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Dips Associated with the A_2 Trajectory*

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Arguments are presented indicating that the $p\Delta A_2$ vertex is primarily spin flip. Using this information, predictions of various cut models for dips at $t=-0.6$ GeV^2 are compared with experiment.

With increasing experimental accuracy it has become evident that there has to be some modification of the description of high-energy scattering in terms of Regge poles alone. From purely theoretic and phenomenological grounds it has become necessary to introduce Regge cuts. In phenomenology the most used cuts are those generated by an absorptive mechanism. The various methods of generating these cuts may be placed into two groups: "weak" or "Argonne" cuts[1] and "strong" or "Michigan" cuts.[2] Into the second grouping one may place the model of Dar *et al.*[3] and of Harari.[4] The contention of the strong-cut advocates is that the gross features of near forward or near backward high-energy scattering is due to strong cancellations of pole and cut contributions. In the weak-cut model, many gross features are still given by the leading Regge poles. In this note we wish to present arguments against the strong-cut model.

One of the features of scattering at forward angles is the appearance, in some reactions, of dips at $t\sim-0.6$ GeV^2. There is an impressive list of reactions where the presence of absence of these dips is accounted for in a pure Regge-pole model[5] and in the strong-cut model.[2–4] Of the three $SU(3)$-related reactions[6]

$$\begin{aligned} &\text{(i)} \quad \pi^+p\rightarrow\pi^0\Delta^{++}, \\ &\text{(ii)} \quad \pi^+p\rightarrow\eta^0\Delta^{++}, \\ &\text{(iii)} \quad K^+p\rightarrow K^0\Delta^{++}, \end{aligned} \tag{1}$$

only the first one is observed to have a dip at $t=-0.6$ GeV^2. Reaction (i) is dominated by the exchange of a ρ trajectory, while (ii) is dominated by the exchange of an A_2 trajectory, and (iii) by the exchange of ρ and A_2 trajectories. The pure Regge-pole model or one including small-cut modifications would ascribe the presence of the dip in reaction (i) to a wrong-signature zero at $\alpha_\rho=0$, while in reactions (ii) and (iii) this zero is canceled by the pole of the A_2 passing through a right integer point.

In the strong-cut description the presence of a dip is determined by the dominant helicity amplitude of the reaction. Reactions dominated by $|\Delta h|=1$ amplitudes exhibit dips at $t=-0.6$ GeV^2, while those with sizable $|\Delta h|=0$ or 2 parts do not.[7]

There is strong evidence that reaction (i) is a $|\Delta h|=1$ transition. Using the ρ-photon analogy, Stodolsky and Sakurai[8] suggested that the $p\Delta\rho$ vertex is an $M1$ transition, implying that for reaction (i) the following relations hold for the t-channel helicity amplitudes:

$$f_{0,0;\frac{1}{2}\frac{1}{2}}=f_{0,0;\frac{3}{2},-\frac{1}{2}}=0\,, \tag{2a}$$

$$f_{0,0;\frac{1}{2},-\frac{1}{2}}=(1/\sqrt{3})f_{0,0;\frac{3}{2},\frac{1}{2}}\,. \tag{2b}$$

These relations imply definite values for the Jackson-frame density-matrix elements of the Δ, namely,

$$\begin{aligned} \rho_{33}&=3/8\,, \\ \mathrm{Re}\rho_{31}&=0\,, \\ \mathrm{Re}\rho_{3,-1}&=\sqrt{3}/8\,. \end{aligned} \tag{3}$$

Equation 2(a) shows that the transition (i) is purely $|\Delta h|=1$ and this will exhibit a dip in a model using the strong absorption. The absence of dips in reactions (ii) and (iii) would be explained by the possibility of large $|\Delta h|=1$ and/or 2 amplitude due to the exchange of the A_2. However, we wish to present arguments that the spin structure of the A_2 exchange is the same as that of the ρ exchange. The density matrices for reaction (ii) have been studied[6,9,10] and found to satisfy the relations of Eq. (3), leading to the suggestion that the $p\Delta A_2$ vertex is likewise an $M1$ transition. The same chain of arguments as above implies that reactions (ii) and (iii) are $|\Delta h|=1$ and thus should exhibit dips.

Why this destructive cut-pole interference should only be present in reaction (i) and be negligible (weak cut) in reactions (ii) and (iii) is hard to understand, especially in the light of the good agreement with experimental data that Mathews[9] has obtained, using

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the simple-$SU(3)$ relations between the vertices (in a pure pole model) to predict the ρ_{ij} and $d\sigma/dt$ for the reaction $K^+p \to K^0\Delta^{++}$ from those of reactions (i) and (ii).

