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A QUARK MODEL FOR FORBIDDEN PEAKS

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A B S T R A C T

A quark model for the forward peaks in the processes forbidden for non-exotic t channel exchanges is proposed. The model gives strong predictions for the decay distributions and polarization of the baryon resonances produced in these processes.

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Recently, forward peaks in the double charge and/or strangeness exchange processes

$$\pi^+ n \rightarrow \pi^- \Delta^{++} \quad (1a)$$

$$\pi^- p \rightarrow K^+ \gamma^{*-} \quad (1b)$$

$$K^- p \rightarrow \pi^+ \gamma^{*-} \quad (1c)$$

$$K^- p \rightarrow K^+ \Xi^{*-} \quad (1d)$$

$$K^- p \rightarrow K^0 \Xi^{*0} \quad (1e)$$

were reported ¹⁾⁻³⁾. No corresponding peaks in the processes involving only spin $\frac{1}{2}$ baryons

$$\pi^- p \rightarrow K^+ \Sigma^- \quad (2b)$$

$$K^- p \rightarrow \pi^+ \Sigma^- \quad (2c)$$

$$K^- p \rightarrow K^+ \Xi^- \quad (2d)$$

$$K^- p \rightarrow K^0 \Xi^0 \quad (2e)$$

were observed ¹⁾⁻⁴⁾.

Obviously, the processes (1a)-(1e) cannot be explained in the framework of exchange models without exotic quantum numbers in the t channel.

In this note we would like to point out the possibility of the interpretation of these phenomena in the quark model. Our model implies that

- a) the decay distributions of the resonances in each of the processes (1b)-(1e) are completely determined and given by

$$W(\theta, \phi) = \frac{3}{8\pi} \sin^2 \theta \quad (3)$$

where the z axis is assumed normal to the production plane. The distribution (3) corresponds to the following spin-density matrix elements in the Jackson or helicity frames ⁵⁾:

$$\rho_{3/2, 3/2} = \frac{1}{8} ; \quad \rho_{1/2, 1/2} = \frac{3}{8} ; \quad \rho_{3/2, -1/2} = -\frac{\sqrt{3}}{8} ; \quad \text{Re } \rho_{3/2, 1/2} = 0 \quad (4)$$

- b) the cross-section for all the processes (1b)-(1e) has to vanish in the forward direction.

From the existing data on the reaction (1b) ⁵⁾, one can estimate the width of the forward dip in this process. The model requires the vanishing of the cross-section as $|t|$ in the forward direction. Assuming a shape of the form

$$|t| e^{at} \quad (5)$$

and using the experimental figure ³⁾ $a \sim 32(\text{GeV})^{-2}$ we obtain the width of the dip of the order of $\sim 0.01 \text{ GeV}^2$.

Making the additional assumption about the factorization of the amplitudes (we discuss it further) one obtains two more predictions:

- i) the properties a) and b) are satisfied also for reaction (1a);
- ii) for the scattering on the polarized target, the up/down asymmetry in all the processes (1a)-(1e) should be 100%.

The mechanism we propose is shown in Fig. 1. The incident baryon absorbs the incident meson. The absorption process is described according to the additivity rules of the quark model. The resulting virtual baryon emits the final meson, again according to the quark additivity rules. Thus, the amplitude for each of the processes (1a)-(1e) is a sum of many terms, each term being a formal product of the three factors:

- a) an absorption amplitude for the absorption of the meson by a quark;
- b) a propagator;
- c) an emission amplitude for a quark emitting meson.

