PHYSICAL REVIEW VOLUME 102, NUMBER 2 APRIL 15, 1956

Interaction of 750-Mev π^- Mesons with Emulsion Nuclei*

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(Received August 24, 1955)

Interactions of 750-Mev π^- mesons with emulsion nuclei have been investigated. In scanning along 133 meters of meson track, several interactions with free protons and protons and neutrons at the edges of nuclei have been found; these events are discussed. The angular distribution of elastic $\pi^- - p$ and $\pi^- - n$ scattering is peaked in the forward direction. About 40% of all scatterings are inelastic with production of mesons.

Characteristics of stars induced by 750-Mev π^- mesons are discussed; in particular, the relatively high frequency of stable and excited fragments in these stars seems to suggest that fragments can be emitted by direct meson interaction.

INTRODUCTION

The interactions of 750-Mev negative π mesons with emulsion nuclei have been studied. Circumstances made it impossible to accumulate as extensive data as originally planned, but it is thought that in the absence of detailed investigations of differential scattering for this energy range the information obtained may be of some value. There is also presented some evidence of characteristics of meson stars which may make their identification easier when scattering measurements cannot be made.

EXPOSURE

G-5 stripped emulsions, 400 microns thick and 2×3 inches wide, have been exposed to 750-Mev negative π mesons from the Brookhaven Cosmotron.

The pions were selected by an analyzing magnet from secondary particles emitted from a beryllium target at 32 degrees to the direction of the proton beam. The emulsions were placed with the 3-inch side parallel to the pion beam which had an angular spread of ±4 degrees. The contamination by fast electrons and μ-mesons has been found to be 6–7%.[1]

SEARCH AND MEASUREMENTS

About 133 meters of meson track have been followed under 1500× magnification, and the interactions found within this path have been registered. In addition, about 6 cc of emulsion have been scanned with lower magnification and 500 π-meson interactions have been found in this volume. The nature of the secondary particles has been determined (1) by grain count, (2) by scattering, wherever the length and dip angle of the track made this procedure meaningful, and (3) by considerations based on the kinematics of meson scattering and meson production.

EVENTS FOUND IN SCANNING ALONG MESON TRACKS

132.8 meters of meson track have been scanned under high magnification and 322 events have been found. Subtracting from the path length 6.5±0.5% for probable μ-meson contamination, the mean free path in the emulsion becomes 38.5±2.2 cm, while the geometric mean free path ($r_0 = 1.38\times 10^{-13}$ cm) is 27 cm.

This mean free path is in fair agreement with a value expected from the $\pi^- - p$ cross section of 42 mb and $\pi^- - n$ cross section of 17.5 mb found by Lindenbaum and Yuan[1] in the same energy interval. Accepting these cross sections and integrating over the emulsion nuclei (number of neutrons $= 1.2\times$ number of protons) leads to a mean free path of 34.7 cm.

TYPE OF EVENTS FOUND

The events found in scanning along meson tracks can be divided in the following groups:

(1)	$\pi^- + p \rightarrow \pi^- + p$	5 events (coplanarity established within 3°).
(1a)	$\pi^- + p \rightarrow \pi^- + p$	6 events (coplanarity established within 4°–12°).
(2)	$\pi^- + p \rightarrow \pi^- + \pi^+ + n$	8 events.
(3)	$\pi^- + p \rightarrow \pi^- + \pi^0 + p$	5 events.
(4)	$\pi^- + p \rightarrow n + \pi^0$ or $n + \pi^0 + \pi^0$.	17 events.
(5)	$\pi^- + n \rightarrow \pi^- + \pi^- + p$	1 event.
(6)	$\pi^- + n \rightarrow \pi^- + n$ or $\pi^- + \pi^0 + n$	15 events (scattering angle $\geqslant 10°$).
(7)	Stoppings with recoil or blob	16 events.
(8)	Scattering of mesons with recoil or blob	17 events.
(9)	232 stars ($\geqslant 1$ prong).	

In the same path length, 87 π^--meson scatterings with angles <10° (without recoil or electron emission)

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* Work performed under the auspices of the U. S. Atomic Energy Commission.

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[1] We are indebted to Dr. L. C. L. Yuan and Dr. S. J. Lindenbaum for this information based on absorption measurements with counters. See also S. J. Lindenbaum and L. C. L. Yuan, Phys. Rev. **100**, 306 (1955).

