that, for negative parity, the angular correlation is a sharp function of both δ and a. Note that (for $\delta \neq \sim\pm\frac{1}{2}\pi$) dominant forward (backward) peaking implies $-\frac{1}{2}\pi < \delta < \frac{1}{2}\pi$ ($\frac{1}{2}\pi < \delta < \frac{1}{2}3\pi$) independent of the scattering length. The key effect (for $\delta \neq \pm\frac{1}{2}\pi$) of a sizable scattering length is to build up a significant peak at the opposite pole ($x = -1$ for $\delta < \frac{1}{2}\pi$, $x = 1$ for $\delta > \frac{1}{2}\pi$). Aside from the branching ratio, this effect could be the most direct way of detecting a strong S-wave π-π interaction.

We have attempted to show in this analysis the richness and comparative completeness of the information obtainable from a study of Reactions (1a) and (1b) at rest. These are low-rate reactions accessible to detailed experimental study for the first time in several current experiments.

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NEW MEASUREMENT OF THE Λ MAGNETIC MOMENT*

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In order to provide a better experimental test of certain baryon models and symmetry schemes, we have remeasured the magnetic moment of the Λ. The method is direct: Polarized Λ's produced in the reaction

$$\pi^+ + N \to \Lambda + K^+ \tag{1}$$

pass through a strong longitudinal magnetic field and the angle of precession of the Λ polarization vector is measured. The precession can be observed by virtue of the asymmetry in the decay $\Lambda \to p + \pi^-$ in which the π^- meson tends to be emitted opposite to the Λ spin direction. In the Λ rest frame, the equation of motion of the polarization vector, $\hat{n}$, is

$$d\hat{n}/dt = (\mu_\Lambda/s\hbar)\hat{n} \times \vec{H}, \tag{2}$$

in which μ_Λ is the Λ magnetic moment, $s\hbar$ is the spin angular momentum, and $\vec{H}$ is the magnetic field. The magnetic moment is expressed in Bohr nuclear magnetons $[1\mu_N = e\hbar/(2m_pc) = 3.15\times10^{-18}$ MeV/G]. For a Λ with momentum $\vec{p}_\Lambda$ in the laboratory system and polarization normal to $\vec{p}_\Lambda$ traveling in the direction of the magnetic field with $\int \vec{H}\cdot d\vec{l} = HL$ before it decays, the polarization vector will precess through an angle ϵ given by

$$\epsilon = -(\mu_\Lambda/s\hbar)(HL)m_\Lambda/p_\Lambda. \tag{3}$$

The sign convention is such that if a Λ precessed clockwise about the magnetic-field direction, it would have a negative magnetic moment. In the Λ rest frame, the angular distribution of π^- mesons from Λ decay is given by

$$N(\theta)d\Omega = (1/4\pi)(1+\alpha\bar{P}\cos\theta)d\Omega, \tag{4}$$

in which θ is the angle between the pion momentum vector and the Λ-polarization vector; α, which is equal to -0.62 ± 0.07,[1] is the decay asymmetry parameter; and $\bar{P}$ is the average Λ polarization.

We used Reaction (1) because it is known to produce highly polarized Λ's over a wide range of production angles[2] and because of the relative ease in detecting K^+ mesons. The π^+ mesons were produced in a copper target exposed to an external proton beam at the Cosmotron. A double-deflection beam transport system[3] was used to select a pion momentum of 1.04 BeV/c with a momentum bite of $\pm 1.5\%$ and to focus the beam onto a beryllium target of 2 cm diameter. From an internal Cosmotron beam of 2×10^{11} protons per pulse, we obtained 1.3×10^5 π^+ mesons (and about twice as many protons) on the beryllium target. Before striking the target, the pions were selected by a threshold Cherenkov counter (B) (see Fig. 1) and were required to pass through a lead collimator and through a hole in a scintillation counter (G). The Λ's produced in the beryllium target passed through a strong magnetic field between the target and the thin-foil spark chamber. The field was produced by a pulsed magnet consisting of a multiturn solenoid wound on a copper flux concentrator.[4] The flux concentrator, which had a conical bore of 30° half-angle, caused the field lines to diverge approximately along the lines of flight of the Λ and K^+ particles.

