harmonic term in $(P\sigma)_{p\text{-}n}$ are both consequences of the special assumptions (b) and (c) mentioned above. If the requirement (3°) and the assumption that ^3S and ^3D do not mix are dropped, then the missing second and fourth harmonic terms will appear (the former arising from interference effects between the $^3S(Y_0^0)$ and $^3D(Y_2^{\pm1})$ partial waves, the latter from interference between different ^3D partial waves). Thus, it may be possible to fit the data of Figs. 2 and 3 of the preceding letter and also the ordinary *n-p* and *p-p* differential cross sections (for unpolarized protons) by using the most general set of phase shifts consistent with $L\leq 2$, together with a single ^3F phase shift [to give the sin 4θ term in $(P\sigma)_{p\text{-}p}$].

The number of parameters available in this scheme is 13 (12 real phase shifts plus one real "mixing parameter" for the $J=1$; $L=0$, 2 part of the scattering matrix[4]), while a Fourier analysis of the data will provide 18 Fourier coefficients—2 from $(P\sigma)_{p\text{-}p}$, 5 from $(P\sigma)_{p\text{-}n}$, and 4 and 7 from the unpolarized *p-p* and *n-p* cross sections, respectively). Of course, even aside from the experimental uncertainties in these Fourier coefficients, it is not likely that a unique set of phase shifts can be found, for as can be seen from Eqs. (2) and (5), the Fourier coefficients are by no means single-valued functions of the phase shifts. Calculations aimed at finding a set of phase shifts consistent with the present knowledge of the cross sections are now in progress.

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π-Meson Production in π-Nucleon Collisions at 1.5 Bev*

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As has been pointed out previously,[1] most π^--p collisions at 1.5 Bev lead to the production of a single additional π meson. Since the last note more data have been obtained. (About 150 π^--p interactions have been examined.) In particular, the reaction

$$\pi^-+p\rightarrow\pi^++\pi^-+n$$

shows characteristics very similar to those of the production of a single π^0. The neutron usually goes backward in the center-of-mass system with an average momentum of 500 Mev/*c*. The π^+ and π^- emerge from the reaction with an average angle of 135° between them in the c.m. system. The angular distribution of the $\pi^++\pi^-$ is very similar to the angular distribution of the $\pi^-+\pi^0$ from the reaction $\pi^-+p\rightarrow\pi^-+\pi^0+p$.

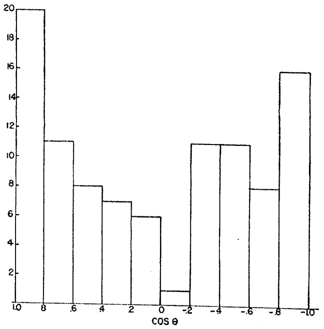

Fig. 1. Angular distribution in the c.m. system of all the π's from the reactions $\pi^-+p\rightarrow\pi^-+p+\pi^0$ and $\pi^-+p\rightarrow\pi^-+n+\pi^+$.

The center-of-mass angular distribution of all the mesons from the above two reactions is given in Fig. 1. There is evidence of peaks in the forward and backward direction in the c.m. system. The forward peak contains mostly fast mesons, and the backward peak relatively slower mesons in the c.m. system, as shown by Fig. 2 which gives the angular distributions of mesons of

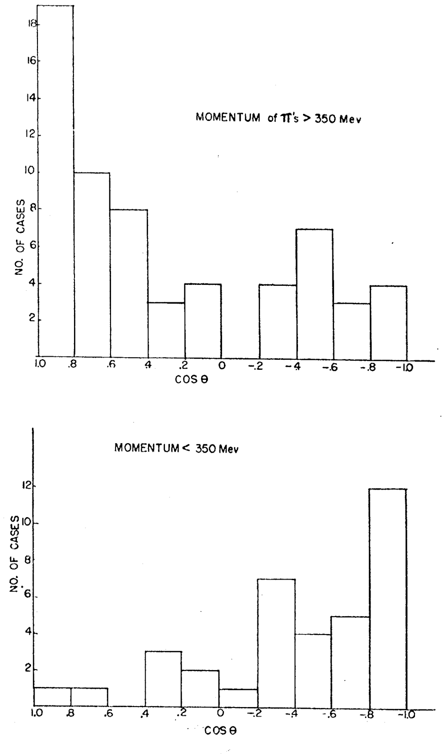

Fig. 2. Angular distributions of mesons of momenta greater than and less than 350 Mev/*c* in the c.m. system.

momenta greater than and less than 350 Mev/c in the c.m. system. These results suggest that the high-energy meson is the primary meson which sometimes suffers relatively small momentum transfers, while the lower-energy meson is the secondary meson which is usually radiated into the backward hemisphere. If the slower meson is the secondary meson, then these results would be consistent with the results of Yuan[2] and Lindenbaum on the spectrum of π's produced in p-nucleon collisions. In almost 50 percent of the cases of π^0 production, the π^0 is the fast meson; thus it is necessary in this picture that the primary meson have a considerable chance of making a charge exchange in the course of the collision with the nucleon.