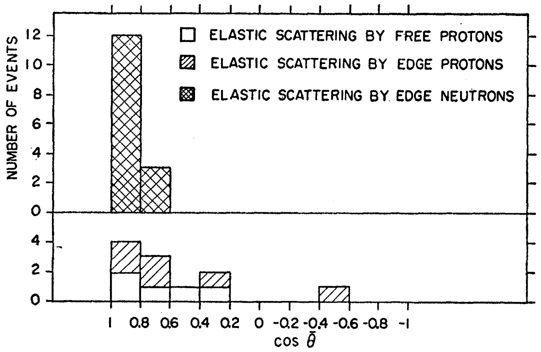

FIG. 1. Angular distribution (c.m. system) of π^- mesons scattered elastically by free protons and by protons and neutrons on the periphery of nuclei.

have been observed. These events probably represent diffraction scatterings on emulsion nuclei. The mean free path for diffraction scattering based on these 87 events is about 1.4 meters. However, the efficiency in the search for these small-angle scatterings was probably low, since most of the observed scattering angles are $\geqslant 2°$.

(1) and (1a). Elastic Scattering by Protons (without Charge Exchange)

The scattering angles of the 5 elastic scattering events (those in which coplanarity was established) are given in the histogram of Fig. 1 (blank boxes); the 6 near-elastic scatterings (shaded boxes in Fig. 1)[2] have probably occurred on bound protons. In two of these cases the dip angles of the emitted tracks are steep, so that the observed deviation from coplanarity may not be real but due to measuring errors. The number of observed events is too small to make any statement as to the angular distribution of scattered mesons, other than the preference for forward scattering in the center-of-mass system (10:1).

The mean free path for elastic $\pi^- + p$ scattering, based only on the 5 events under (1) is $24.8 + 11.4$ meters, while the mean free path for all $\pi^- + p$ interactions (cross section 42 mb) is expected to be 7 meters; the elastic cross section without charge exchange is 12 ± 5.4 mb or about one third of the total cross section. If one assumes the relation

$$(\pi^- + p \rightarrow \pi^- + p)/(\pi^- + p \rightarrow n + \pi^0)$$
$$= 5/4 \text{ (equal weight for state } \tfrac{3}{2} \text{ and } \tfrac{1}{2}),$$

then about 60 percent of all interactions with protons should be elastic.

(2) and (3). Inelastic Scattering with Meson Production

In elastic scattering events it is possible to determine on the basis of coplanarity whether the event occurred on a bound or free proton. In inelastic scattering it is possible to make this distinction only if the momenta of the particles are known accurately. In most of the events described in the following section, the momentum of only one of the emitted particles could be determined within 10%. The events may thus have occurred on either bound or free protons. The absence of evaporation tracks or other visible evidence of nuclear interaction would indicate that the proton, if bound, is probably on the periphery of the nucleus.

Fifteen events were observed in which two mesons, or one meson and one proton, were emitted with no other track or recoil visible. Energy and momentum analysis show that 13 of these 15 events can be classified as inelastic scattering by free protons or by protons at the edge of the nucleus. In all, nine cases of the type $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ were found; in addition to the eight found in scanning along meson tracks, one case was picked up by tracing a $\pi - \mu - e$ decay to its origin. In this case the positive meson was emitted in the backward direction and was slower than the negative meson. In the other eight cases none of the mesons came to rest in the stack, so that the sign of the charge could not be determined. In six of these cases one of the mesons, probably the negative one, is much faster than the other and is projected in the forward direction. In two cases the momenta of the two mesons are nearly equal.

In 4 of the 5 cases of π^0 production, $\pi^- + p \rightarrow \pi^- + \pi^0 + p$, the π^0 meson is faster and is more strongly directed forward than the π^- meson.

When the momenta and angular distribution of nucleons and mesons in π^0 and π^+ production are compared, no difference could be found within the limits set by the small number of cases. Therefore, in the histograms of Figs. 2 and 3, both are included. The shaded box in each of the histograms represents a case of $\pi^- + n \rightarrow p + \pi^- + \pi^-$ which will be mentioned later. The mean value of the nucleon momentum is 275 Mev/c; for the faster meson the mean value is 345 Mev/c, and for the slower meson 182 Mev/c.