The K^+ mesons produced in Reaction (1) were selected by ionization, velocity, and by their decay into fast particles. The three tapered scintillation counters (S_{1-3}) were required to give pulses greater than minimum ionizing. A liquid threshold Cherenkov counter (π) vetoed fast particles. This counter had an inner cell of FC-75 and an outer cell of water to allow

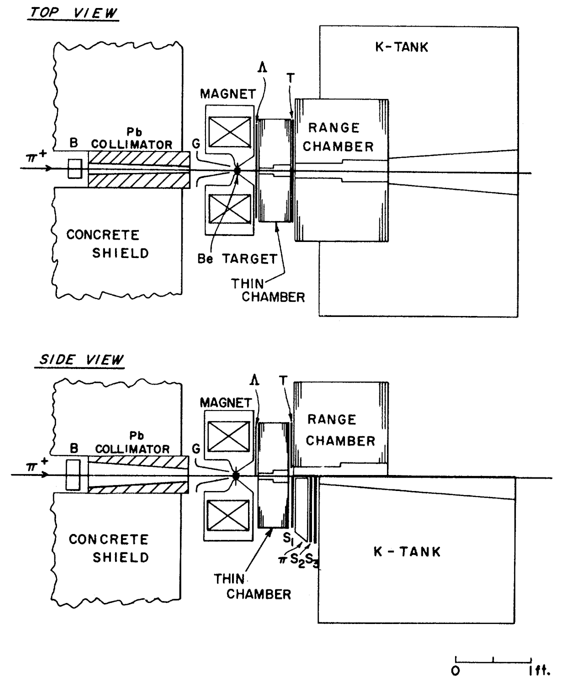

FIG. 1. Schematic diagram of experimental equipment.

for the decrease of velocity with angle. The K^+ mesons then stopped and decayed in a water-filled Cherenkov counter (K tank). The Cherenkov pulse from the fast decay particles was required to occur between 0.5 and 4.5 K^+ lifetimes after the prompt signal in the scintillation counters, thereby reducing triggers from protons which interacted in the water.

The Λ's which decayed within the thin-foil spark chamber were selected by requiring a signal from the scintillation counter (T) but no signal from the counter (Λ). The K^+ tracks were also observed in this chamber. The thin-foil chamber was constructed of phosphor bronze[5] foil of 1 mil thickness. The range chamber, made of aluminum and brass plates of graduated thickness, could stop the proton from the Λ decay. To minimize the number of background tracks and to reduce triggers from possible interactions in the chamber, it was necessary to have a hole in the spark chambers to allow passage of the unscattered beam.

The spark chambers were photographed in 90° stereo. Auxiliary mirrors were used in order to eliminate blind spots due to the beam hole in the spark chambers. The magnetic-field integral at the time the event occurred was measured by a long thin solenoid in the magnet and displayed on an oscilloscope which

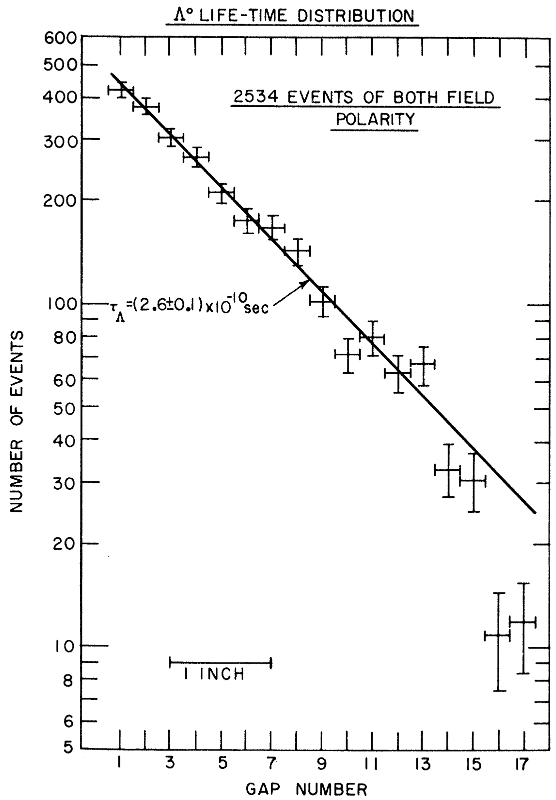

FIG. 2. Lifetime distribution of selected events in the thin-plate chamber. Only the first 13 gaps were used in fitting and geometric biases were ignored.

