SPIN-PARITY ANALYSIS IN THE DORREN, RITTENBERG AND YAFFE MODEL

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It is shown that the dual model given by Dorren, Rittenberg and Yaffe, similar to the dual Pokorski-Satz model, leads to the Gribov-Morrison rule for the parent states. In the Pokorski-Satz model this parity rule does not apply to the daughters. In the model considered by us the first daughter under N_γ-trajectory satisfies the Gribov-Morrison rule.

There exists an experimental spin-parity rule in the diffraction dissociation (DD) reactions, the so-called Gribov-Morrison rule [1]. It was shown that the dual Pokorski-Satz (PS) model [2] leads simply to the Gribov-Morrison rule for the parent states and that in this model the rule does not apply to the daughter states [3].

Our calculations show that in the Dorren, Rittenberg and Yaffe model (DRY) [4] the daughter with spin 3/2 under N_γ-trajectory satisfies the Gribov-Morrison rule.

We consider the diffraction dissociation of nucleon $A+N \rightarrow A+\pi N$, where A is any meson or baryon. The diagram of this process is shown in Fig. 1.

In the case of nucleon dissociation the Gribov-Morrison rule takes the form $P = (-1)^{J-\frac{1}{2}}$, where $J(P)$ is the spin (parity) of the produced resonance.

We use the same procedure as in Ref. [3]. Factorisation property of DRY-amplitude allows us to study the reaction $\mathscr{P}N \rightarrow \pi N$ as shown in the upper vertex in Fig. 1. Amplitudes $f_{J\pm}$ of definite spin J and parity $P = \pm(-1)^{J-\frac{1}{2}}$ may be expressed in terms of the invariant amplitudes A and B. We investigate (πN)-resonances in the s_{23}-channel. Residues of A and B at the pole $s_{23} = M_J^2$ are polynomials in $\cos\Theta$ (Θ — scattering angle) of the degree $J_{-\frac{1}{2}}$

$$A = m_0 \sum_{k=0}^{J-\frac{1}{2}} a_k(\cos\Theta)^k, \quad B = \sum_{k=0}^{J-\frac{1}{2}} b_k(\cos\Theta)^k. \tag{1}$$

The constant m_0 has been inserted to give a's and b's the same dimensions [3]. This leads to the following expressions for the residues of $f_{J'\pm}$ ($J' \leqslant J$, J — spin of parent state)

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at the pole $s_{23} = M_J^2$ (see Ref. [3])

$$g_{J\pm}(s_{23} = M_J^2) = \frac{\sqrt{\pi}}{2^{J'-\frac{1}{2}}} \frac{\Gamma(J'+\frac{1}{2})}{\Gamma(J'+1)} \Big\{ [\pm m_0 a_{J'-\frac{1}{2}} + M_J b_{J'-\frac{1}{2}}(M_J^2)] K_\pm K'_\mp$$

$$+ \frac{J'+\frac{1}{2}}{2(J'+1)} [\mp m_0 a_{J'+\frac{1}{2}}(M_J^2) + M_J b_{J'+\frac{1}{2}}(M_J^2)] K_\mp K'_\pm \Big\}$$

$$+ \text{terms in } (a_{J'+\frac{3}{2}}, b_{J'+\frac{3}{2}}) + \ldots + \text{terms in } (a_{J'+\frac{n}{2}}, b_{J'+\frac{n}{2}}), \tag{2}$$

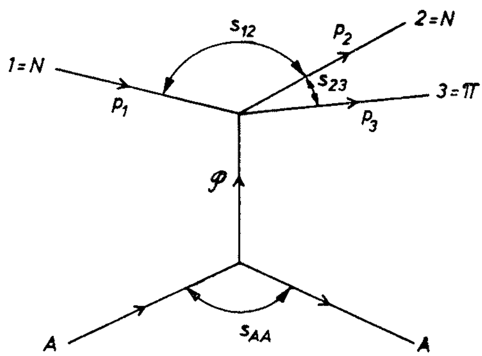

Fig. 1. Pomeron exchange diagram

where $P = \pm(-1)^{J'-\frac{1}{2}}$, $K_\pm = \sqrt{E \pm m}$, $K'_\pm = \sqrt{E' \pm m}$, m — nucleon mass, $E(E')$ — total energy of initial (final) nucleon, $n = 2(J-J')-1$, J — highest spin at mass M_J.

