EXPERIMENTAL CHECK OF SOME SU(6) CROSS-SECTION EQUALITIES*

T. Binford, D. Cline, and M. Olsson
Department of Physics, University of Wisconsin, Madison, Wisconsin
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Barger and Rubin have derived some relations between various amplitudes for meson-baryon scattering within the formalism of SU(6) theory.[1] We present here some additional relations that follow from their work and a comparison of these relations with the available experimental evidence. The relations are nominally expected to hold only for s waves and low momenta.

The relation

$$\sigma(K^- + p \to \Lambda + \pi^0) = 3\sigma(K^- + p \to \Sigma^0 + \pi^0) \quad (1)$$

follows from Table I of reference 1 when the amplitude for $K^- + p \to \Sigma^0 + \pi^0$ is expressed in terms of the amplitudes for $K^- + p \to \Sigma^- + \pi^+$ and $K^- + p \to \Sigma^+ + \pi^-$, using isotopic spin conservation. We have compiled all experimental data known to us for equality (1)[2-4]; the result of this compilation is shown in Fig. 1. The data are plotted for the same K^- laboratory momentum for each channel. If the data are plotted and corrected according to the prescription of Meshkov, Snow, and Yodh,[5] the fit to the SU(6) prediction at low K^- energy is somewhat less satisfactory. It appears possible that this relation will hold at higher K^- energy away from the various resonances in the K^-N channel. Near threshold, where the relation should hold, agreement is probably destroyed by the $Y_0^*(1405)$.

Another interesting equality that can be obtained from reference 1 is

$$\sigma(\pi^- + p \to \Sigma^0 + K^0) + \tfrac{1}{3}\sigma(\pi^- + p \to \Lambda + K^0)$$
$$= \sigma(\pi^- + p \to \Sigma^- + k^+) + \sigma(\pi^+ + p \to \Sigma^+ + K^+). \quad (2)$$

A compilation of experimental data for relation (2)[6-9] is shown in Fig. 2. The relation is plotted for equal Q values in the various channels. It is seen that the relation holds fairly well for higher energies and also near threshold. Since very good experimental data are available, a stronger statement may be made very near to the threshold. In this region, the total cross section is all s wave and may be parametrized in the following way:

$$\sigma = A(E - E_t)^{1/2}, \quad A \text{ in } \mu\text{b/MeV}^{1/2},$$

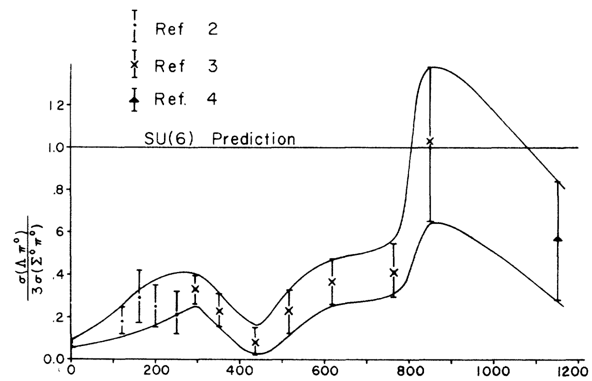

FIG. 1. Comparison of the ratio of cross sections for $K^- + p \to \Lambda + \pi^0$ and $K^- + p \to \Sigma^0 + \pi^0$ with the prediction of SU(6) theory. The error corridor is drawn for one standard deviation and is an eyeball fit to the data.

where E is the incident laboratory pion kinetic energy and E_t is the energy at threshold. The cross-sectional equality now reduces to

$$A_{\Sigma^+} + A_{\Sigma^-} = A_{\Sigma^0} + \tfrac{1}{3}A_\Lambda.$$

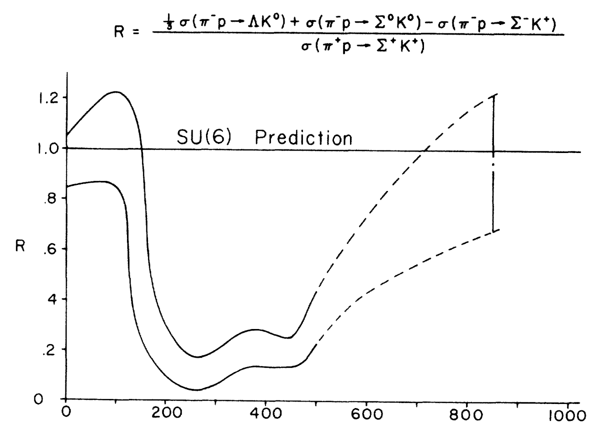

FIG. 2. Comparison of the SU(6) prediction for R with available experimental evidence. The agreement of R with the SU(6) prediction may be partially destroyed at intermediate Q values by the coupling of the Σ^+K^+ channel to the 1920 N^*.[7] The experimental data for this plot are given in the following references for the stated reaction: $\pi^+ + p \to \Sigma^+ + K^+$, reference 8; $\pi^- + p \to \Sigma^- + K^+$, reference 9; $\pi^- + p \to \Sigma^0 + K^0$, reference 9; $\pi^- + p \to \Lambda + K^0$, reference 9 and reference 6.

Experimentally,[6] this equality becomes

$$46.2 \pm 2 = 49.6 \pm 4,$$

showing excellent agreement. It is probably significant that this relation holds near threshold, and that there is no s-wave resonance in this region.