Figure 2 gives the angular distribution (in the center-of-mass system) (a) of nucleons, (b) of fast mesons, and (c) of slow mesons.

In the angular distribution of nucleons the backward direction is the preferred one (12:3), and in the angular distribution of fast mesons the forward direction is preferred.

Figure 3(a) shows the distribution of the angle between the two mesons in the c.m. system; the mean angle is 132°; (b) gives the angle between the nucleon and the faster meson, and (c) between the nucleon and the slower meson. There seems to be a slight indication of an angular correlation between the nucleon and the slower meson. Under the assumption that this correlation is connected with an excited nucleon state, decaying into nucleon and (slower) meson, the Q-values of this "excited state" have been calculated. The Q-values are

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[2] The meaning of the cross-hatched squares in the same figure will be discussed later.

spread over an energy interval of 30–170 Mev, and there is, at least within the small statistics, no indication of a maximum value.

(4) and (7). Charge-Exchange Scattering and Possible $\pi^-+p\rightarrow\pi^0+\pi^0+n$ Reaction

Two events have been found with only one electron pair and no additional track. In the first event, two light tracks emerge at an angle of $4\frac{1}{2}$° and $\frac{1}{2}$°, respectively, from the incoming meson track. One track can be identified as that of an electron of energy 22±2 Mev, while the other track is either that of an electron of 200^{+30}_{-20} Mev, or of a meson of 150±25 Mev. The grain count in this track is 1.08±0.05 compared with 1.00±0.04 for the incoming meson track. This and the fact that no decay electron of 22 Mev is known, speaks for the assumption that both tracks are those of electrons. The angle of the pair is 5 degrees and the resultant makes an angle of $1\frac{1}{2}$° with the incoming meson. In the second event, the slower particle is an electron of 130^{+50}_{-20} Mev; its track has a grain count of 1.04±0.4, and makes an angle of 5° with the incoming meson track. The faster particle leaves at an angle of $1\frac{1}{2}$°; from similar considerations to those given before, it is very probable that this track is that of an electron and that the energy is 350^{+70}_{-20} Mev. The angle of the pair is $6\frac{1}{2}$° and the resultant makes an angle of $2\frac{1}{2}$° with the incoming meson. In both events the asymmetry in the energy of the electrons and the pair angle are unexpectedly large.

From energy and momentum considerations, the second event can be explained as charge-exchange scattering with direct pair production; the scattering occurs on a free or edge proton and the angle of emission of the π^0 is between 8 and 14 degrees. The maximum lifetime of the π^0 is $(2.8\pm0.2)\times10^{-15}$ sec, estimated from the separation of the last grain of the incoming meson and the first grain of the pair.

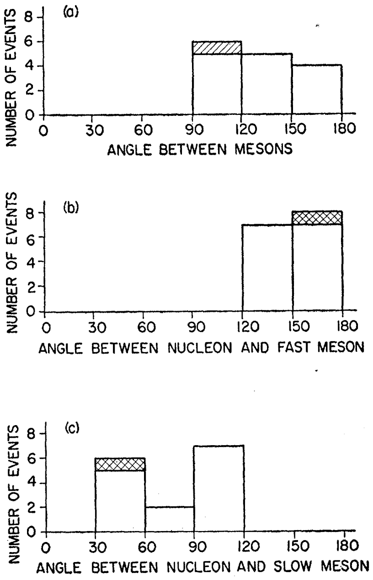

FIG. 3. Distribution of angles between π^- mesons and of angles between nucleons and π^- mesons and nucleons (c.m. system) in collisions with meson production.

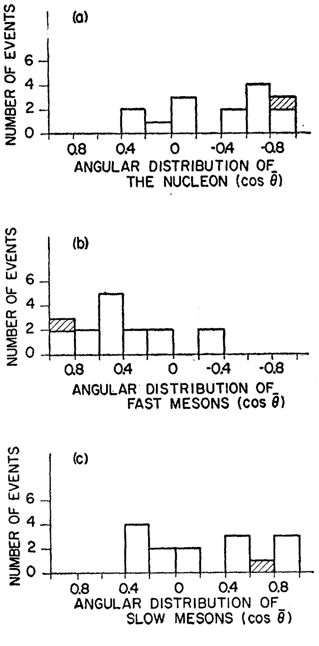

FIG. 2. Angular distribution (c.m. system) of nucleons and π^- mesons in collisions with meson production.