We believe that the experimental evidence favors the "Argonne"[8] recipe for generating cuts, in which the absorptive correction only causes moderate changes from the pure pole term and where the dips are a result of the ghost-eliminating factors present in the pole amplitude.

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Dynamical Enhancement of Symmetry Breaking in K_{l3} Decay*

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The possible dynamical enhancement of the second-order symmetry-breaking corrections to a recently derived expression for the K_{l3} form factors is investigated.

RECENTLY, Dashen and Weinstein[1] derived a theorem for the form-factor ratio $\xi(0)$ in K_{l3} decay. It states that

$$\lambda_+ \frac{m_K{}^2 - m_\pi{}^2}{m_\pi{}^2} + \xi(0) = \frac{1}{2}\left(\frac{f_K}{f_\pi} - \frac{f_\pi}{f_K}\right) + O(\epsilon^2), \quad (1)$$

where $\xi(0)$ and λ_+ are defined in the usual manner, viz.,

$$\xi(0) = f_-(0)/f_+(0),$$

λ_+ is defined by

$$f_+(t) = f_+(0)(1 + \lambda_+ t/m_\pi{}^2),$$

and the f_i are defined by

$$\langle 0|A_\mu{}^{K^-}|K^+\rangle = f_K p_\mu{}^K,$$
$$\langle 0|A_\mu{}^{\pi^-}|\pi^+\rangle = f_\pi p_\mu{}^\pi.$$

The $O(\epsilon^2)$ terms are those of second order in the $SU_3 \times SU_3$ symmetry-breaking parameter ϵ.

If one uses the values $\lambda_+ = 0.06$ and $\xi(0) \simeq -0.9 \pm 0.4$, given by the latest X_2 collaboration experiment,[2] and the value $f_K/f_\pi = 1.23 \pm 0.05 + O(\epsilon^2)$, then the left-hand side of (1) is $\sim -0.16 \pm 0.4$ and the right-hand side $\sim 0.23 \pm 0.05$, so that the theorem is indeed satisfied, but just within the quoted errors. It may thus be important to obtain an estimate of the neglected $O(\epsilon^2)$ terms, for if they are for some reason dynamically enhanced and of such a sign as to spoil the agreement of (1) with experiment, then the procedure of doing perturbation theory around an $SU_3 \times SU_3$ symmetry limit may be rather suspect.[3]

The purpose of this investigation is to make an approximate calculation of the $O(\epsilon^2)$ term in order to get an indication of its sign and magnitude. We find that the dominant corrections contribute in such a manner as to improve (through only marginally) the agreement with experiment.

In order to proceed, we first make an assumption about the form of the symmetry breaking. We make the usual ansatz[4] that the hadronic Hamiltonian is

$$H = H_0 + \epsilon(u_0 + cu_8),$$

where H_0 is invariant under $SU_3 \times SU_3$ and the u_i are elements of the representation $(3,\bar{3}) + (\bar{3},3)$ with $\epsilon \ll 1$ and $c + \sqrt{2} = \eta \ll 1$.

In this model, we have the divergence equations

$$[Q_A{}^{\pi^+}(0), \partial^\mu A_\mu{}^{K^0}(0)] \equiv \Sigma_+{}^{\pi K}(0) = f(c)\partial^\mu V^{\mu K^+}(0), \quad (2a)$$

$$[Q_A{}^{K^0}(0), \partial^\mu A_\mu{}^{\pi^+}(0)] = \Sigma_+{}^{K\pi}(0) = [f(c) - 1]\partial^\mu V_\mu{}^{K^+}(0), \quad (2b)$$

$$[Q_A{}^{\pi^-}(0), \partial^\mu A_\mu{}^{\bar{K}^0}(0)] = \Sigma_-{}^{\pi K}(0) = -f(c)\partial^\mu V_\mu{}^{K^-}(0), \quad (2c)$$

$$[Q_A{}^{\bar{K}^0}, \partial^\mu A_\mu{}^{\pi^-}] = \Sigma_-{}^{K\pi}(0) = [1 - f(c)]\partial^\mu V_\mu{}^{K^-}(0), \quad (2d)$$

where $f(c) = (2\sqrt{2} - c)/3c$. Also.

$$[Q^{\pi^+}(0), \Sigma_-{}^{\pi K}(0)] = \partial^\mu A_\mu{}^{\bar{K}^0}(0) \quad (3)$$

and

$$\Sigma_-{}^{K\pi}(0) - \Sigma_-{}^{\pi K}(0) = \partial^\mu V_\mu{}^{K^-}(0). \quad (4)$$

This last equation is, of course, true independently of the form of the symmetry breaking.

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