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ISOTOPIC SPIN RELATIONS IN HYPERON PRODUCTION

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ISOTOPIC SPIN RELATIONS IN HYPERON PRODUCTION *

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Experiments on Σ - K production on hydrogen for pion incident energies around 1 BeV seem to indicate that: [1,2]

$$\sqrt{\sigma_+} + \sqrt{\sigma_-} \approx \sqrt{2\,\sigma_o} \qquad (1)$$

where:

$$\sigma_+ \longrightarrow \pi_+ + p \longrightarrow K_+ + \Sigma_+$$

$$\sigma_o \longrightarrow \pi_- + p \longrightarrow K_o + \Sigma_o$$

$$\sigma_- \longrightarrow \pi_- + p \longrightarrow K_+ + \Sigma_-$$

Isotopic spin analysis would predict only an inequality whereas experiments seem to show an equality in (1).

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The general amplitude $\pi + N \longrightarrow K + \Sigma$ can be expressed as

$$(N\ A\ \vec{\pi}.\vec{\Sigma} + i B \vec{\tau}.\ \vec{\pi} \wedge \vec{\Sigma}\ K). \tag{2}$$

In perturbation calculations A and B are real. Thus the experiments results can be understood in the form that the non-i-spin-flip amplitude $A \approx 0$ and only the i-spin-flip amplitude B contributes to the production process at these energies.

If $A_o \approx 0$ we have even a more constringent relation there (1):

$$\sigma_+ \approx \sigma_- \approx 1/2\ \sigma_o. \tag{3}$$

Relation (3) is indeed favored by the experimental results[2] (Fig. 1). In the following we try to find the implications of this result on the basis of simple perturbation ideas.

Assuming even $\Lambda - \Sigma$ and $K - \pi$ parities we have three graphs given in Fig. 2.

These give

$$A \sim \left(\frac{g_{K\Sigma N}\ g_{NN\pi}}{p_N \cdot p_\pi} + \frac{g_{K\Lambda N}\ g_{\Lambda\Sigma\pi}}{p_\Sigma \cdot p_\pi} \right) \not{p}_\pi$$

$$B \sim \left(\frac{g_{K\Sigma N}\ g_{NN\pi}}{p_N \cdot p_\pi} - \frac{g_{K\Sigma N}\ g_{\Sigma\Sigma\pi}}{p_\Sigma \cdot p_\pi} \right) \not{p}_\pi \tag{4}$$

where p's are the corresponding 4-momentum and we have neglected $\Lambda - \Sigma$ mass difference. For the energy region considered $p_\Sigma \cdot p_\pi / p_N \cdot p_\pi \approx 2/3$. Thus we may conclude that

$$\frac{g_{K\Sigma N}}{g_{K\Lambda N}} \approx -3/2\ \frac{g_{\Lambda\Sigma\pi}}{g_{NN\pi}} \tag{5}$$

It is interesting to mention that relation (5) corresponds to Gell-Mann's D-coupling in the unitary theory[3] as:

$$g_{K\Sigma N} = -\sqrt{3}\ g_{K\Lambda N}\ ;\quad g_{\Lambda\Sigma\pi} = 2/\sqrt{3}\ g_{NN\pi}\ .$$

The angular distribution is however roughly isotropic.

In addition to the three graphs of Fig. 2 there is a fourth graph (Fig. 3), with a K^* exchange[4] which contributes to both amplitudes A as well as B. If spin of K^* is unity or if K^* is scalar this will lead (as for $K - \Lambda$ production[5]) to a forward peaking of K-mesons. This type of peaking does seem to show itself for a $K\Sigma$-production only at higher energies ($\gtrsim$ 1.3 BeV[2-5]). This seems to indicate that $N\Sigma K^*$ coupling is energy dependent and our neglect of this around 1 BeV may be justified.

When $\Lambda - \Sigma$ parity is odd and $K - \pi$ even the experimental relation (1) can be obtained only if the K^* graph is no longer neglected. The relations of coupling constant are not any more simple. The angular distribution of K's may now be peaked backwards at $E_\pi \approx 1$ BeV the forward peak due to the K^* graph becoming important at higher energies, as indicated by the experimental results.[1,2,5]

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REFERENCES

1. F. Crawford et al, Phys. Rev. Lett. 3, 394, (1959).

2. C. Baltay et al, Rev. Mod. Phys. 33, 374 (1961).

3. M. Gell-Mann, The Eight-fold Way, California Institute of Technology report, 1961.

4. M. Alston et al, Phys. Rev. Lett. 5, 520 (1960).

5. M. Gell-Mann and J. Tiomno, Proceedings of the 1960 Annual International Conference on High-Energy Physics at Rochester (Interscience Publishers, New York, 1960) p. 508. A. Salam and J. C. Ward, Phys. Rev. Lett. 5, 390 (1960). Also J. Tiomno, A. Videira and N. Zagury, Phys. Rev. Lett. 6, 120 (1961). M. Beg and P. DeCelles, Phys. Rev. Lett. 6, 145 (1961). C. Chan, Phys. Rev. Lett. 6 383 (1961).

