where A_0 and A_2 are the scattering amplitudes for $I=0$, 2, respectively. Let the p-wave amplitude be

$$\int_{-1}^{+1} A_1 \cos\theta \, d\cos\theta = G(q^2), \qquad (3)$$

where

$$G(q^2) = -16\pi(\omega/q)e^{i\delta_1} \sin\delta_1.$$

Equation (3) can be converted into a differential equation for f which yields

$$f(x) = -\tfrac{1}{2}\int_0^x \frac{G(y)}{y}\,dy - \tfrac{3}{4}G(x) - \tfrac{1}{4}x\,G'(x). \qquad (4)$$

It is clear that the determination of the s phase requires a continuation of the p phase shifts to $q^2 < 0$. Using an effective-range approximation for the phase shifts, Eq. (4) yields

$$2a_0 - 5a_2 = 18a_1. \qquad (5)$$

Using the p-wave scattering lengths of Frazer and Fulco[3] and Bowcock et al.,[4] respectively, in Eq. (5) yields[5]

$$2a_0 - 5a_2 = 4.8\mu^{-1},\ 0.73\mu^{-1}. \qquad (6)$$

In comparison with this, Sawyer and Wali[6] obtain $0.9\mu^{-1}$ and Schnitzer[7] gets $\sim 0.005\mu^{-1}$. Combining the $I=0$ s-wave scattering length $a_0 = 1\mu^{-1}$ determined by Efremov et al.[8] and Ishida et al.[9] with the value of a_2 given in reference 6, we obtain $2a_0 - 5a_2 = 4.5\mu^{-1}$; and combining the Khuri and Treiman[10] value of $a_2 - a_0 = 0.8\mu^{-1}$ with that of references 8 and 9, we obtain $2a_0 - 5a_2 = -7\mu^{-1}$.

Based on the best p phase shift of reference 5 and Eq. (6), we conclude that a positive and large π-π scattering length in the $I=0$ state is inconsistent with experiment.

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K^- ABSORPTION AND THE $K\Sigma N$ PARITY

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The angular distributions for the three processes,

$$K^- + p \rightarrow \pi^- + \Sigma^+, \qquad (I)$$

$$K^- + p \rightarrow \pi^+ + \Sigma^-, \qquad (II)$$

$$K^- + p \rightarrow K^- + p, \qquad (III)$$

at 400-Mev/c lab-system K momentum, appear to contain large $\cos^2\theta$ terms.[1] The experimental data are scanty, but roughly 3/4 of the events for each of the three processes corresponds to a center-of-mass scattering angle in the regions $|\cos\theta| > \frac{1}{2}$.[1] It is generally assumed that these large $\cos^2\theta$ terms (which we shall refer to as the 400-Mev/c anomaly) result from interactions in the $P_{3/2}$ state of the K^--p system. The purposes of this note are to point out that if the $K\Sigma N$

parity is even, the anomaly may occur in the $D_{3/2}$ $K^- - p$ state, and to suggest a Σ^+ polarization measurement that would clarify the experimental situation.

We consider two different possibilities concerning the intrinsic parities $\mathcal{P}$ of the particle pairs, $\bar{K}N$, $\pi\Lambda$, and $\pi\Sigma$:

$$\mathcal{P}(\bar{K}N) = \mathcal{P}(\pi\Lambda) = \mathcal{P}(\pi\Sigma), \quad \text{(A)}$$

$$\mathcal{P}(\bar{K}N) = \mathcal{P}(\pi\Lambda) = -\mathcal{P}(\pi\Sigma). \quad \text{(B)}$$

In both parity cases we denote the partial wave amplitude for any of the three processes by the symbol $t_{a,b}$, where a represents the total angular momentum, and b the orbital angular momentum in the initial $(K^- + p)$ state. If parity assignment (A) is correct, it is highly probable that the large $\cos^2\theta$ terms result from the amplitudes $t_{3/2,1}$, as it is difficult to construct a reasonable model in which D- or F-wave interactions are strong while P-wave interactions are weak at such a low energy. Furthermore, an $I = 1$, $P_{3/2}$ pion-hyperon resonance seems likely in this case.[2] On the other hand, if parity assignment (B) is correct, $P_{3/2}$ $\pi\Sigma$ pairs result from $D_{3/2}$ $\bar{K}N$ pairs, and vice versa. Since the center-of-mass momenta in the $\pi\Sigma$ and $\bar{K}N$ states are comparable at 400-Mev/c bombarding momentum, one cannot predict with any confidence which of the two amplitudes $t_{3/2,1}$ or $t_{3/2,2}$ is more likely to be large for $\Sigma + \pi$ production. In either case, the requirements of unitarity and analyticity could lead to a large value of the corresponding $K^- - p$ elastic scattering amplitude.