The first event represents with great probability direct pair production in an event of type $\pi^-+p-n+\pi^0+\pi^0$. The assumption of elastic scattering with charge exchange would lead to a π^0 emitted in the backward direction (c.m. system).

Thirty-one events have been found in which the meson stops in the emulsion. Sixteen of these events show small recoils, or blobs, or electron interactions.

In 15 events no nuclear interaction is visible and these may represent $\pi^-+p-n+\pi^0$ and $\pi^-+p-n+\pi^0+\pi^0$ reactions; however, it is not excluded that some cases may represent interactions with nuclei (protons in the interior of the nucleus) leading to neutron emission only. The number of stoppings observed (15), plus the 2 cases with electron pairs, is unexpectedly high in comparison with the cases leading to charged meson production, even within the meager statistics.[3]

(5), (6), and (8). Interaction of π^- Mesons with Neutrons (Periphery of the Nucleus)

Fifteen events of meson scattering through angles $\geqslant 10$ degrees without visible nuclear interaction have been found, while in 17 other cases meson scattering is accompanied by recoils or slow-electron emission.

The first 15 events may represent elastic scattering on peripheral neutrons or scattering with π^0 production; however, it is not excluded that in some of these events the scattering occurred on protons in nuclei where the emission of the slow proton has been suppressed by the exclusion principle. The scattering angles (c.m. system)

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[3] A high percentage of stoppings has been reported for 1.5-Mev negative pions by W. D. Walker and J. Crussard, Phys. Rev. **98**, 1416 (1955).

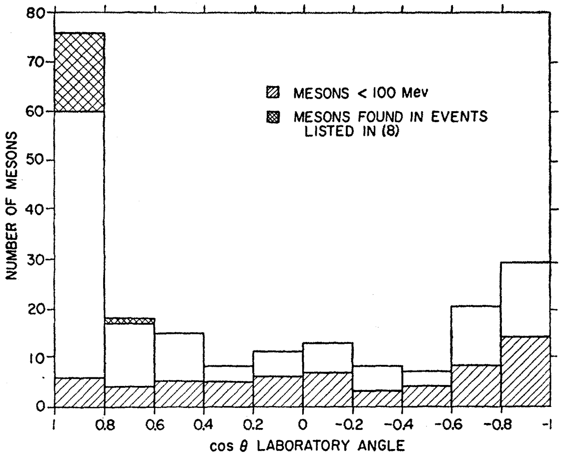

FIG. 4. Angular distribution (laboratory system) of π^- mesons scattered in nuclei.

in these 15 cases are plotted in Fig. 1 as cross-hatched boxes, under the assumption that they are elastic scatterings.

One case of $\pi^- + n \rightarrow p + \pi^- + \pi^-$ has been observed; the angles of the emitted mesons, the angle of the proton, and the angles between the particles (c.m. system) are plotted in Figs. 2 and 3 (cross-hatched boxes).

The 17 events of type (8), in which meson scattering is accompanied by recoils or slow-electron emission, are plotted in Fig. 4 (cross-hatched boxes).

The total number of $\pi^- + p$ collisions is 41, taking 11 [groups 1 and 1(a)] as the number of elastic scatterings observed. The mean free path in the emulsion is 3 ± 0.5 meters or about one-half of the mean free path for π^- collisions on free protons, calculated with a cross section of 42 mb. Therefore, one-half of all observed collisions must have occurred on bound protons on the periphery of nuclei.

We find the ratio

$$\frac{\pi^- + p \rightarrow \pi^- + p}{(\pi^- + p \rightarrow \pi^0 + \pi^- + p) + (\pi^- + p \rightarrow \pi^+ + \pi^- + n)} = \frac{11}{13}.$$

Judging from this ratio and assuming again equal weights for the $\frac{3}{2}$ and $\frac{1}{2}$ state in Fermi's theory, 44% of all $\pi^- + p$ collision are inelastic; however, the above ratio is possibly an underestimate, since as mentioned before, some of the events listed in (6) may actually be scatterings by peripheral protons. The value 44% is in good agreement with the value 40% for the percentage of inelastic scatterings, derived from the ratio of elastic to total $\pi^- + p$ scattering [60%, as discussed in the section dealing with groups 1 and 1(a)].

