energy between Q and $Q+dQ$ is given by[4]

$$p(Q,E)dQ=(K/EQ^2)dQ, \qquad (2)$$

where K is a constant. Using for this resonance $Q_{\min}=12.3$ ev and $Q_{\max}=2160$ ev, the function $\eta(E,E_i)$ was numerically calculated on a computer using a Monte Carlo method.

The function $\eta(E,E_i)$ gives the yield per proton at energy E_i from a resonance of infinitesimal width with a monoenergetic beam incident on the target. To account for nonzero resonance width and finite-beam energy resolution, the products of $\eta(E,E_i)$ values and thin-target yield curve values were graphically integrated to give curve A in Fig. 1. The thin-target curve chosen for the calculation was from a target of 60-ev thickness.

Curve A exhibits the peak and shallow minimum predicted by Lewis. The amplitudes of the peaks on experimental yield curves vary by a factor of two. This strongly suggests that surface contamination of the target plays an important role even on targets being continuously evaporated. Some of the discrepancy between the calculated curve of Fig. 1 and the data points B, which exhibit the highest experimentally observed peak, may be attributed to contaminants. On the other hand, the peak in the calculated curve may also be too high because of approximations in stopping-power theory.

The point of half plateau yield on the calculated yield curve, which is commonly assumed to be E_R, does not fall at E_R. For the parameters used here, the half-value point is about 100 ev below E_R.

Experimental work is being extended to other resonance reactions and an attempt will soon be made to utilize higher beam energy resolution. Calculations have shown that the Lewis peak increases in amplitude as resolution improves and as the values of $Q_{\max}$ and $Q_{\min}$ increase.

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†Present address: Department of Physics, University of Wisconsin–Milwaukee, Milwaukee, Wisconsin.

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ASYMMETRY PARAMETERS IN THE DECAYS $\Sigma^+ \to p+\pi^0$ AND $\Lambda \to p+\pi^-$*

E. F. Beall, Bruce Cork,† D. Keefe, P. G. Murphy,‡ and W. A. Wenzel
Lawrence Radiation Laboratory, University of California, Berkeley, California
(Received September 1, 1961)

In recent years, several authors have proposed theories that predict, either on the basis of various forms of global symmetry and the $|\Delta\vec{T}|=\frac{1}{2}$ rule,[1-6] or on the basis of extended chirality invariance,[7] that the asymmetry parameters in the decays $\Sigma^+\to p+\pi^0(\alpha_0)$ and $\Lambda\to p+\pi^-(\alpha_\Lambda)$ should obey the relations $\alpha_0 \approx -\alpha_\Lambda$. Here we have

$$\alpha = 2\mathrm{Re}(S^*P)/(|S|^2+|P|^2),$$

where S and P are the amplitudes for the two possible angular-momentum channels in each decay. Other theories predict the same sign for α_0 and α_Λ.[8,9] Asymmetry measurements have shown $|\alpha_0|$ and $|\alpha_\Lambda|$ to be large.[10-12] Two published measurements of the sign of α_Λ are in disagreement.[13,14] The experiment reported in this Letter was designed to establish the signs and magnitudes of both α_0 and α_Λ by measuring the polarization of the decay proton from $\Sigma^+\to p+\pi^0$ and $\Lambda\to p+\pi^-$ with a carbon-plate spark chamber.

Figure 1 shows the apparatus used in the experiment. Positive pions of 1.19-Bev/c momentum from the Bevatron were incident upon a liquid-hydrogen target, producing the reactions $\pi^++p\to\Sigma^++K^+$, $\Sigma^+\to p+\pi^0$. During approximately one-third of the run, the hydrogen target was replaced by a block of lithium deuteride. In this case, π^+ mesons of 1.02-Bev/c momentum produced the reactions $\pi^++n\to\Lambda+K^+$, $\Lambda\to p+\pi^-$. The production of a Σ^+ or Λ hyperon was indicated as in earlier experiments[10] by the identification of a K^+ with a counter telescope, including detection of the decay of the K^+ in the large water Čerenkov counter C_K. The hollow-plate spark chamber in the K^+ telescope and the carbon-plate "proton" spark chamber were triggered by a coincidence between the K^+ telescope signal, the signal from the "proton" counter telescope that detected particles with $v/c<0.75$ entering the carbon-plate chamber, and the pulse from a gas Čerenkov