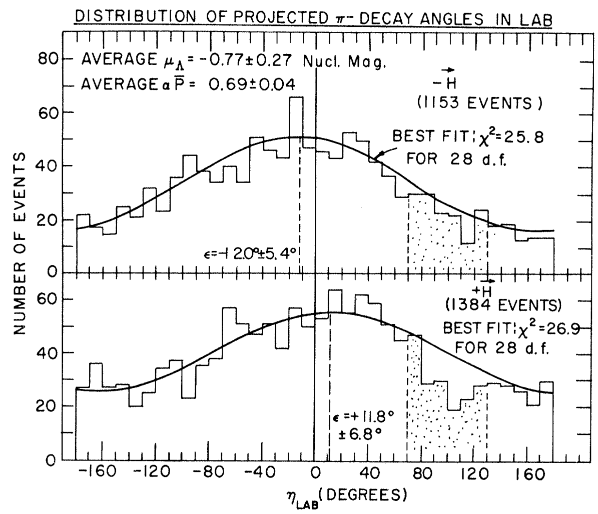

FIG. 3. Best fit curves to the Λ-decay distribution. The dotted region about 90° was not used.

was photographed with the event. The field polarity was reversed at regular intervals throughout the experiment.

The film was scanned for the vee indicating the Λ decay, and a K^+ track pointing back to the target. Three points on each track were measured in each view. A computer program reconstructed the geometry and the kinematics of the event and calculated the momentum of the target neutron in the Be nucleus.

Final selection of events required the kinematically accepted events to lie within a fiducial volume, and to have a Λ momentum consistent with Reaction (1) and a neutron momentum <400 MeV/c. Of approximately 7600 Λ-like events found in the scanning, 2537 events from the first measurement satisfied these criteria. More data are expected from a second measurement of the rejected events, now in process. A lifetime distribution of these selected events is shown in Fig. 2. The best lifetime fit to the distribution, ignoring possible geometric biases, is $(2.6 \pm 0.1)\times 10^{-10}$ sec, which is consistent with the known lifetime $(2.62 \pm 0.02)\times 10^{-10}$ sec.[6]

The last few points in the lifetime plot are low due to inefficiencies in recognizing Λ events which decay late in the thin-foil chamber. The average momentum of the Λ's is 589 MeV/c, and the average field integral is 447 kG-cm.

In determining the precession angle, it was convenient to project the π^--momentum vector onto a plane normal to the Λ (and magnetic-field) direction. The decay distribution is then given by

$$N(\eta)d\eta = (\tfrac{1}{2}\pi)[1 + \tfrac{1}{4}\pi\alpha\bar{P}\cos(\eta-\epsilon)]d\eta, \qquad (5)$$

where η is the angle between the initial Λ-polarization direction and the projected pion momentum vector. The distributions in η of the selected events for the two magnetic-field directions are shown in Fig. 3. The region about $\eta = +90°$ is slightly deficient in events, since this corresponds to Λ decays with the π^- directed toward the beam hole in the thin-foil chamber. As a result, events within the ±30° interval about 90° were not considered. The two histograms were independently fitted to (5) by varying $\alpha\bar{P}$ and ϵ until a minimum of χ^2 was reached. The parameters for a best fit were $\alpha\bar{P} = 0.60 \pm 0.05$ and $\epsilon = +11.8° \pm 6.8°$ for the positive field ($\vec{P}_\Lambda$ and $\vec{H}$ parallel), and $\alpha\bar{P} = 0.82 \pm 0.06$ and $\epsilon = -12.0° \pm 5.4°$ for the negative field ($\vec{P}_\Lambda$ and $\vec{H}$ antiparallel). This gives an average $\alpha\bar{P} = 0.69 \pm 0.04$ and a Λ magnetic moment of -0.77 ± 0.27 μ_N. Our result is consistent with the results of the four other experiments[7-10] shown in Table I.

According to SU(3) the magnetic moments

Table I. Summary of measurements of the Λ magnetic moment.

