SLAC-PUB-514
October 1968
(TH)

A REMARK ON K^+ PHOTOPRODUCTION AND VECTOR DOMINANCE†

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Abstract

It is shown that an actual test of the vector dominance model in K^+ photoproduction is very hard to make because of complications due to crossing. The exchange of only trajectories with the same signature is in disagreement with vector dominance by at least a factor of 2.

†Work supported by the U. S. Atomic Energy Commission

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(Submitted to Physics Letters)

It has been shown[1,2] that the vector dominance model (VDM) of the hadronic electromagnetic current[3] satisfactorily relates the two processes

$$\gamma p \to \pi^+ n \tag{1}$$

and

$$\pi^- p \to V^o n \tag{2}$$

where $$V^o = \rho,\ \omega,\ \phi \quad .$$

Therefore in this note we assume the validity of the VDM in order to investigate the problem of K^+ photoproduction in the reaction:

$$\gamma p \to K^+ \Lambda \tag{3}$$

The VDM assumption results in the relation between amplitudes:

$$T(\gamma p \to K^+\Lambda) = \sum_{V^o = \rho, \omega, \phi} \frac{e}{f_v} T(V^o_{tr} p \to K^+\Lambda) \tag{4}$$

Where V_{tr} means that we take only transversely polarized vector mesons. Unfortunately the process $V^o p \to K^+\Lambda$ is not accessible to experiment but the crossed reaction

$$K^- p \to V^o \Lambda \tag{5}$$

can be studied.

A comparison can be made at 5 GeV since there are accurate measurements of reaction (3) as a function of t at this energy[4] and data for the three processes (5) at 4.1 and 5.5 GeV.[5] However, these latter measurements are statistically rather poor so that a detailed comparison as a function of t is impossible.

We assume that for energies ~5 GeV processes (3) and (5) are dominated by a set of t channel one-particle (or Regge pole) exchanges. For a given exchange i one gets the relation between amplitudes:

$$T_i(V^o_{tr}p \to K^+\Lambda) = \epsilon_i\, T_i\,(K^-p \to V^o_{tr}\Lambda) \tag{6}$$

where $\epsilon_i = \pm 1$. Explicitly we have $\epsilon_i = (-1)^{I_V + J_i}$ where I_V is the isospin of V^o and J_i the spin of the exchanged particle[6] $\left(\text{or } (-1)^{J_i} \text{ is the signature of the trajectory}\right)$.

Obviously relation (6) will not hold if initial and final state absorption, or Regge cuts, play a non-negligible role in these reactions; however, only the differences in absorption between initial and final states of the crossed reactions are involved and not the individual absolute values.

The fact that ϵ_i depends on J_i clearly shows that an <u>actual test of VDM</u> using reactions (3) and (5) is <u>impossible</u> without using specific models describing the processes.[7] This remark also applies to the reactions[8]

$$\gamma p \to \pi^- \Delta^{++} \quad . \tag{7}$$

and

$$\pi^+ p \to V^o \Delta^{++} \quad . \tag{8}$$

Let us nevertheless assume that reactions (3) and (5) are described by only one t channel diagram or by a set of t channel diagrams all having the same signature. Then Eqs. (4) and (6) yield the following theoretical cross section:

$$\frac{d\sigma^{th}}{d\Omega_{cm}}\,(\gamma p \to K^+\Lambda) = \left| \sum_V e^{i\phi_V}\, \frac{e}{f_V}\, \epsilon_V \sqrt{R_V \rho_{11}^{h,v}\, \frac{d\sigma}{d\Omega_{cm}}\,(K^-p \to V^o\Lambda)} \right|^2 \tag{9}$$

Where ϕ_V is the phase of the amplitude for reaction (5), R_V is the phase-space ratio between reactions (3) and (5), $\rho_{ij}^{h,v}$ is the vector meson density-matrix element and the helicity system and $\epsilon_V = (-1)^{I_V}$.

Due to the lack of statistics for reaction (5) we compare the total forward cross sections ($\cos\theta_{cm} > 0$), σ_f. The relevant cross sections at 5.5 GeV are[5]

$$\sigma_f\,(K^- p \to \rho^o \Lambda) = (17 \pm 6)\ \mu b$$

$$\sigma_f\,(K^- p \to \omega\, \Lambda) = (19 \pm 6)\ \mu b$$

$$\sigma_f\,(K^- p \to \phi\, \Lambda) = (30 \pm 9)\ \mu b$$

All three amplitudes are comparable and we therefore expect a large isoscalar contribution which was not the case in π^+ photoproduction. In this context we should mention that ω and ϕ dominance so far has not been experimentally tested.

Let us compute an upper limit of the right hand side of Eq. (9). For this purpose we set $\phi_V = 0$, $\text{sign}\left(\frac{\epsilon_V}{f_V}\right) = +1$ and $\rho_{11}^{h,v} = \frac{1}{2}$. For f_V we use the recently measured $\Gamma(e^+e^- \to V^o)$ from Orsay.[9] We also interpolate the cross sections between 4.1 and 5.5 GeV to get the values at 5 GeV. We finally get:

$$\sigma_f^{th}(\gamma p \to K^+\Lambda) \leq (155 \pm 34)\ nb \tag{10}$$

to be compared with the measured number[4]

$$\sigma_f^{exp}(\gamma p \to K^+\Lambda) = (300 \pm 40)\ nb \tag{11}$$

Thus we conclude that in K^+ photoproduction the exchange of only trajectories with some signature is incompatible with vector dominance.

The reasons for the discrepancy can probably be found in the following (in order of increasing degree of speculation):

(a) trajectories with different signature are exchanged

(b) the factorization property (6) does not hold (cuts ?)

(c) ω and ϕ dominance is not a good approximation.

There is no reason to expect the possibility (a) not to be true. Therefore the possibility of checking (b) and (c) seems remote unless one gets good data on $K^- p \rightarrow V^0 \Lambda$ allowing a study as a function of t in order to study the different contributions.

In conclusion, the test of VDM in K^+ photoproduction is by no means straightforward and one must be very careful in making such a test. However, we may conclude that with the data available so far the exchange of only trajectories with same signature (K, K^*_T ... or K^*_V ...) is incompatible with the VDM.

ACKNOWLEDGEMENTS

We are very grateful to Professor H. Harari for illuminating discussions.

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