The third equality to be compared with experimental data is

$$\sigma(K^- + p \to \Xi^- + K^+) = 4\sigma(\pi^- + p \to \Sigma^- + K^+). \qquad (3)$$

This relation was reported in reference 1. A comparison of this relation with experimental data[9,10] for equal Q values in each reaction is shown in Fig. 3. Very poor agreement is achieved. However, it might be noted that throughout this region the angular distributions show similar behavior. In both reactions, the baryon becomes sharply peaked forward as the Q value rises.

Some interesting predictions of SU(6) for some equalities between meson-baryon scattering cross sections that were derived by Barger and Rubin have been compared above with the available experimental evidence.[1] The limited data available suggest two possibilities: (1) The relations fail badly near resonances. (2) Good agreement, when it occurs, seems to be achieved near thresholds and at high energy, but not between. The comparison of the elastic-cross-section predictions of SU(6) (Johnson-Treiman relation) with experiment can be similarly interpreted.[11,12]

We wish to thank Dr. V. Barger and Dr. M. H. Rubin for many informative discussions. We also wish to thank Professor M. L. Good for suggesting one of the cross-section equalities and for stimulating discussions. Thanks go to Dr. J. Kim for the use of unpublished data, and to Dr. R. Kofler for discussions on some experimental data. After completing this paper we received a preprint from Carter, Coyne, and Meshkov from which relations (1), (2), and (3) may also be derived. They obtained relations (1) and (3).

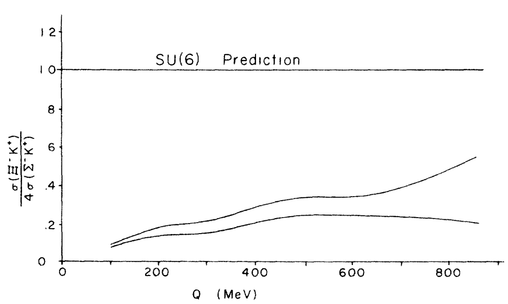

FIG. 3. Comparison of the ratio of cross sections of $K^- + p \to \Xi^- + K^+$ (reference 10) and $\pi^- + p \to \Sigma^- + K^+$ (reference 9).

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W-SPIN ANALYSIS OF WEAK DECAYS IN $\tilde{U}(12)$

D. Horn

Department of Physics, Tel-Aviv University, Tel-Aviv, Israel

and

M. Kugler and H. J. Lipkin

Weizmann Institute of Science, Rehovoth, Israel

and

S. Meshkov,* J. C. Carter,† and J. J. Coyne

National Bureau of Standards, Washington, D. C.

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The nonrelativistic SU(6) theory[1] has been applied by several authors to the analysis of the weak decays of baryons.[2,3] Several interesting results were obtained, but their validity is restricted to zero-momentum-transfer vertices. In this note we investigate these processes in the light of the relativistic extension of SU(6).[4] We will use the $\tilde{U}(12)$ theory.[5] The calculation is highly simplified by the use of W-spin technique.[6]

The three components of the W-spin operator are defined by $W_z = S_z$, $W_\pm = \gamma_0 S_\pm$ for the $\underline{12}$ representation of $\tilde{U}(12)$. This suffices to define them for all representations; in particular, we find for the $\underline{12}^*$ $W_z = S_z$, $W_\pm = -\gamma_0 S_\pm$. These operators commute with the Lorentz transformations in the z direction, and are therefore sufficient to describe relativistically processes in which all strongly interacting particles move in this direction. Both the leptonic and nonleptonic decays are of this kind. Using the W spin, an $SU(6)_W$ group can be constructed in a fashion analogous to the construction of the ordinary $SU(6)_S$. A $\tilde{U}(12)$-invariant theory must be invariant under these two subgroups separately.

The $\underline{143}$ representation of $\tilde{U}(12)$ contains four $\underline{35}$ representations of SU(6). These four different representations can be characterized by the γ_0 eigenvalue of the quarks and antiquarks out of which they are constructed. We designate them by UU, UD, DU, and DD, where U and D stand for γ_0 up and down (+ and −) eigenvalues, respectively. Using the definition of the W spin, one can show that the $\underline{35}_{UD}$ and $\underline{35}_{DU}$ of $SU(6)_W$ are identical with the $\underline{35}_{UD}$ and $\underline{35}_{DU}$ of $SU(6)_S$, respectively. For each state the W^2 and W_z assignments are identical with those of S^2 and S_z. The situation is different for the UU and DD representations. Because of the different phases of the W-spin operators when applied to quarks and antiquarks of the same γ_0, it turns out that in these representations the $(W=1, W_z=0)$ state is an $(S=0, S_z=0)$ state, while the $(W=0, W_z=0)$ is $(S=1, S_z=0)$. All other states remain unchanged. Such an interchange of states will be called WS flip. Generally no WS flip can occur for representations composed solely of quarks or of antiquarks, such as the $\underline{364}$ baryon representation. Because of the field equations the mesons at rest are assigned to $\underline{35}_{UU}$, and therefore a WS flip occurs for them.

The U-D classification of the $\tilde{U}(12)$ generators is fixed merely by their behavior under SU(4) defined by the Dirac algebra. We find that for the matrices 1, γ_0, $\gamma_k\gamma_l$, and $\gamma_k\gamma_5$ no WS flip occurs, while the remaining combinations γ_5, γ_k, $\gamma_0\gamma_5$, and $\gamma_0\gamma_k$ are all subject to WS flip.

The analysis of the weak currents proceeds as follows: We assume that the various weak currents belong to the adjoint representation of $\tilde{U}(12)$. Moreover, the vector and axial-vec-