Experiment	Detector	Events	Magnetic moment
Cool et al.[a]	Spark chamber	254	-1.5 ± 0.5 μ_N
Kernan et al.[b]	Cloud chamber	20	0.0 ± 0.6
Anderson and Crawford[c]	H_2 bubble chamber	8553	-1.39 ± 0.72
Charrier et al.[d]	Emulsion	151	-0.5 ± 0.28
This experiment	Spark chamber	2220	-0.77 ± 0.27
Weighted average			-0.73 ± 0.17 μ_N

[a]Reference 7. [b]Reference 8. [c]Reference 9. [d]Reference 10.

of the spin-$\frac{1}{2}$ baryon octet are given by[11]

$$\mu = \mu_2 - \mu_1 Q - \mu_2[U(U+1) - \tfrac{1}{4}Q^2], \qquad (6)$$

where Q and U are the charge and U spin of the particle, respectively. The two constants μ_1 and μ_2 can be evaluated in terms of the well-known neutron and proton moments, from which one predicts $\mu_\Lambda = -\frac{1}{2}\mu_n = -0.95\mu_N$. In SU(6) a relation between the two coupling constants in SU(3) can be found,[12] and thus the number of constants in (6) is reduced to one. This leads to a prediction of the magnetic moment of the neutron in terms of that of the proton, $\mu_n = -\frac{2}{3}\mu_p$, which agrees with the experimental value within a few percent. As a result, the predictions of the magnetic moments of the other particles in the baryon octet are essentially the same as in SU(3).

Both our result and the weighted average of the five experiments $[(-0.73 \pm 0.17)\mu_N]$ are in reasonable agreement with the predicted value of -0.95 μ_N by Coleman and Glashow[11] on the basis of SU(3) and octet dominance. If one uses the "mass-corrected" prediction of Bég and Pais,[13] $\mu_\Lambda = -0.78$ μ_N, then the agreement is more striking.

The SU(3) prediction remains unchanged if triplets with one-third integral charge (quarks) exist. Nauenberg,[14] using an integral-charged-triplet model,[15] predicts the Λ magnetic moment to be -1.59 μ_N. Our result is not consistent with such a large contribution to the magnetic moment due to integral charged triplets. However, this contribution may be canceled by a possible singlet current.

We wish to thank Dr. R. L. Cool for his interest and useful discussions. The magnet was designed and tested at MIT with the help of Dr. H. Brechna. Professor J. Friedman and Dr. E. Loh contributed to the design of the experiment. Dr. A. B. Clegg aided in the preliminary state of the experiment. We are indebted to Dr. E. O. Salant and Dr. R. P. Shutt and their groups for providing us with film-measuring equipment. We also wish to thank W. Merkle, J. Harris, and the rest of the Cosmotron staff for their cooperation. The technical assistance of E. Druek, G. Munoz, H. Sauter, F. Seier, and O. Thomas is greatly appreciated.

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ERRATA

NONLINEAR SCATTERING OF RADIATION FROM PLASMAS. D. F. DuBois [Phys. Rev. Letters 14, 818 (1965)].

A type-setting error resulted in multiplying together two separate equations numbered (6). The factors to the right of $\delta(\omega+\omega_0-\omega_A)$ in (6) constitute a separate equation which reads as follows:

$$(n_A+1)Q_s^{(4)>}=n_A Q_s^{(4)<}.$$

Reference 12 should be cited after the fourth sentence in the last paragraph on page 820. References 12, 13, and 14 on pages 820 and 821 should be displaced by one to read 13, 14, and 15, respectively. In the final paragraph the reference to 15 should read 12.

ANTIPROTON-PROTON ANNIHILATION AT REST INTO TWO PSEUDOSCALAR MESONS AND SU(6) SYMMETRY. M. Konuma and E. Remiddi [Phys. Rev. Letters 14, 1082 (1965)].

There is the following fifth term in Eq. (5), which does not contribute to the amplitudes of the final two-pseudoscalar-meson state:

$$I_{5\mu}{}^{\nu}=\overline{B}_{\alpha\beta\gamma}B^{\alpha\beta\gamma}(M_{\delta}{}^{\nu}(1)M_{\mu}{}^{\delta}(2)-M_{\mu}{}^{\delta}(1)M_{\delta}{}^{\nu}(2)).$$