Finally, the ratio of $\pi^- + p$ to $\pi^- + n$ scatterings (considering in both cases events without evaporation tracks or recoils) is $41:16 = 2.6$, while the ratio of the cross sections for $\pi^- + p$ to $\pi^- + n$ interactions found in this energy interval by Lindenbaum and Yuan is $42:17.5 = 2.4$.[1] Because of the reasons mentioned, this good agreement may be only coincidental.

SUMMARY OF $\pi^- - p$ AND $\pi^- - n$ SCATTERINGS

About 40% of all $\pi^- - p$ collisions are inelastic, leading to meson production. The angular distribution in elastic $\pi^- - p$ and $\pi^- - n$ collisions is strongly peaked in the forward direction. The number of observed stoppings of mesons, interpreted as charge exchange scattering and production of π^0 mesons, is unexpectedly high.

In inelastic collisions with meson production, the nucleon is predominantly scattered in the backward direction. There seems to exist a slight angular correlation between the nucleon and the slower backward-scattered meson.

INTERACTION OF π^- MESONS WITH NUCLEI

In addition to 266 nuclear events (233 stars, 17 meson scatterings with recoils or electron interactions, plus 16 stoppings with recoils or electron interactions), 500 stars have been found in area-scanning.

The stars have been analyzed especially with respect to mesons leaving the nucleus. (40 ± 4)% of all stars have 1 emitted meson and only (3 ± 1)% have two emitted mesons.[4] These values are very similar to those obtained in the case of stars induced with 500-Mev π^- mesons.[5] The fact that no increase in emitted mesons is observed can be explained by the higher interaction cross section of 750-Mev mesons and by an increased meson production leading to mesons in an energy interval of 100–300 Mev which have a small mean free path in nuclear matter.

The angular distribution (lab system) is given in Fig. 4; the shaded boxes in the histogram refer to π^- mesons below 100 Mev and the cross-hatched boxes to events without evaporation prongs but with recoils or slow electrons. Forward emission of mesons in 750-Mev pion-induced stars is more pronounced than in the case of 500 Mev. Here the ratio of forward to backward mesons is nearly 1.7:1, while this ratio is 1.2:1 in the case of 500-Mev mesons. This may be due partly to the increased center-of-mass motion—$\bar{\beta} = 0.48$ for 750-Mev and 0.40 for 500-Mev pions—but it mainly reflects the increased forward scattering in meson-nucleon collisions.

STAR SIZE

In this section, some data on star size and prong distribution are collected in order to obtain information on the energy dissipation of mesons in nuclei. If the π^- meson is completely absorbed, the total excitation energy is nearly 900 Mev; and in heavy elements (which are responsible for about 80% of all stars), stars with 9–15 prongs would be expected.

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[4] These values have been obtained by grain count and scattering measurements and by considerations based on the kinematics of the interaction process. Tracks with minimum grain density are assumed to be those of mesons, since the maximum kinetic energy of protons in the extreme forward direction is 750 Mev.

[5] M. Blau and M. Caulton, Phys. Rev. 96, 150 (1954).

On the other hand, it can be anticipated that stars with fast forward-scattered mesons are small, consisting of a few short prongs in light elements and 1–2 prongs in heavy elements. One would also expect small stars without any charged mesons, corresponding to charge-exchange scattering. However, less than 20% of all first encounters with a nucleon within the nucleus should lead to charge-exchange scattering, and only in a fraction of these encounters will the neutral meson leave the nucleus without further interaction.

As already mentioned, about 60% of all stars have no charged meson; 62% of these mesonless stars have no fast proton $\geqslant 60$ Mev and a mean prong number of only 4 ± 0.4. Only 2% have prong number $\geqslant 9$.

The small mean prong number in these stars suggests that a great amount of energy is carried away by fast neutral particles for which the nucleus is rather transparent. While the number of fast neutron recoils in scattering processes should be only slightly higher than the number of fast protons, additional fast neutrons are produced in the absorption process of π^- mesons in proton-neutron pairs.