In the course of scanning for the hydrogenic interactions, a considerable number of events have been found which appear to be π^- n interactions occurring on the edge of a nucleus.

The following reactions have been found:

$$\begin{aligned} &\pi^-+n\rightarrow\pi^-+n \text{ or } \pi^-+n+\pi^0, && \text{55 cases} \\ &\quad\rightarrow\pi^-+\pi^-+p, && \text{4–6 cases} \\ &\quad\rightarrow\pi^++\pi^-+\pi^-+n, && \text{1 case.} \end{aligned}$$

The events of the first category appear as rather large-angle deflections of the π^-. Sometimes a slow electron emerges from the vertex of the interaction (presumably the β decay of the residual nucleus having lost a neutron). Only deflections of more than 10° have been counted here. There are in addition a great number of cases of deflections of 2°–3° which are mostly diffraction scatterings off nuclei. The c.m. angular distribution of the π^- from this first group is very similar to the angular distribution of the π^- from the two corresponding reactions with protons.

The observed ratio of π^--n and π^+-p interactions is consistent with the following facts:

(1) equal π-p and π-n cross sections at 1.5 Bev as measured by Cool, Madansky, and Piccioni;[3]

(2) about half of the "π-p" interactions observed here occur on free protons, the rest on edge protons.[1]

Recent results of Lindenbaum and Yuan[4] indicate that the $T=\frac{3}{2}$ meson-nucleon state may play an important role in meson production processes in this energy range. If one assumes that all meson production in π-nucleon collisions goes by means of the production of a nucleon excited into a $T=\frac{3}{2}$ state with the subsequent decay into a meson and a nucleon, then one finds by the application of the principle of charge independence that the reaction $\pi^-+p\rightarrow\pi^++\pi^-+n$ predominates over the reaction $\pi^-+p\rightarrow\pi^-+\pi^0+p$ by about a factor of two, and that the reaction $\pi^-+n\rightarrow\pi^-+\pi^0+n$ predominates very much over $\pi^-+n\rightarrow2\pi^-+p$. The latter statement is consistent with the data presented and the former statement is not. (39 cases of $\pi^-+p\rightarrow\pi^++\pi^-+n$ and 42 cases of $\pi^-+p\rightarrow\pi^-+\pi^0+p$ have been observed.)

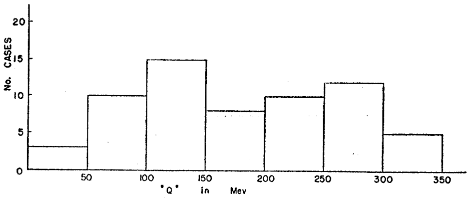

FIG. 3. Distribution of the Q values of an assumed intermediate excited nucleon in the π^--p interactions in which a π^0 or π^+ is produced.

An excited nucleon in the $T=\frac{3}{2}$ state would presumably usually decay with a "Q" value of about 150–160 Mev. Figure 3 shows the apparent Q values calculated from the π^--p collisions in which a π^0 or π^+ is produced assuming the slower meson to be the secondary. There is only a slight indication of a peak in the region of 160 Mev. Unfortunately the experimental errors in the energy measurements and the motions of the target nucleon (in the case of edge collisions) could smear any such Q curve almost to the extent observed.

The distribution of angles between the two π mesons in the center-of-mass system[1] seems to be consistent with the excited-nucleon model.

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Nuclear Resonance Fluorescence in Hg^{198} and the Lifetime of the 411-kev Excited State of Hg^{198} *

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NUCLEAR resonance fluorescence in Hg^{198} has been studied by Moon and co-workers[1–3] and by Malmfors.[4]

Using an ultracentrifuge to provide the necessary Doppler shift to the 411-kev gamma ray, Davey and Moon[3] measured a lifetime of $(3.2\pm0.7)\times10^{-11}$ second for the 411-kev electric quadrupole transition in Hg^{198}.

Malmfors[4] produced an appreciable Doppler broadening of the incident gamma line by heating a source of radioactive Au^{198}. From his measurements of the resulting resonance fluorescence, he deduced a lifetime of 9×10^{-11} second.

Davey and Moon's[3] value for the lifetime agrees with the result of Graham and Bell[5] who determined the same lifetime by the delayed-coincidence method as $(1.5\pm2.4)\times10^{-11}$ second.