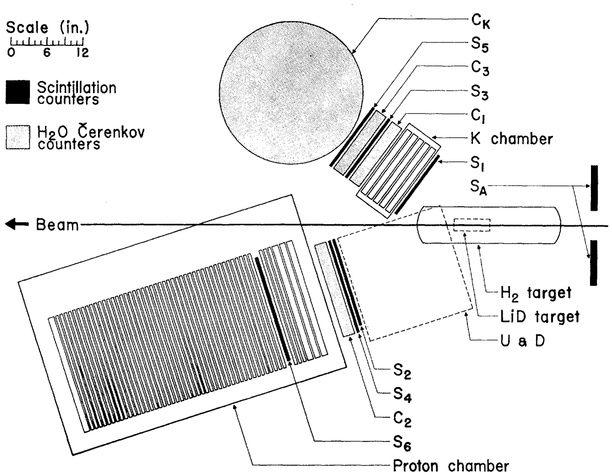

FIG. 1. Plan view of the apparatus used in the experiment. Hyperons were produced either in the H_2 target or in the LiD target. Scintillation counters S_1, S_3, and S_5 detected the K^+ meson; S_2, S_4, and S_6 are scintillation counters that detected the decay proton. The 2-in. water Čerenkov counters C_1, C_2, and C_3 were used to reject particles with $v/c > 0.75$. The water Čerenkov counter C_K stopped the K^+ and detected its decay particle; scintillation counter S_A rejected events not originating in the target; scintillation counters U and D detected pions from Λ decay. The K spark chamber consists of five 1-in. hollow plates with 0.003-in. aluminum surfaces. The proton spark chamber consists of four 1-in. hollow plates and 49 0.5-in. graphite plates sprayed with silver paint. Both chambers were filled with argon.

counter which was located in the incident beam to detect the π^+ meson. Two 90-deg stereo views of each chamber were then photographed. The U and D counters detected those π^- mesons from Λ decay that went approximately up or down with respect to the production plane.

All Σ^+ events with a single proton scattering in the carbon plates of greater than 3-deg projected angle in either view were measured. (Only those events with greater than 5 deg in either view were used in the analysis.) The measured K^+ and proton space angles and proton range allowed us to make a once-overdetermined kinematical fit to the Σ^+ production and decay. The scattering angle and residual range were used to determine the analyzing power of carbon for each event, with the analyzing-power data which have been summarized by Birge and Fowler.[13] Acceptance criteria involving goodness of kinematical fit, maximum and minimum scattering angle, and scattering within a fiducial region of the chamber were imposed. Out of approximately 25 000 pictures, 358 events satisfied all the acceptance criteria and were used as data.

If the polarization of the hyperon is nonzero, the helicity of the decay proton is no longer minus α.[15] However, we have

$$\left[\frac{N(\theta)p_V(\theta) - N(\pi-\theta)p_V(\pi-\theta)}{N(\theta)+N(\pi-\theta)}\right] = -\alpha\cos\theta,$$

where θ is the angle between the proton momentum and the normal to the Σ-K production plane, $p_V(\theta)$ is the polarization of the proton perpendicular to the production plane, and $N(\theta)$ is the number of events. Similarly, we have[16]

$$\left[\frac{N(\theta)p_H(\theta) + N(\pi-\theta)p_H(\pi-\theta)}{N(\theta)+N(\pi-\theta)}\right] = -\alpha\cos\psi,$$

where ψ is the angle between the proton momentum and the direction in the Σ-K production plane which is perpendicular to the hyperon momentum. All of the above quantities refer to the hyperon rest frame. We have used the approximations that the proton and hyperon momenta are parallel in the laboratory system and that the polarization of the proton is the same in the hyperon rest frame as it is in the laboratory system. Therefore, the likelihood functions,

$$L_V(\alpha) = \prod_{i=1}^{358} (1 - \alpha\cos\theta_i A_i \cos\phi_{S_i})$$

and

$$L_H(\alpha) = \prod_{i=1}^{358} (1 - \alpha\cos\psi_i A_i \sin\phi_{S_i}),$$

were computed. Here, A is the carbon analyzing power and ϕ_S is the angle between the plane of scattering and Σ-K production plane. The common logarithms of $L_V(\alpha)$, $L_H(\alpha)$, and $L(\alpha) = L_V(\alpha)L_H(\alpha)$ are plotted in Fig. 2. It should be noted that $L_V(\alpha)$ and $L_H(\alpha)$ independently imply that α_0 is positive. The combined data give $\alpha_0 = +0.75 \pm 0.17$. Corrections for systematic effects have not been included. This value for α_0 agrees well with the lower limit for $|\alpha_0|$ obtained from a measurement of $\alpha_0\bar{p}_\Sigma$ by Cork et al.[10]

