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VECTOR DOMINANCE MODEL AND THE PRODUCTION OF $\pi^{\pm}$ MESONS

WITH POLARIZED PHOTONS

A. Białas *)

CERN - Geneva

and

K. Zalewski

Institute of Nuclear Research, Cracow

A B S T R A C T

It is shown that the predictions of the vector dominance model agree reasonably well with the recent data on the production of π^+ and π^- mesons by polarized photons. The result is achieved by evaluating the ρ production data in the Donohue-Högaasen reference frame.

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*) On leave from Jagellonian University and Institute of Nuclear Physics, Cracow, Poland.

A serious discrepancy between the predictions of the vector dominance model of photoproduction and the measurements of π^+ and π^- production off nucleons by polarized photons was reported recently ¹⁾. In the present paper we would like to point out a possible explanation of this difficulty. Our main conclusion is that, if suitably interpreted, the existing data do not show any sizeable deviation from the vector dominance model.

The predictions of the vector dominance model for photoproduction of π^+ and π^- mesons off nucleons are usually expressed in the form of the two relations ²⁾

$$\frac{1}{2}(\sigma^+ + \sigma^-) = \beta \left(\sigma_{\perp\perp}^S + \frac{1}{9} \sigma_{\perp\perp}^\omega \right) \quad (1)$$

$$A \equiv \frac{\sigma_{\perp\perp}^+ + \sigma_{\perp\perp}^- - \sigma_{\parallel\parallel}^+ - \sigma_{\parallel\parallel}^-}{2(\sigma^+ + \sigma^-)} = \frac{\sigma_{\perp\perp}^S + \frac{1}{9} \sigma_{\perp\perp}^\omega}{\sigma_{\perp\perp}^S + \frac{1}{9} \sigma_{\perp\perp}^\omega} \quad (2)$$

where $\sigma_{\perp\perp}^\pm, \sigma_{\parallel\parallel}^\pm$ denote the differential cross-sections for production of $\pi^\pm$ mesons by the photons polarized perpendicular and parallel to the scattering plane, respectively; $2\sigma^\pm = \sigma_{\parallel\parallel}^\pm + \sigma_{\perp\perp}^\pm$. Furthermore,

$$\sigma_{ij}^V = g_{ij}^V \sigma^V \quad (3)$$

where g_{ij}^V are the density matrix elements and σ^V the differential cross-sections for the process $\pi^- p \rightarrow V n$. Finally $\beta = \alpha\pi / g_s^2 \approx (4 \pm 1) 10^{-3}$ ³⁾.

It is clear from formulae (1) and (2) that, since these formulae contain the density matrix elements of vector mesons, the values of their right-hand sides depend on the reference frame in which the matrix elements are calculated. Thus, the results, when calculated, e.g., in helicity and in Jackson frames, will be rather different. This introduces a certain ambiguity in the interpretation

of the experimental data because it is impossible to justify the choice of any given reference system with the z axis in the scattering plane without further assumptions ^{4),5)}.

Therefore, in order to disprove the vector dominance model of photoproduction of π^+ and π^- mesons, one has to show that there exists no frame of reference in which both formulae (1) and (2) are valid.

In the present paper we investigate this problem and show that there exists a frame of reference in which the predictions of the vector dominance model are fulfilled by the existing data. This is the so-called Donohue-Högaasen frame ⁶⁾, which is defined by the condition ⁷⁾

$$\text{Re } g_{10} = 0 \quad (4)$$

Before discussing experimental data, we would like to rewrite the relation (1) in the way which is more suitable for further analysis. It is easy to see that the relation (1) can be, using (2), transformed into

$$\frac{1}{2}(\sigma_{\perp}^{+} + \sigma_{\perp}^{-}) = \beta \left[\sigma_{1,1}^s + \sigma_{1,-1}^s + \frac{1}{9}(\sigma_{1,1}^{\omega} + \sigma_{1,-1}^{\omega}) \right] \quad (5)$$

The set of relations (1) and (2) is equivalent to (5) and (2). However, Eq. (5) enjoys a property which is very important for our investigation. Namely, it is invariant with respect to any rotation of the vector-meson reference frame around the normal to the scattering plane ⁸⁾. Therefore relation (5) is not affected by the ambiguity we are concerned with. On the contrary, as shown below, relation (2) is rather sensitive to the choice of the reference frame of vector meson.

Figure 1 ^{1),9)-14)} shows the comparison of relation (2) with experimental data in helicity, Jackson and Donohue-Högaasen frames of reference. It is clear from this figure that the data in the Donohue-

Högaasen system agree with relation (2) ¹⁵⁾. One sees, furthermore, that relation (2) is indeed quite sensitive to the choice of the reference frame.