It is instructive to consider the theoretical possibility of a low-energy $j = 3/2$ resonance in either the $\pi\Sigma$ or $\bar{K}N$ state under parity assumption (B), assuming that the pion-baryon interactions are of the conventional, renormalizable, Yukawa type. The Born approximation terms resulting from the pseudoscalar $\pi\Sigma\Sigma$ and $KN\Lambda$ interactions may contribute large pole terms to some of the P-wave amplitudes. If certain small recoil terms are neglected, the Born approximation vanishes for $P_{3/2}$ $\bar{K}$-N elastic scattering.[3] On the other hand, the pole terms for $P_{3/2}$ π-Σ elastic scattering are $\frac{2}{3}f_{\pi\Sigma\Sigma}^2/(\omega\mu^2)$ and $-\frac{4}{3}f_{\pi\Sigma\Sigma}^2/(\omega\mu^2)$ for the states of isotopic spins 1 and 0, respectively.[4] [The corresponding pole term for $I = 3/2$, $P_{3/2}$, π-N scattering is $\frac{4}{3}f_{\pi NN}^2/(\omega\mu^2)$.] The positive, $I = 1$ pole term might lead to a π-Σ resonance,[4] and hence to large values of the $\bar{K}$-N absorption and scattering amplitudes $t_{3/2,2}$. It is not known whether or not the 400-Mev/c anomaly results from a pion-hyperon resonance, but if it does, the observed small value (~0.4) for the $(K^- + p \to \pi^0 + \Lambda)/(K^- + p \to \pi^{\mp} + \Sigma^{\pm})$ branching ratio fits better with parity assignment (B) than with (A). [If $\mathcal{P}(\Sigma) = \mathcal{P}(\Lambda)$, one expects the $\pi + \Lambda$ component of the $I = 1$, $P_{3/2}$ resonance to be stronger than the $\pi + \Sigma$ component.[2,3]]

One can hope to determine the parity of the amplitude responsible for the 400-Mev/c anomaly by observing interference with the amplitude $t_{1/2,0}$, known to be large at lower energies for all three processes under discussion. We assume that the angular momentum of the anomaly is 3/2. The interference between $t_{1/2,0}$ and the $j = \frac{3}{2}$ amplitudes in the differential cross section for any of the three processes is proportional to the quantity

$$2\,\mathrm{Re}[2t_{1/2,0}t_{3/2,1}^* \cos\theta \pm t_{1/2,0}t_{3/2,2}^*(3\cos^2\theta - 1)],$$

where the lower sign applies only for $\pi + \Sigma$ production under parity assumption (B). Since it is likely that the amplitudes $t_{1/2,0}$ for the three processes are still appreciable at 400 Mev/c, the approximate symmetry of the 400-Mev/c cross sections around 90° is favorable evidence that the $K^- - p$ orbital parity of the anomaly is even. This evidence is weak, however, since the $j = \frac{3}{2}$ amplitudes may be nearly 90° out of phase with the amplitudes $t_{1/2,0}$. The existence of an appreciable $\cos\theta$ term in the $K^- - p$ elastic scattering angular distribution[1] at 300 Mev/c might be considered as evidence that the amplitude $t_{3/2,1}$ is growing with energy. This $\cos\theta$ term is not large, however, and may result from a small admixture of the amplitude $t_{1/2,1}$. We conclude that there is no strong experimental evidence concerning the parity of the 400-Mev/c anomaly.