Because of the Fermi momentum of the target neutron, we could not use precise kinematical fitting on the Λ events. Therefore, the U and D counters were used to determine whether the π^- meson went up or down with respect to the K^+-π^+

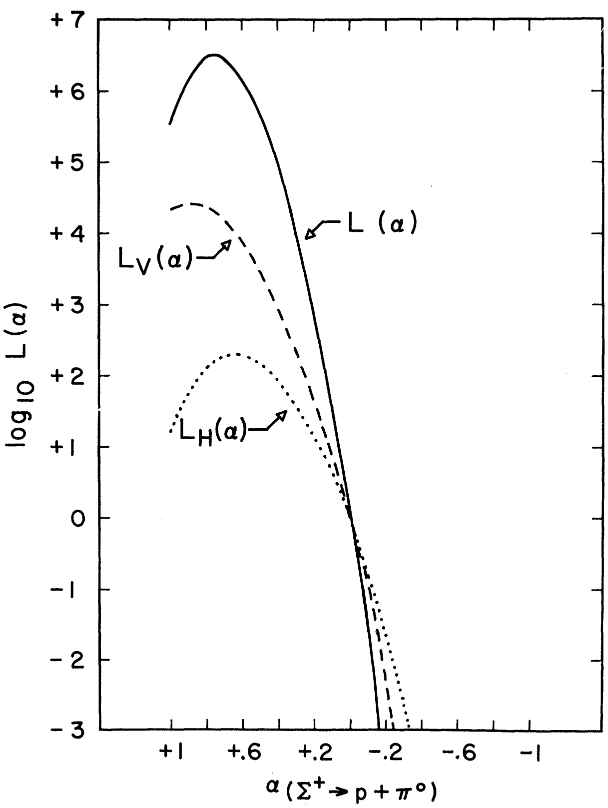

FIG. 2. Common logarithms of the likelihood functions $L_V(\alpha) = \prod_i (1 - \alpha A_i \cos\theta_i \cos\phi_{S_i})$, $L_H(\alpha) = \prod_i (1 - \alpha A_i \times \cos\psi_i \sin\phi_{S_i})$, and $L(\alpha) = L_V(\alpha) L_H(\alpha)$ for $\Sigma^+ \rightarrow p + \pi^0$.

plane, and a measurement of the polarization of the proton perpendicular to this plane correlated with the presence of a U or D count allowed a determination of the sign of α from the relation

$$\left[\frac{N_D \langle p_V \rangle_D - N_U \langle p_V \rangle_U}{N_D + N_U}\right] = -\alpha \langle \cos\theta \rangle,$$

with averages taken over all proton directions. From measurements of $\alpha_\Lambda \bar{p}_\Lambda$ by Crawford et al.,[11] it is known that $|\alpha_\Lambda| > 0.75 \pm 0.17$. If it is assumed that $|\alpha_\Lambda| > 0.6$, a maximum-likelihood analysis of our data indicates that α_Λ is negative with a confidence of at least 25:1. This result disagrees with the early experiment of Boldt et al.,[14] but agrees with the recent experiments by Birge and Fowler[13] and Leitner et al.[17] Thus, the evidence that α_Λ is large and negative is now quite strong.

The above results imply: (a) The predictions by Nakamura and Konuma[7] that $\alpha_0 < 0$ and that $\alpha_\Lambda > 0$ are in disagreement with experiment. (b) The phenomenological theory by Bludman,[8] which predicts $\alpha_\Lambda \approx +\alpha_0$, is in disagreement with experiment. (c) The S-wave bound-pion model of Barshay and Schwartz[9] (which has been quoted as evidence for odd Σ-Λ relative parity[18]) is also in disagreement with experiment. (d) The evidence that $\alpha_{(\Xi^- \rightarrow \Lambda + \pi^-)}$ is positive[19] is strengthened. (e) A fundamental prediction of the global (or doublet) symmetry theories,[1-6] viz., $\alpha_\Lambda \approx -\alpha_0$, is now confirmed.[20]

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‡Work done while on leave from the Rutherford High Energy Laboratory, Harwell, Didcot, England.