The comparison of relation (5) with the data is presented in Fig. 2 ^{1),9)-14),16)-19)}. The prediction from the vector meson production agrees, within the experimental errors, with the photoproduction points.

The experimental test of relation (1) in the Donohue-Högaasen frame is given in Fig. 3 ^{9)-14),16)-19)}. It is seen that the use of the Donohue-Högaasen frame of reference does not spoil the rough agreement between relation (1) and the data.

In conclusion we would like to point out that :

- (i) There exists at present no significant discrepancy between the experimental data and the vector dominance model of the π^+ and π^- photoproduction off nucleons.
- (ii) The existing data indicate that the extrapolation of the scattering amplitudes in the vector meson mass from 0 to m_ρ , if performed in the Donohue-Högaasen frame of reference, introduces no significant corrections to the vector dominance model predictions.

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REFERENCES

- 1) C. Geweniger et al. - "Pion Production with Polarized Photons and Test of Vector Dominance Model", DESY 68/44, and private communications from Professor W. Jentschke and Drs. M. Kramer and D. Schildknecht.
- 2) See, e.g., M. Kramer and D. Schildknecht - "Vector Dominance Model and $\pi^\pm$ Production by Unpolarized and Linearly Polarized Photons", DESY 68/33.
- 3) S.C.C. Ting - Proceedings of the Stanford Conference (1967).
- 4) See, e.g., Appendix of Ref. 5).
- 5) H. Fraas and D. Schildknecht - Nuclear Phys. B6, 395 (1968).
- 6) J.T. Donohue and H. Högaasen - Phys.Letters 25B, 554 (1967).
- 7) We consider only the frames with the z axis in the scattering plane. Then, condition (4) defines the frame of reference up to the rotation by $\pi/2$. We fixed the frame by requiring $S_{1-1}/S_{11} = \max$. [Ref. 15].
- 8) See, e.g., Refs. 2) and 6).
- 9) D.H. Miller et al. - Phys.Rev. 153, 1434 (1967).
- 10) L.D. Jacobs - Thesis, UCRL 16877.
- 11) D.R. Clear et al. - Nuovo Cimento 49A, 399 (1967).
- 12) R.L. Eisner et al. - Phys.Rev. 164, 1699 (1967).
- 13) N. Armenise et al. - Nuovo Cimento 54A, 999 (1968), and private communication from Dr. J. Quinquart.
- 14) J.A. Poirier et al. - Phys.Rev. 163, 1462 (1967).
- 15) It can be shown that the quantity $A = S_{1-1}/S_{11}$ takes the extremal value in the Donohue-Högaasen system. It is therefore clear from Fig. 1 that one cannot obtain a better agreement with the data by further rotation of the reference frame 7).
- 16) A.M. Boyarski et al. - Phys.Rev.Letters 20, 300 (1968).
- 17) P. Heide et al. - Phys.Rev.Letters 21, 248 (1968).
- 18) Orsay (I.P.N.)-Bari-Bologna-Firenze collaboration - Proceedings of the Topical Conference of High Energy Collision of Hadrons, CERN Report 68-7 (1968).
- 19) H.O. Cohn et al. - Phys.Letters 15, 344 (1965).

FIGURE CAPTIONS

Figure 1 Comparison of relation (2) with the experimental data in different frames of reference. The vector meson data come from Refs. 9)-14). It was averaged both in energy and momentum transfer. Photoproduction points come from Ref. 1).

Figure 2 Comparison of relation (5) with experimental data. The contribution of the ω production to relation (5) was estimated from Refs. 18) and 19).

Figure 3 Comparison of relation (1) with experimental data in the Donohue-Högaasen frame. The contribution of the ω production was estimated as in Fig. 2.

$$A \equiv \frac{\sigma_{\perp} - \sigma_{\parallel}}{\sigma_{\perp} + \sigma_{\parallel}} = \frac{\sigma_{1-1}^p}{\sigma_{11}^p}$$

VECTOR MESON PRODUCTION

$\circ$ DONOHUE - HØGGAASEN FRAME
 $\square$ JACKSON FRAME
 $\triangle$ HELICITY FRAME

Δ PHOTOPRODUCTION

$-t, \text{GeV}^2$

FIG.1

$$\sigma_1^+ + \sigma_1^- = \frac{\alpha\pi}{\gamma_p^2} (\sigma_{11}^{\rho} + \sigma_{11}^{\rho} + 1/9 \sigma_{11}^{\omega} + 1/9 \sigma_{11}^{\omega})$$

FIG.2

FIG.3