In further considerations we take, in analogy with [3],

$$A = mR_+(\tfrac{1}{2}-\alpha_{N_\alpha}(s_{23}), -\alpha_\pi(s_{12}), \tfrac{1}{2}-\alpha_{N_\alpha}(s_{13}))$$

$$+MR_-(\tfrac{1}{2}-\alpha_{N_\gamma}(s_{23}), -\alpha_\pi(s_{12}), \tfrac{1}{2}-\alpha_{N_\gamma}(s_{13})),^1 \tag{3}$$

$$B = R_+(\tfrac{1}{2}-\alpha_{N_\alpha}(s_{23}), 1-\alpha_\pi(s_{12}), \tfrac{1}{2}-\alpha_{N_\alpha}(s_{13}))$$

$$+R_-(\tfrac{1}{2}-\alpha_{N_\gamma}(s_{23}), 1-\alpha_\pi(s_{12}), \tfrac{1}{2}-\alpha_{N_\gamma}(s_{13})), \tag{4}$$

where α_{N_α} is N_α-trajectory, α_{N_γ} is N_γ-trajectory, α_π — degenerate π/A_1-trajectory, m — mass of nucleon, M — mass of N* (1520). $R_\pm$ have the form given by the DRY-model [4]

$$R_\pm(z_{23}, z_{12}, z_{13}) = \int_0^1 dx[x^{z_{23}-1}(1-x)^{z_{12}-1}|1-(1-K)x|^{\alpha_{\mathcal{P}}}$$

$$\pm x^{z_{23}-1}(1-x)^{z_{13}-1}|1-Kx|^{\alpha_{\mathcal{P}}} + x^{z_{13}-1}(1-x)^{z_{12}-1}|K-1+x|^{\alpha_{\mathcal{P}}}]. \tag{5}$$

We take trajectories in the form

$$\alpha_\pi(s) = -0.02+s, \quad \alpha_{N_\alpha}(s) = -0.38+s, \quad \alpha_{N_\gamma}(s) = -0.8+s$$

and $\alpha_{\mathcal{P}} = 1$ for the pomeron trajectory.

[1] Factors m and M are required by the Born amplitudes at the nucleon and N^* (1520) poles [3].

Calculations were done for the first daughters under missing states: 3/2 on N_α and 5/2 on N_γ trajectories. All results are shown in Table I.

TABLE I

Comparison of the ratio of the production intensities of natural-parity and unnatural-parity resonances in the dual Pokorski–Satz and the Dorren, Rittenberg and Yaffe models. (Data for PS-model from [3]). Calculations done at $s_{AA} = m_{\mathcal{P}}^2 \approx 0$

J	$\frac{1}{2}$	$\frac{3}{2}$	$\frac{5}{2}$	$\frac{7}{2}$	$\frac{9}{2}$	Daughters		Model
						$N_\alpha : J' = \frac{1}{2}$	$N_\gamma : J' = \frac{3}{2}$	
$\left\lvert \frac{g_{J+}}{g_{J-}} \right\rvert^2$	∞	∞	12	42	6.1	0.9	0.67	PS
						0.9	8.7	DRY

Our calculations lead to the following conclusions:

1) Because the difference between PS and DRY models is only in the satellite terms, both models lead simply to the Gribov-Morrison rule in the sense that resonances of natural parity dominate over their parity partners at least the order of magnitude in the production intensity. For high masses of resonances the ratio of production intensities tends to unity.

2) From the Pokorski-Satz model it follows that the Gribov-Morrison rule does not apply to the daughters [3]. However, it was suggested in [3] that satellite terms could conceivably affect predictions for the daughters. Satellite terms (in comparison with PS-model) arise in DRY-model in a natural way, but this fact does not change the predictions for $J' = 1/2$ daughter under N_α-trajectory. In PS-model we have $B \approx 0$ [3], and in DRY-model $A \approx 0$. This leads simply to approximate equality of g_{J+} and g_{J-} (see Table I). Table I shows also the results for $J' = 3/2$ daughter under N_γ-trajectory are different in PS and DRY models. DRY-model tells us that in this case the Gribov-Morrison rule is satisfied.

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