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PERIPHERAL COLLISIONS AND THE $(\frac{3}{2}, \frac{3}{2})$ RESONANCE IN THE REACTION $p+p \rightarrow n+p+\pi^+$ AT 970 Mev

V. E. Barnes and D. V. Bugg
Cavendish Laboratory, Cambridge, England

and

W. P. Dodd, J. B. Kinson, and L. Riddiford
Department of Physics, University of Birmingham, Birmingham, England

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As a continuation of earlier work with a diffusion cloud chamber[1] at the Birmingham University 1-Bev proton synchrotron, proton-proton scattering has been studied with improved accuracy and statistics using a 9-inch liquid hydrogen bubble chamber.[2] Protons were scattered out of the synchrotron at 4° from a carbon target, and the collimated beam was estimated to have an energy spread of ±10 Mev at the bubble chamber. 3007 events within a 1° beam spread and a restricted fiducial region of the chamber have been analyzed so far, yielding the cross sections shown in Table I.

Table I. Cross sections for p-p scattering at 970 Mev.[a]

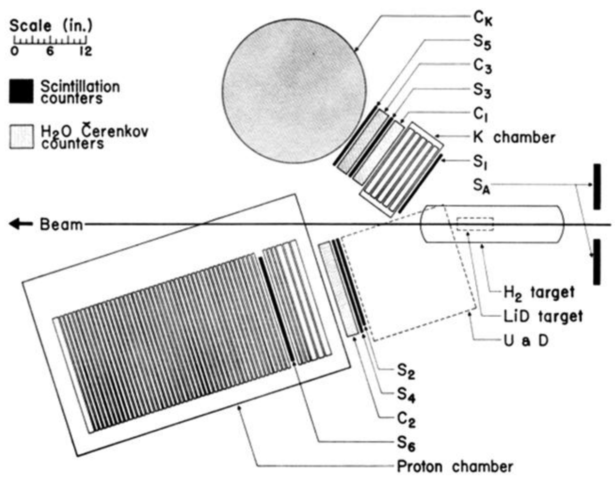
Reaction	No. of events	Cross section (mb)
(1) $p+p \rightarrow p+p$	1554	24.4 ±1.0
(2) $\rightarrow d+\pi^+$	35	0.55 ±0.1
(3) $\rightarrow p+n+\pi^+$	1170	18.4 ±0.8
(4) $\rightarrow p+p+\pi^0$	239	3.8 ±0.35
(5) $\rightarrow p+p+\pi^++\pi^-$	1	...
(6) $\rightarrow p+n+\pi^++\pi^0$	1	...
(7) $\rightarrow d+\pi^++\pi^0$	1	...
Either (3) or (4)	6	...

[a]These cross sections are normalized to a total cross section of 47.3 ±1.0 mb interpolated from the many counter experiments. The elastic scattering cross section includes a correction for scanning losses at very small angles. This table does not include data from the diffusion cloud-chamber experiment, where the number of uncertain events was greater.

In separating reactions (3) and (4), the accuracy of measurement was such that it was frequently necessary to assume only one pion to be created in the interaction and to identify proton or π^+ on the basis of bubble density. However, since only one case of reaction (6) was definitely established, and only one example of double-charged pion production (5) was observed, it is unlikely that the events classed as reactions (3) and (4) contain many cases of double pion production. In only six cases was it impossible to distinguish between (3) and (4). A useful check on the identifications is that the center-of-mass angular distributions were symmetrical backwards and forwards within statistical errors.

Chew and Low[3] have suggested that inelastic reactions in which one pion is created should be strongly influenced at low momentum transfer by poles in the S matrix lying just outside the physical region. The physical interpretation is that there is a large cross section for peripheral collisions of one nucleon with a virtual pion in the field of the other, with a small momentum transfer, Δ, to the latter. In the present experiment there are two poles, since the initial state consists of two protons, and the resulting cross section must be symmetrical between them.

Bonsignori and Selleri[4] have pointed out that, in p-p scattering, peripheral interactions will be most important in reaction (3) where the neutron acts as "spectator" and the proton and π^+ interact in a $T=\frac{3}{2}$ state. They find good agreement with the diffusion cloud chamber results for low momentum transfer. Using this approach, Selleri[5]



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