0 to −0.25. With counter techniques, Ilford G5 nuclear-emulsion targets give $a=-0.12\pm0.2$ or $(50\pm8)\%$ of the maximum value.[1,2] The $\mu-e$ angular distribution can also be measured directly in the emulsion using scanning techniques. The weighted mean of all such scanning measurements is $a=-0.12\pm0.015$ as compiled at the recent Rochester conference.[4] This 50% depolarization must be due in some way to the effect of the local magnetic fields produced by neighboring electrons. For example, if the muon experiences a local field of $6.3\times10^4$ gauss (the classical field of a Bohr magneton at a distance of one Bohr radius) for a time $10^{-10}$ sec, it will precess 31°. This effect could be reduced by causing the neighboring electrons to precess faster than $10^{10}$ revolutions per second. An external magnetic field of 10 kilogauss causes a free electron to precess at a rate $2.8\times10^{10}$ revolutions per second. The reduction of depolarization by such a technique can be calculated exactly for the case of one electron bound to the $\mu^+$ in a 1S state (muonium). With no external magnetic field the formation of muonium gives a 50% depolarization, while in a field of 9000 gauss, muonium formation would give rise to only a 1.5% depolarization. Quantitatively the fraction of depolarization due to munoium formation in an external magnetic field $H$ is $0.5/(1+x^2)$ where $x=e\hbar H/(mc\Delta E)$. $\Delta E$ is the 1S hyperfine splitting of muonium and $m$ is the reduced mass of the electron-muon system.

Using the magnetic resonance setup of Garwin, Lederman, and Sachs, we applied a field of 9±1 kilogauss along the beam direction to a small stack of G5 nuclear emulsion in which $\mu^+$ mesons from the 85-Mev Nevis $\pi^+$ beam were stopped. The plates were area scanned for $\mu$ endings. All muons were traced back more than 650 microns in order to eliminate any contributions from $\pi-\mu-e$ decays. Out of a total of 3009 $\mu^+$ endings, only 5 had doubtful or "missing" secondaries. From this and other checks, we conclude that the data are free from forward-backward selection bias. We found 1315 decay positrons in the forward hemisphere, and 1689 in the backward hemisphere. This gives a result $a=-0.249\pm0.036$ which is 3.6 standard deviations away from the zero-field value of $a=-0.12$. This result indicates that the application of an external magnetic field along the spin direction reduces the amount of depolarization and improves nuclear emulsion as a tool for experiments involving muons.

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# Small-Angle Photoproduction of Positive Mesons from Hydrogen*

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THE angular distributions of photomesons produced in hydrogen have previously been measured adequately only in a range of angles from 40° to 180° c.m.[1,2] A recent paper by Moravcsik[3] points out that in such a restricted angular range it is quite possible to analyze the angular distributions by a polynomial including terms up to $\cos^2\theta$, representing S- and P-wave production only. However, the basic Chew-Low theory of photoproduction contains a term of the form $[\boldsymbol{\varepsilon}\cdot\mathbf{q}\boldsymbol{\sigma}\cdot(\mathbf{K}-\mathbf{q})]/[q_0K-\mathbf{q}\cdot\mathbf{K}]$, where $\mathbf{K}$ and $\boldsymbol{\varepsilon}$ are the photon momentum and polarization, $\mathbf{q}$ and $q_0$ the momentum and energy of the meson, and $\boldsymbol{\sigma}$ the nucleon spin.[4] This term arises from the interaction of the meson current with the incident photon and, because of the denominator, mixes in higher angular-momentum states. The effect of this term should be most noticeable in the shape of the distribution at forward angles and in forward-backward asymmetry.

In this experiment we have measured the relative angular distributions for the yield of positive pions produced by (260±5)-Mev gamma rays. Figure 1 shows the experimental arrangement. The target is a 2-inch liquid hydrogen vessel with thin Mylar walls (0.015 in.). The mesons were detected by their characteristic $\pi-\mu$ decay in a six-counter telescope whose complexity was dictated by the need to cope with the heavy electron and $\gamma$-ray background. Mesons are par-

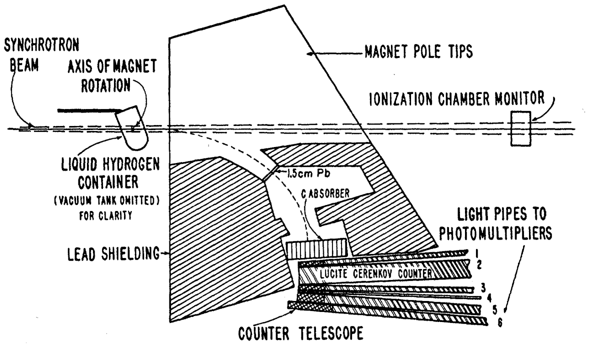

FIG. 1. Experimental arrangement.