Further information may be obtained by measuring the up-down asymmetry of the proton emitted in the decay of the Σ^+ of reaction (I), since this asymmetry measures the Σ^+ polarization. The interference between $t_{1/2,0}$ and the $j = \frac{3}{2}$ amplitudes in the polarization intensity (percentage polarization in the direction of $\vec{k}_i \times \vec{k}_f$, multiplied by the differential cross section) is proportional to

$$2\,\mathrm{Im}[\pm t_{1/2,0}t_{3/2,1}^* - 3t_{1/2,0}t_{3/2,2}^* \cos\theta]\sin\theta,$$

where the lower sign again applies only if the intrinsic parities of the initial and final particle pairs are opposite. The parity of the 400-Mev/c anomaly in $\Sigma^+ + \pi^-$ production may be determined definitely from angular distribution and polarization intensity measurements in the range of

K lab-momentum 150-400 Mev/c. In fact, the detection of either a large $\sin\theta$ or $\cos\theta\,\sin\theta$ dependence of the polarization intensity at 400 Mev/c would provide a strong clue to this parity, since it is likely that the amplitude $t_{1/2,0}$ is still larger than $t_{1/2,1}$ at this energy.

We conclude that the appropriate polarization measurements should be made in order that the parity of the 400-Mev/c anomaly in reaction (I) may be determined. If the K^- - p orbital angular momentum involved is even, it is unlikely that the intrinsic parities of the $\bar{K}N$ and $\pi\Sigma$ states are equal.

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ODD $\Lambda\Sigma$ PARITY AND THE NATURE OF THE $\pi\Lambda\Sigma$ COUPLING*

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In various symmetry models of strong interactions it has often been assumed that Λ and Σ belong to the same "supermultiplet" in some approximation.[1-3] Such a picture necessarily requires that the relative $\Lambda\Sigma$ parity be even. The purpose of the present Letter is twofold. We first summarize the recent experimental developments which are indicative of odd $\Lambda\Sigma$ parity. Secondly, we point out some unusual features of the scalar $\pi\Lambda\Sigma$ coupling; in particular we show that the scalar coupling constant is "calculable" from m_π, m_Λ, and m_Σ, and that the scalar coupling constant we calculate is in good agreement with that deduced from hypernuclear physics.

We wish to point out that, although even $\Lambda\Sigma$ parity has been tacitly assumed by many theoreticians, the available experimental data are suggestive of odd, rather than even, $\Lambda\Sigma$ parity. We can see this in the following eightfold way:

(1) According to recent Cornell data on associated photoproduction,[4] the angular distribution of

$$\gamma + p \rightarrow \Sigma^0 + K^+ \quad (1)$$

at $E_\gamma = 1140$ Mev (threshold $E_\gamma = 1040$ Mev) seems anisotropic, and is reminiscent of a retarded $\sin^2\theta$ distribution, whereas at comparable K momenta the angular distribution for

$$\gamma + p \rightarrow \Lambda^0 + K^+ \quad (2)$$

shows practically no structure. This feature agrees with the conventional view that the photoproduction of a charged meson near threshold takes place via the electric dipole absorption of the incident photon, only if K is pseudoscalar with respect to Λ (for which there is evidence from K^--He experiments[5]) but scalar with respect to Σ.[6]

(2) If a Taylor-Moravcsik type extrapolation analysis[7] is made for reaction (1), the available data strongly favor even $K\Sigma$ parity provided that only s waves and s-p interference are significant for the contributions other than the one-K exchange term (meson current term), or, what amounts to the same thing, provided that $(1-\beta_K\cos\theta)^2(d\sigma/d\Omega)$ can be correctly extrapolated to $\cos\theta = \beta_K^{-1}$ by the use of a third-order polynomial with one constraint.[8] (The de Broglie wavelength of the K particle in the c.m. system is as large as 1.0×10^{-13} cm so that our cubic extrapolation may be justified.) Since there is some evidence for odd $K\Lambda$ parity elsewhere,[5,7] we see that odd $\Lambda\Sigma$ parity is favored.

(3) In the angular distribution for the reaction

$$\pi^- + p \rightarrow \Lambda^0 + K^0 \quad (3)$$

at the ΣK threshold, an anomaly in the $\cos^3\theta$ term has been reported by Schwartz and collaborators.[9] If f waves are relatively unimportant for the final ΛK system at $p_K^{(\mathrm{c.m.})} \approx 230$ Mev/c ($\lambda\!\!\!^-_K \approx 0.85\times10^{-13}$ cm), then this anomaly should be attributed to p-d interference, which in turn