Five pairs of protons with angular separation $\geqslant 130°$, whose energies are greater than 70 Mev (up to 140 Mev) have been found. These pairs are probably created in the absorption of positive mesons (meson production and reabsorption) and indicate that energy freed in meson absorption can be considerably higher than the rest mass of the meson. Furthermore, in explaining the small size of mesonless stars, one has to consider collisions resulting in production of neutral mesons; since the neutral meson is probably faster than the charged meson,[6] its probability of escaping absorption will be greater. The star size in this case is then mostly determined by the absorption of a slow meson of around 200 Mev.

Finally, the great number of observed π^--meson stoppings raises the question of a possibly greater proportion of collisions leading to charge exchange than is calculated with the Fermi statistical theory.

PRONG DISTRIBUTION (STARS WITH AND WITHOUT EMITTED MESONS)

The appearance of π^--meson stars (750 Mev) is quite different from that of stars initiated by fast nucleons; in meson stars, contrary to the case for nucleon stars, more than 1 minimum track in the forward direction is seldom observed and the nucleon cascade in the forward direction (light and dark gray tracks), characteristic for stars produced by fast nucleons, is absent. These facts are easily understandable in view of the kinematics of meson-nucleon scattering and meson-meson production. Fast nucleons causing cascades in the extreme forward direction would require backward scattering of mesons, infrequent at this energy.

Because of the absence of a forward cascade, an isotropic prong distribution in meson stars should be expected. However, there is a distinct anisotropy, manifesting itself in bunching of black and dark gray tracks at angles between 45° and 135°. The small cascades (2–5 prongs) are predominantly present in stars where only slow mesons, or none, are emitted.

In order to establish that these "bunches of tracks" are not chance coincidences in a random distribution, the angular separation of neighboring tracks (projected angle) and the number of tracks in certain angular intervals have been investigated in stars of 6, 7, and 8 prongs; it has been found that the observed angular correlation is beyond statistical fluctuations.[7]

The observed irregularity in prong distribution can be due at least in part to small cascades originating from fast nucleons accelerated in meson scattering or meson absorption, but probably most of these cascades originate from excited nucleon complexes disintegrating in flight.

Evidence supporting this assumption is as follows: (1) Fragments $Z\geqslant 3$ emitted in these stars have a relatively high frequency. (2) There occur cases of neighboring tracks with nearly equal velocity. A few of these cases could be analyzed: 4 cases of Be^8 decaying into two α particles from the ground level, 1 case of Li^6 decaying into He^4+d from the 2.2-Mev level, 1 case of a Li^7 nucleus decaying into $\alpha+t$ from the 4.6-Mev level, one highly excited a particle decaying into proton +triton and finally B^9 decaying from the 2.4-Mev level into $\alpha+\alpha+p$. (3) Tracks are observed originating from a common stem $(5-46\mu)$ and separating later; here the particles (2-4 in number) after separating do not have equal velocity. Some of these cases may be splittings after collision with emulsion nuclei, although this would presume a very short collision path.

STABLE FRAGMENTS IN π^--MESON STARS

Emission of stable and excited fragments $(Z\geqslant 3)$ is a common feature in large cosmic-ray stars, but it is unexpected in relatively small stars as observed in this experiment.

The energy distribution and angular distribution of fragments in cosmic-ray stars have been investigated by Perkins[8] and other authors.[9] Perkins found that the number of fragments emitted from stars increases rapidly with star size or nuclear temperature.

For cosmic-ray stars with 8–13 prongs (the smallest star size investigated) Perkins found 5 fragments in 58

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[6] Compare the data on π^0 production in $\pi^-+p\rightarrow\pi^-+\pi^0+p$ events.

[7] As an example, the frequency of 3 tracks within an angular interval of 10° has been investigated. According to the χ^2 test, the observed frequency has only a probability of 0.1% of being found in a random distribution.

[8] D. H. Perkins, Proc. Roy. Soc. (London) **203**, 399 (1950).

[9] P. E. Hodgson and D. H. Perkins, Nature **163**, 439 (1949); A. Bonelli and C. Dillworth, Phil. Mag. **40**, 947 (1949); T. Crussard, Bombay Conference on Fundamental Particles, 1950 (unpublished); S. O. C. Sorensen, Phil. Mag. **40**, 947 (1949); **42**, 188 (1951).

stars, considering only fragments with range $\geqslant 30$ microns and dip angle $\leqslant 30°$.