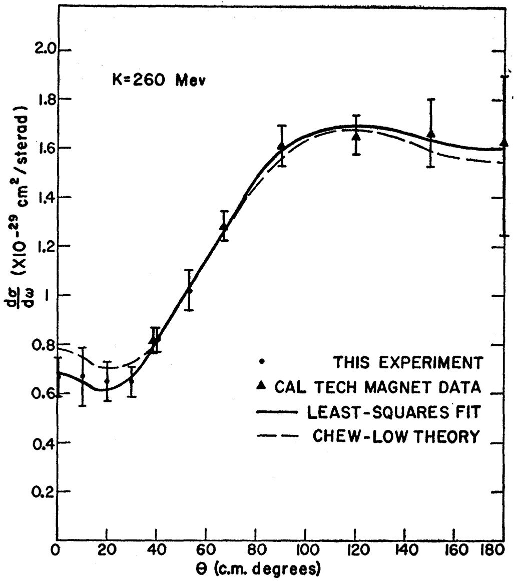

FIG. 2. Differential cross section for photoproduction of positive pions from hydrogen for a photon energy of 260 Mev.

tially identified by a coincidence 1+3+4−2−6, where 2 is a Lucite Čerenkov counter that is insensitive to pions in the energy band detected by the telescope. This energy band is determined by selecting a carbon absorber that requires the pion to stop and decay in the fifth detector, where it is identified by a delayed coincidence with the $\mu$-meson pulse. A lead scatterer 1.5 cm thick, placed halfway down the channel, helped materially to reduce the number of accidental counts due to electrons. Since the amount of material in the path of the meson is quite large, absolute measurements of cross sections by this method would be impractical. However, for measurements of the relative yield, in the restricted angular range where our measurements were made, the change in efficiency of the telescope can be readily estimated.

The angular distributions, measured in a range from 0° to 53° c.m. and normalized to the California Institute of Technology magnet data,[2] are shown in Fig. 2. The experimental points have been corrected for the relative change in efficiency of the counter telescope as a function of angle; the largest correction, between the 0° point and the 53° point, amounted to less than 6%. The solid line is a least-squares fit to an expression of the form

$$\sum_{n=0}^{4}\frac{A_n(\cos\theta)^n}{[1-(V/c)\cos\theta]^2},$$

where $V$ is the velocity of the meson in the c.m. system. The dashed line is a theoretical curve taken from the Chew-Low theory, including some recoil terms, as evaluated by Moravcsik.[3] The table below compares the least-squares coefficients with those obtained from theory, when the total cross sections are normalized to $2\pi$ in both cases.

| | $A_0$ | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
|---|---|---|---|---|---|
| Theory | 0.56 | −1.03 | 0.38 | 0.18 | −0.083 |
| Experiment | 0.57 | −1.03 | 0.36 | 0.15 | −0.04 |

These measurements are being continued for higher-energy photons on hydrogen and deuterium.

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## Experimental Situation on Parity Doubling

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IN a recent publication[1] we have presented experimental results which give clear evidence against theoretical models of the type proposed by Lee and Yang[2] in which $K$ particles as well as $\Lambda^0$ and $\Sigma^{\pm,0}$ hyperons exist in two forms of opposite parity. The experiments show that just half of the $\theta^0$ particles produced in association with the $\Lambda^0$ are of the type which decays into two pions with a mean life of $10^{-10}$ sec. The other half have a long lifetime. If there is no parity doubling, this result is immediately understood in terms of $\theta_1{}^0$ and $\theta_2{}^0$ which are related to the $\theta^0$ and $\bar{\theta}^0$ mesons in the manner discussed first by Gell-Mann and Pais[3] and in the light of parity nonconservation by Lee, Oehme, and Yang.[4] Instead of the observed factor of one-half, the parity-doubling theories predict a factor of $\frac{1}{4}$ except under assumptions which appear not only artificial but also improbable.[1]

Nevertheless Treiman and Wyld[5] have recently revived the parity-doubling theories with a specific model in which the mean life of one of the $K^+$ states is very short compared to $10^{-8}$ sec. We wish to point out here that this proposal can be ruled out on experimental grounds. A mean life in the region $\sim 10^{-10}-10^{-9}$ sec would have been detected already in experiments with emulsions, especially the $G$-stack experiments.[6] For shorter times we appeal to our own work with the