E.g., for the processes (1b) and (2b) the formulae are

$$\begin{aligned} T(\pi^- p_{\pm 1/2} \rightarrow K^+ Y_{\mp 1/2}^{*-}) &= \pm \sqrt{\frac{2}{3}} a_{\pm} \bar{b}_{\pm} \\ T(\pi^- p_{\pm 1/2} \rightarrow K^+ Y_{\pm 1/2}^{*-}) &= \mp (a_{\pm} \bar{b}_{\mp} + a_{\mp} \bar{b}_{\pm}) \\ T(\pi^- p_{\pm 1/2} \rightarrow K^+ \Sigma_{\pm 1/2}^-) &= \frac{1}{3} (a_{\mp} \bar{b}_{\pm} - 2 a_{\pm} \bar{b}_{\mp}) \end{aligned}$$

(6)

Here the subscripts denote the transversities of the baryons. $a_{\pm}$ and $b_{\pm}$ are the effective amplitudes ^{*)} for the emission of a meson by the quarks

$$\begin{aligned} a_{\pm} &= T(p_{\pm 1/2} \rightarrow \pi^+ n_{\mp 1/2}) \\ b_{\pm} &= T(p_{\pm 1/2} \rightarrow K^+ \lambda_{\mp 1/2}) \end{aligned}$$

(7)

$\bar{a}_{\pm}$ and $\bar{b}_{\pm}$ denote the corresponding absorption amplitudes. The propagators and the summation over intermediate states are not written explicitly.

Since, experimentally, the cross-sections for the processes (2b)-(2e) are zero or nearby, we have

*) They depend, in general, on the intermediate baryon state.

$$a_+ \bar{b}_- \simeq a_- \bar{b}_+ \simeq 0 \quad (8)$$

Thus

$$T(\pi^- p_{\pm 1/2} \rightarrow K^+ Y_{\pm 1/2}^{*-}) = 0 \quad (9)$$

and only transitions into the transversity $\pm \frac{3}{2}$ states survive. This gives our first prediction a). Prediction b) follows from the remark that our transition amplitude is inconsistent with helicity conservation. Since in the forward scattering helicity must be conserved there must be no such scattering, i.e., the cross-section must vanish.

Factorizability is the assumption that the products $a_+ \bar{b}_+$, etc., can be treated as ordinary products. Then (8) and the condition that the total amplitude for Y^{*-} production does not vanish imply

$$a_+ = \bar{b}_+ = 0 \quad \text{or} \quad a_- = \bar{b}_- = 0 \quad (10)$$

Substituting (10) into (6) we obtain the prediction ii) as presented above.

Similar arguments work for the reactions (1c), (1d) and (1e). Process (1a) is different in that there is no corresponding reaction with the production of the $\frac{1}{2}^+$ particle. Consequently, the information about the vanishing amplitudes must be deduced from (10). This gives the prediction i).

In concluding we would like to stress that the model described in this note is not a necessary consequence of the quark model. We think, however, that the model is interesting because of its simplicity and because of its well-defined predictions which can be tested experimentally.

R E F E R E N C E S

- 1) M.A. Abolins, O.I. Dahl, J. Danburg, D. Davies, P. Hoch, D.H. Miller, R. Rader and J. Kirz, Phys.Rev.Letters 22, 427 (1969).
- 2) P.M. Dauber, P. Hoch, R.J. Manning, D.M. Siegel, M.A. Abolins and G.A. Smith, Phys.Rev.Letters (to be published).
- 3) A. Bashian, G. Finocchiaro, M.L. Good, P.D. Grannis, O. Guisan, J. Kirz, Y.Y. Lee, R. Pittman, G.C. Fischer and D.D. Reeder, "Study of the forbidden exchange reactions $\pi^- p \rightarrow K^+ \Sigma^-$ and $\pi^- p \rightarrow K^+ Y^{*-}$ at 6 and 10 GeV/c", preliminary data reported by P.D. Grannis at the Lund Conference, June 1969.
- 4) O.I. Dahl, L.M. Hardy, R.I. Hess, J. Kirz, D.H. Miller and J.A. Schwarz, Phys.Rev. 163, 1430 (1967);
P.M. Dauber, J.P. Berge, J.R. Hubbard, D.W. Merrill and R.A. Muller (to be published).
- 5) See, e.g., A. Kotanski and K. Zalewski, Nuclear Phys. B4, 553 (1968).

FIG.1

Diagram representing the proposed model for the processes (1b) and (2b).