With 750-Mev π^- mesons, 16 fragments (range $r \geqslant 30\mu$, dip angle $\leqslant 30°$) have been found in 249 stars with prong numbers $\geqslant 5$; only 14% of these stars have more than 8 prongs. The percentage of stars with fragments is therefore not essentially smaller in spite of smaller star size and presumably lower nuclear temperature.

The frequency of fragments with $r \geqslant 30\mu$ in stars produced by nucleons with energies of 300–400 Mev (where meson production is still infrequent) is much smaller, about 0.75%.

The fragments are emitted in the near forward direction. However, there are also fragments around 90°. The latter are probably fission fragments and frequently of energies below 4 Mev/nucleon. In one star, 2 fragments in opposite directions around 90° have been observed.

Five fragments in the near forward direction definitely have energies >4 Mev/nucleon and therefore have been accelerated by forces other than Coulomb repulsion.

Fast fragments are also emitted in small stars with less than 5 prongs. A fragment ($Z=3$) with 360-μ range is emitted at 54° in a 1-prong star, and from another star with 1 dark and 1 gray prong a fragment emerges with $Z=4$ or 5 and 240-μ range in a direction at 74° to the incoming meson.

The emission of fast fragments is a process not fully understood and several hypotheses have been proposed.

The relatively high frequency of fragments in small-size stars, observed here, seems to indicate a direct connection between fragment emission and meson interaction.

The fact that fragments (stable and unstable) originate predominantly in stars without mesons, or with slow emitted mesons, suggests more specifically a connection with the absorption process of mesons taking place in an nucleon complex within the nucleus. If all fragments were the result of surface oscillations in highly excited nuclei, they should not be found in the small stars reported here. Also, if all fragments were knock-ons in nucleon cascades, more fragments should be found in stars produced by nucleons of 300–400 Mev than in the case of 750-Mev mesons, because in the former case the nuclear path is longer and secondary nucleons will be more frequent and more energetic than in the meson case where first collisions lead predominantly to forward-scattered mesons and, therefore, slower nucleons.

FAST ALPHA PARTICLES

In connection with fragments for which $Z \geqslant 3$, the relative abundance of fast α particles in π^--meson stars should be mentioned. 4% of all stars have α particles with energies $\geqslant 50$ Mev; most of these fast α particles come from stars without mesons or with slow emitted mesons. In one case with an α particle of 180 Mev emitted at 15°, a slow meson of 50 Mev is emitted in the backward direction. This case and possibly others as well may be explained as elastic scattering of the incoming π^- meson by an α complex within the nucleus; the scattered meson leaves the nucleus after having lost energy in further collisions.

SEARCH FOR HEAVY MESONS, HYPERONS AND BOUND HYPERONS

About 500 π^--meson stars have been inspected for emission of heavy mesons and secondary stars caused by the disintegration of bound hyperons, but none have been found. 40 π^- mesons have been followed to their origin, but no Λ^0 has been found. If one takes into account the Fermi energy, associated production of K-mesons and Λ^0 particles should be just possible at an energy of 750 Mev. The number of stars investigated is not large enough to decide if the absence of Λ^0's is proof of no single Λ^0 production.

CONCLUSIONS

In the interaction of 750-Mev negative π mesons with nuclei, a large percentage of the mesons—about 40%—is completely absorbed. The absorption process probably takes place by repeated scattering and meson production and reabsorption. The small mean prong number of mesonless stars suggests that part of the energy is spent in emission of fast neutral particles.

In π^--meson stars, angular correlations between tracks and emission of fast α particles and stable and excited fragments are observed. These phenomena commonly are observed only in large stars induced by high-energy meson-producing nucleons. Therefore, it is tempting to assume that these phenomena are connected with direct meson interaction and that meson interaction and meson absorption involves in some way nuclear substructures within the nucleus.

Mesons escaping absorption are preferentially emitted in the forward direction, the ratio of mesons emitted forward to those emitted backward (laboratory system) being 1.8.

ACKNOWLEDGMENTS

In the earlier part of this work Dr. M. Caulton assisted greatly in scanning along meson tracks and in performing scattering measurements, and the authors are indebted to him.

We wish to thank especially Mrs. E. Medd for her competent help in scanning and grain counting.