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JOHNSON-TREIMAN RELATIONS FROM VECTOR-MESON EXCHANGE*

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It is perhaps worth pointing out that the relations in the SU(6) theory between Kp and πp total cross sections, derived by Johnson and Treiman,[1] follow also from more conventional alternative assumptions:

(I) If exchanges of octet vector-meson Regge trajectories give rise to the cross-section differences involved in the relations, then both Johnson-Treiman relations,

$$\tfrac{1}{2}[\sigma(K^+p)-\sigma(K^-p)]=[\sigma(K^0p)-\sigma(\bar{K}^0p)] \quad (1a)$$

and

$$\tfrac{1}{2}[\sigma(K^+p)-\sigma(K^-p)]=\sigma(\pi^+p)-\sigma(\pi^-p), \quad (1b)$$

are obtained, provided only that the vector-meson trajectories have pure F-type (conserved-current) coupling to the baryons.

(II) Exchange of the unitary-singlet vector-meson state makes no contribution to the differences (1). Furthermore, φ-ω mixing leaves the relations unchanged in the zeroth-order approximation. The possible octet of even-signature boson Regge trajectories suggested by Pignotti[2] also makes no contributions to the differences in (1), the neutral members being even under charge conjugation.[3,4]

Assertion (I) may immediately be verified by using the Clebsch-Gordan coefficients from SU(3) to relate coupling constants.[5] The total cross-section predictions arise from the usual application of the optical theorem to the Regge-exchange amplitude.

Alternatively, we may directly see the equivalence of the SU(6) theory and the vector-meson-exchange model for these predictions in the following way: The meson-baryon scattering-matrix elements are written in terms of the forms $\bar{B}(1)B(2)M(3)M(4)$, where $\bar{B}$, B, and M are the standard tensors for the baryon ($\underline{56}$) and meson ($\underline{35}$) states in the SU(6) space.[6-9] Of the four possible SU(6)-invariant forms, three are symmetrical under the interchange of the [spin, SU(3)] indices of $M(3)$ with those of $M(4)$. Such symmetrical terms give equal contributions to the forward-scattering amplitudes of $m+b\to m+b$ and of $\bar{m}+b\to\bar{m}+b$, where b is any particular baryon and m is any particular pseudoscalar meson. Thus only the single antisymmetrical form contributes to the differences in (1),

$$A(m+b\to m+b)-A(\bar{m}+b\to\bar{m}+b)$$
$$\sim\bar{B}^{ABC}(1)B_{ABD}(2)$$
$$\times[M_C{}^E(3)M_E{}^D(4)-M_E{}^D(3)M_C{}^E(4)]. \quad (2)$$

By inserting Sakita's expression for $\bar{B}^{ABC}B_{ABD}$ [reference 9, Eq. (3)], it is easily shown that the form for the coupling of the baryon octet, N, to the pseudoscalar octet, Π, is (all space coordinates suppressed)

$$A(m+b\to m+b)-A(\bar{m}+b\to\bar{m}+b) \sim(\bar{N}N)_{8A}(\Pi\Pi)_{8A}, \qquad (3)$$

where the subscript $8A$ stands for the antisymmetrical octet combination. This is exactly the form which would be induced by the exchange of an octet of vector mesons.

The experimental confirmation of Relation (1a) discussed by Good and Xuong[5] is at a somewhat lower energy than that at which one might expect vector-meson exchange to dominate the cross-section differences. Their energies are lower than those involved in the Regge-exchange fit to K-nucleon scattering by Phillips and Rarita,[4] who included exchange of Pignotti's R trajectory in addition to ρ, and lower than the energies at which Logan[10] has fit π^-p charge-exchange data with a single ρ trajectory.

Nevertheless, vector-meson exchange is apparently not ruled out as the origin of the agreement of the Johnson-Treiman relations with the experiments summarized by Good and Xuong.[5]

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LEPTONIC DECAYS OF THE BARYONS†

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In a recent paper[1] one of us (V.D.S.) proposed a model for the weak interactions based on the conservation of a new quantum number I' and of its third component I_3'. The $\Delta I=\frac{1}{2}$ rule was a built-in feature of the model. The purpose of this paper is to calculate the branching ratios for the leptonic decays of the baryons using the weak isospin model and to show that, under reasonable assumptions, the results can all be expressed in terms of three independent parameters. These three parameters can be determined from the three best known reactions, and the comparison between the remaining experimental and predicted branching ratios can serve as a test of the model under the assumptions made. The results of the $\Delta S=\Delta Q$ rule can be compared and discussed.

Let us begin by listing below all of the possible amplitudes for the leptonic baryon decays:

$$\langle pL^-|T|n\rangle = 6^{-1/2}[\langle B_1L|T|B_0\rangle_0{}^0+2^{-1/2}\langle B_1L|T|B_1\rangle_1{}^0], \qquad (1.1)$$

$$\langle pL^-|T|\Lambda\rangle = 3^{-1/2}\langle B_1L|T|\Lambda\rangle_0{}^1, \qquad (1.2)$$

$$\langle nL^-|T|\Sigma^-\rangle = 6^{-1/2}[\langle B_0L|T|\Sigma\rangle_1{}^1+2^{-1/2}\langle B_1L|T|\Sigma\rangle_1{}^1], \qquad (1.3)$$

$$\langle\Lambda L^-|T|\Sigma^-\rangle = 3^{-1/2}\langle\Lambda L|T|\Sigma\rangle_1{}^0, \qquad (1.4)$$

$$\langle\Lambda L^+|T|\Sigma^+\rangle = 3^{-1/2}\langle\Lambda L|T|\Sigma\rangle_1{}^0, \qquad (1.5)$$

$$\langle nL^+|T|\Sigma^+\rangle = 6^{-1/2}[\langle B_0L|T|\Sigma\rangle_1{}^1-2^{-1/2}\langle B_1L|T|\Sigma\rangle_1{}^1], \qquad (1.6)$$

$$\langle\Lambda L^-|T|\Xi^-\rangle = 3^{-1/2}\langle\Lambda L|T|B_1\rangle_1{}^{-1}, \qquad (1.7)$$

$$\langle\Sigma^+L^-|T|\Xi^0\rangle = 6^{-1/2}[\langle\Sigma L|T|B_0\rangle_0{}^{-1}-2^{-1/2}\langle\Sigma L|T|B_1\rangle_1{}^{-1}], \qquad (1.8)$$

$$\langle\Sigma^-L^+|T|\Xi^0\rangle = 6^{-1/2}[\langle\Sigma L|T|B_0\rangle_0{}^{-1}+2^{-1/2}\langle\Sigma L|T|B_1\rangle_1{}^{-1}], \qquad (1.9)$$

$$\langle\Sigma^0L^-|T|\Xi^-\rangle = 6^{-1/2}\langle\Sigma L|T|B_1\rangle_1{}^{-1}, \qquad (1.10)$$

$$\langle pL^-|T|\Sigma^0\rangle = 6^{-1/2}\langle B_1L|T|\Sigma\rangle_1{}^1, \qquad (1.11)$$

$$\langle\Sigma^0L^-|T|\Sigma^-\rangle = 6^{-1/2}\langle\Sigma L|T|\Sigma\rangle_1{}^0, \qquad (1.12)$$