DUALITY VERSUS s CHANNEL HELICITY CONSERVATION
IN DIFFRACTION DISSOCIATION

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ABSTRACT

General s channel helicity conservation is shown to be incompatible with the multiperipheral description of diffraction dissociation and hence with the inter-relation between s channel resonances and t channel exchanges provided by duality.
The recent observation of s channel helicity conservation (SCHC) in diffractive $\gamma$ photoproduction \(^1\) and similar results in dispersion theoretical investigations of elastic $\pi^-$N scattering \(^2\) led to the hypothesis that such behaviour is a common feature of all diffractive resonance production \(^3\). If one takes this extreme attitude then, by duality arguments \(^4\), which, together with resonance saturation, allow an expansion of t channel exchanges in terms of direct channel resonances (see Fig.1), one arrives at the conclusion that SCHC should hold for the whole of the diffraction dissociation. In the present letter, we want to show that in its usual form the reggeized multi-peripheral matrix element \(^5\) is not compatible with SCHC.

The argument is, in fact, very simple. Consider the diffraction dissociation

$$a + b \rightarrow a' + c + d,$$  \(\text{(1)}\)

where, for convenience, all particles are taken as spinless (see Fig.2). s channel helicity conservation, in this case, means that in the (cd) rest system, the projection of the (cd) angular momentum along the direction of the recoil particle $a'$ vanishes. This in turn implies that the matrix element for reaction (1) must be invariant under rotation of $\vec{q}_c$ ($=-\vec{q}_d$) around the "helicity direction" $\vec{q}_a$, i.e., it should not depend on the azimuthal angle $\gamma$ defined by

$$\cos \gamma = \frac{\vec{q}_a \cdot (\vec{z} \times \vec{q}_c)}{|\vec{z} \times \vec{q}_c|}, \quad \sin \gamma = \frac{\vec{z} \cdot (\vec{z} \times \vec{q}_c)}{|\vec{z} \times \vec{q}_c|}$$  \(\text{(2)}\)

with

$$\vec{z} = \frac{\vec{q}_a}{|\vec{q}_a|}, \quad \vec{x} = \frac{\vec{q}_a \times \vec{q}_c}{|\vec{q}_a \times \vec{q}_c|}, \quad \vec{z} \times \vec{x} = \frac{\vec{q}_a \times \vec{q}_c}{|\vec{q}_a \times \vec{q}_c|}.$$

For an extension of these considerations to particles with spin, see Refs. 6) and 7).
The multiperipheral matrix element for reaction (2), on the other hand, is usually written as 5)

\[ M = \sum_i \beta_i(t_{aa}) S_{ac} \delta(\theta_i) \alpha_i(t_{bc}, t_{bd}, \omega_c \beta_i(t_{bd}) S_{cd} \delta_i(t_{bd}) + (c \rightarrow d), \]

where \( t_{xy} = (q_x - q_y)^2 \), \( s_{xy} = (q_x + q_y)^2 \), \( m_x^2 = q_x^2 \); \( x, y = a, a', b, c, d \) (see Fig.2), \( \delta_i \) is the pomeron trajectory. The sum runs over all possible Regge trajectories \( \delta_i \), \( \beta_i \) and \( \beta_i \) denote the pomeron and one-Regge vertex functions times signature factors, \( \delta_i \) is the double Regge vertex, while \( \omega_c \) is the Toller angle of the configuration given in Fig. 2. In the applications, one normally neglects the \( \omega \) dependence; then, among the independent variables appearing in (3), only \( t_{bd} \) and \( t_{bc} \) depend on \( \gamma \), and the only combination of these, which is independent of \( \gamma \), reads

\[ t_{bc} + t_{bd} = t_{aa} + m_e^2 + m_d^2 + m_b^2 - S_{cd}. \]

Therefore, unless the \( t_{bc}, t_{bd} \) dependence drops out as well, the matrix element (3) is in conflict with SCHC. Furthermore, allowing an \( \omega \) dependence in \( \delta_i (t_{aa}, t_{bd}, \omega) \) does not help; the elimination of the \( \gamma \) dependence, if at all possible this way, would completely change the multiperipheral character of the matrix element.

Thus, in the description of diffraction dissociation, at least one of the following three concepts has to be abandoned:

1. the factorized multiperipheral Regge form of pomeron exchange;
2. SCHC for diffractive resonance production in general.

It might well be that SCHC holds only for elastic reactions. The \( \phi^0 \) photoproduction then has to be interpreted in terms of an elastic matrix element continued in an external mass (vector meson dominance); this \( \phi \) is no longer dual to any channel exchange \( \gamma \). In this context, it is of particular interest to test \( \phi p \rightarrow \ubar + \tau^- p \) with linearly polarized photons.
outside the $S$ band, where SCHC predicts the $2\pi$ system to decay isotropically in $\gamma + \phi$ and like $\cos^2(\phi - \gamma)$ or $\sin^2(\phi - \gamma)$ (or a mixture thereof) depending on whether the pomeron behaves as a natural or unnatural parity object $^9$ ($\phi$ is the angle that the photon polarization vector is rotated around the photon direction out of the reaction plane defined by the proton momenta $^{10}$).

Present experiments appear to have too low statistics to draw any definite conclusions for $m_{\pi\pi} \geq 500$ MeV $^{11}$.

3. Duality plus resonance saturation in the diffraction dissociation.

If one does not require a dual resonance description of the dissociation vertex, one could imagine the resonance contributions obeying SCHC and, in addition, OPE terms not subject to SCHC. This, however, appears difficult to incorporate into a picture in which the pomeron is obtained by unitarity bootstrap from (non-pomeron) dual amplitudes. In any case, the generally accepted interpretation of the $A_1$ phenomenon as a strong support for duality $^{12}$ would have to be reconsidered, since the Deck effect violates SCHC.

In conclusion, SCHC has such a strong impact on duality considerations for diffractive production reactions that one should further investigate its range of validity $^7$, in particular in those regions of phase space where multiperipherality is expected to hold best.

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REFERENCES


   It is difficult whom to give credit for the postulate of SCHC, in diffractive two-body reactions, which, as a working principle was already used in the early days of the absorptive model. See also the discussion of:


5) See, e.g., Chan Hong-Mo, CERN Topical Conference on High Energy Collisions of Hadrons (1968), and literature quoted there.


9) W.J. Meggs and K. Schilling, private communication.

10) For details of notation, see:

11) P. Seyboth, private communication.

FIG. 1

FIG. 2