6. M. I. Soloviev, Proceedings of the 1960 Rochester Conference, p. 388.

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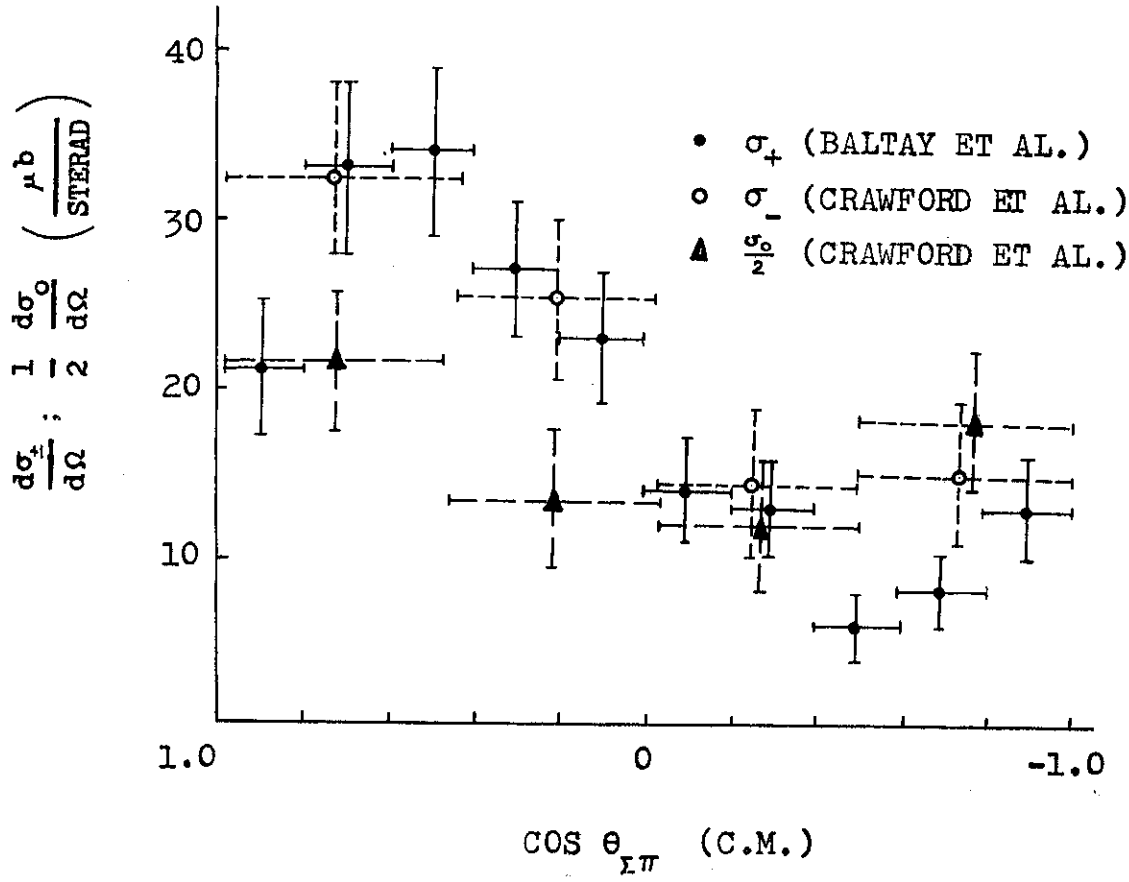

Fig. 1 - Angular distributions in $\pi_{\pm} + p \longrightarrow K + \Sigma$ reactions at 1.08 BeV (Lab.). The Σ_0 cross section is divided by 2.

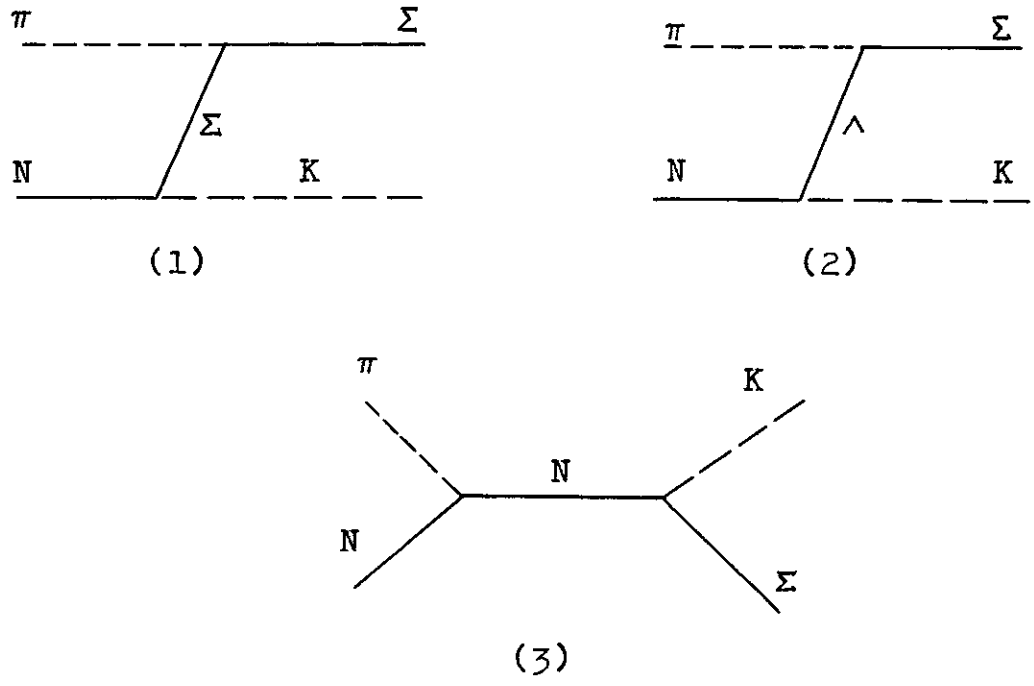

Fig. 2 - Feynman diagrams for Σ production.

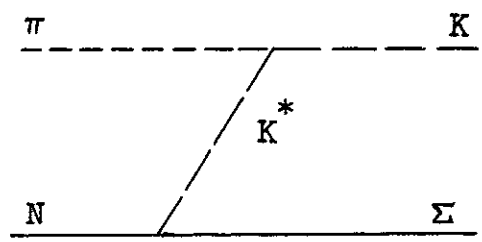

Fig. 3 - Diagram for Σ production with intermediate K^*.