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ROTATION OF FRAME AND THE VECTOR DOMINANCE DISCREPANCY FOR $\pi^{\pm}$ PRODUCTION BY POLARIZED PHOTONS*

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ABSTRACT

Experimental data on $\pi^{\pm}$ production by polarized photons are compared with a Vector Dominance Model prediction which is independent of a possible ambiguity regarding the frame used to evaluate the ρ^{0} density matrix; a discrepancy of more than a factor of two is found.

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The Vector Dominance Model (VDM) has been successfully used to relate the reaction

$$\pi^- p \rightarrow \rho^o n \qquad (1)$$

to the reactions

$$\gamma p \rightarrow \pi^+ n \qquad (2a)$$

$$\gamma n \rightarrow \pi^- p \qquad (2b)$$

initiated by unpolarized photons.[1] A more detailed test of the model can be made by comparing the density matrix elements of the ρ^o in reaction (1) with photo-production data obtained with linearly polarized photons; the model predicts[2]

$$\frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel} = \frac{\rho_{1-1}}{\rho_{11}} \qquad (3)$$

where $\sigma_\perp$ ($\sigma_\parallel$) is the sum of the differential cross sections for reactions (2a) and (2b) for photons polarized perpendicular (parallel) to the plane of production. Experimentally[3] it was found that the VDM prediction was not satisfied when the ρ^o density matrix was evaluated in the standard helicity frame. It has since been shown that the discrepancy cannot be explained by interference effects of the ρ^o with non-resonant background,[4] nor by the neglect of the isoscalar-photon terms.[5]

Since the photon in reactions (2a) and (2b) has mass zero, the choice of frame in which to evaluate the density matrix is somewhat ambiguous.[6] Bialas and Zalewski[7] have taken the point of view that VDM fails only if there exists no frame with z axis in the scattering plane in which agreement can be obtained. They then find agreement for Eq. (3) when the density matrix is evaluated in the Donohue-Högaasen frame.[8]

The VDM relation[9]

$$\sigma_\perp/2 = \frac{\alpha\pi}{\gamma_\rho^2}\left[(\rho_{11} + \rho_{1-1})\frac{d\sigma}{dt}\right]_{\pi^- p \rightarrow \rho^o n} \qquad (4)$$

is independent of rotation of frame about the production normal[10] and makes a convenient test of the model, independent of the possible ambiguity of Bialas and Zalewski. A comparison of the two sides of Eq. (4) is shown in the figure for data[11,12] near 4 GeV/c; the value $\gamma_\rho^2/4\pi = 0.52^{+0.07}_{-0.06}$, as obtained from the reactions $\rho^0 \longleftrightarrow e^+e^-$, has been assumed.[13] The figure contradicts the conclusion[14] of Bialas and Zalewski that agreement is obtained for the absolute values of the cross sections; we find that the VDM predictions of Eq. (4) are a factor of two or three smaller than the measured photoproduction cross sections.

A value for $\gamma_\rho^2/4\pi$ of about 0.2 would be needed to satisfy the model; this is far from the commonly accepted value and is in the wrong direction to explain the recent data on ρ^0 photoproduction from complex nuclei.[15] The systematic errors involved in comparing the different reactions are probably about ±20% and it seems very unlikely that they are responsible for the discrepancy. We thus conclude that the VDM discrepancy remains even when allowing for the ambiguity of frame suggested by Bialas and Zalewski.

REFERENCES

1. A. M. Boyarski et al., Phys. Rev. Letters 21, 1767 (1968); this paper contains references to previous work.
2. M. Krammer and D. Schildknecht, Nucl. Phys. B7, 583 (1968).
3. Chr. Geweniger et al., Phys. Letters 28B, 155 (1968).
4. R. Diebold and J. Poirier, Phys. Rev. Letters 22, 255 (1969).
5. By taking the sum of reactions (2a) and (2b), the isovector-photon and isoscalar-photon interference terms drop out. The isoscalar terms themselves should contribute only a few percent of the isovector terms; see for example L. J. Gutay et al., Phys. Rev. Letters 22, 424 (1969).
6. H. Fraas and D. Schildknecht, Nucl. Phys. B6, 395 (1968).
7. A. Bialas and K. Zalewski, Phys. Letters 28B, 436 (1969).
8. This frame is related to the helicity frame by a rotation about the production normal (y axis); see J. T. Donohue and H. Högaasen, Phys. Letters 25B, 554 (1967).
9. Again, the few per-cent isoscalar-photon terms are neglected.
10. Since the expressions on the two sides of the equation correspond to linear polarizations along the production normal, the equation is independent of rotations about this direction. See Ref. 2 for an explicit derivation.
11. The photoproduction data are taken from:
    P. Heide et al., Phys. Rev. Letters 21, 248 (1968);
    Z. Bar-Yam et al., Phys. Rev. Letters 19, 40 (1967); Ref. 3, and data quoted by B. Richter, Proc. of 14th Int'l. Conf. on High Energy Physics, 3 (1968).
12. The ρ^0 data are taken from the compilation of the Notre Dame-Purdue-SLAC Collaboration, P. B. Johnson et al., Phys. Rev. 176, 1651 (1968). The

density matrix elements were obtained for these particular momentum-transfer intervals by fitting the data in the helicity frame, including terms corresponding to an s-wave background and s-p interference.

