Furthermore, its success in this respect depends directly on those peculiar features of the nucleon wave function that were found necessary[1] to account for the nucleon magnetic moments. The peculiarities are as follows:

(1) The total probability that pions occur with a total orbital angular momentum $L=1$ is small, of the order of 10 percent.

(2) The probability that a pair of pions occurs in the $L=1$ state is rather large, comparable to or possibly greater than the probability for the occurrence of a single pion (which must have $L=1$).

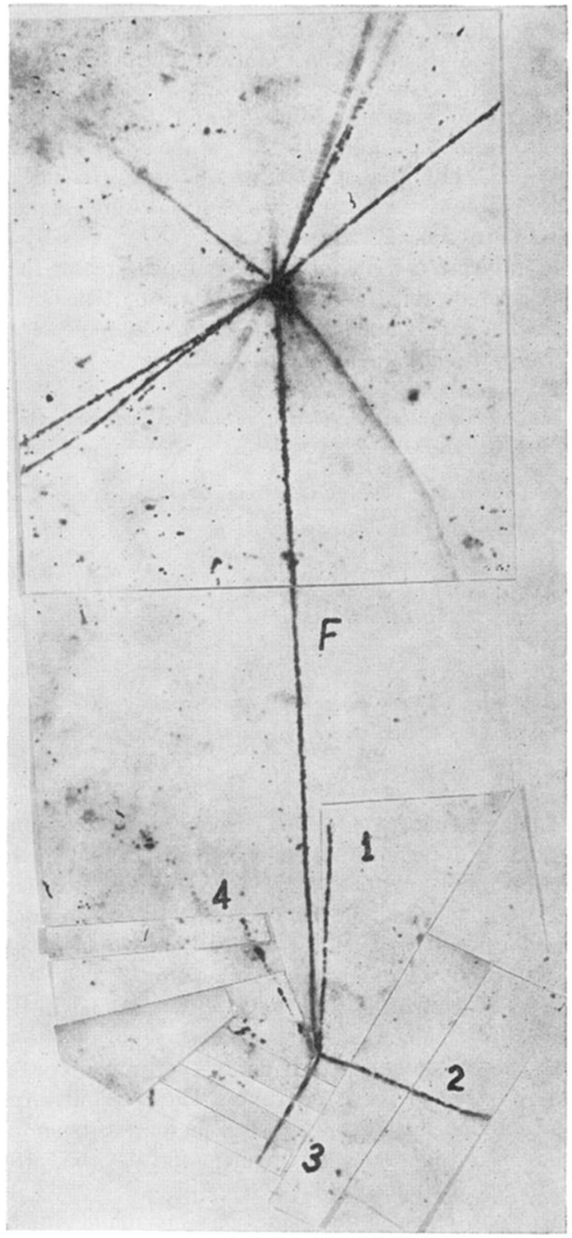

FIG. 1. A nuclear fragment F from a cosmic-ray star stops in the emulsion and produces a secondary star which has four prongs. Tracks 1 and 3 were produced by a proton or deuteron or triton; and track 2 by an α particle. Track 4 is most likely due to a negative π meson. (Observer: J. Slowey.)