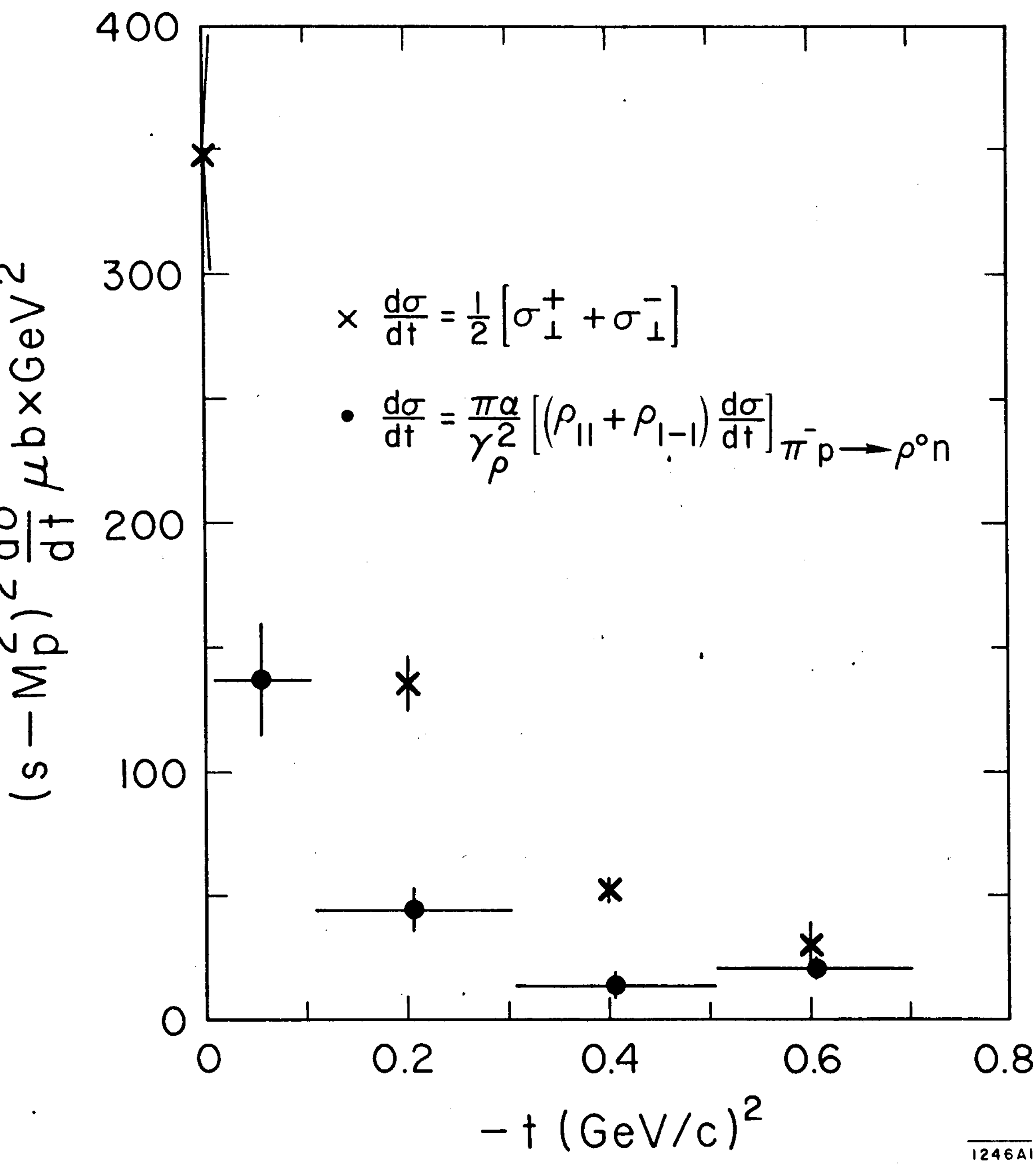
13. S. C. C. Ting, Proc. of 14th Int'l. Conf. on High Energy Physics, 43 (1968).

14. Figure 2 of Ref. 7 is devoted to the same test of VDM as is the figure of this letter, but with ρ^o data at 2.7 and 8 GeV/c. The 2.7 GeV/c data have large error bars and do not provide much information. The VDM prediction of Ref. 7 based on the 8 GeV/c ρ data looks much like the 4 GeV/c prediction presented here. Assuming the photoproduction cross sections to scale as $(s-M_p^2)^{-2}$ then implies the same discrepancy at 8 GeV/c as at 4 GeV/c.

15. G. McClellan et al., Phys. Rev. Letters 22, 377 (1969);
F. Bulos et al., Phys. Rev. Letters 22, 490 (1969).

FIGURE CAPTION

Comparison of the VDM prediction of Eq. (4) with experiment. The 3.4 GeV photoproduction data are from Ref. 11 and the 4 GeV/c ρ^o data used to make the prediction are from Ref. 12. The factor $(s-M_p^2)^2$ eliminates the energy dependence of the quantities to a good approximation. The value $\gamma_\rho^2/4\pi = 0.52$ was used to make the prediction.



400
300
200
100
0
0
0.2
0.4
0.6
0.8
$(s - M_p^2)^2 \frac{d\sigma}{dt}\ \mu b \times GeV^2$
$\times\ \frac{d\sigma}{dt} = \frac{1}{2}\left[\sigma_\perp^+ + \sigma_\perp^-\right]$
$\bullet\ \frac{d\sigma}{dt} = \frac{\pi\alpha}{\gamma_\rho^2}\left[\left(\rho_{11} + \rho_{1-1}\right)\frac{d\sigma}{dt}\right]_{\pi^- p \to \rho^\circ n}$
$-t\ (GeV/c)^2$
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