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ON DIFFRACTIVE $K\bar{K}$ PHOTOPRODUCTION IN A DUAL RESONANCE APPROACH

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A B S T R A C T

The recently proposed dual resonance model for diffraction dissociation is applied to diffractive $K\bar{K}$ photoproduction.

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In this note we want to investigate the reaction $\gamma P \rightarrow K\bar{K}P$ in the framework of the dual resonance model ¹⁾ for diffraction dissociation ²⁾, which was recently shown to describe well the experimental results for diffractive two-pion photoproduction ³⁾. For $K\bar{K}$ production this model presents some additional theoretically interesting features. It is moreover found to be in full agreement with the existing experimental data, these being, however, rather scanty.

Diffractive K^+K^- photoproduction is illustrated in Fig. 1, with $\mathbb{P}$ denoting Pomeron exchange. Analogously to Ref. 3) we write the corresponding matrix element for $\gamma P \rightarrow K^+K^-P$ as

$$M = e^{\frac{a}{2} t_{PP}} \bar{s} V \quad (1)$$

with $t_{PP} = (p-p')^2$, $\bar{s} = (p+q)^2$, and $a = 5 \text{ GeV}^{-2}$. In terms of

$$\begin{aligned} s &= (k^+ + k^-)^2; \quad t = (q - k^-)^2; \quad u = (q - k^+)^2 \\ s + t + u &= 2m_K^2 + t_{PP}; \quad R^\pm = k^+ \pm k^- \end{aligned} \quad (2)$$

the amplitude V for $\mathbb{P}\gamma \rightarrow K^+K^-$ can be written

$$V = \beta \left\{ \frac{(R_q^+) R_\Lambda^- - (R_q^-) R_\Lambda^+}{(R_q^+)} \epsilon_\Lambda^\mu \right\} A(s, t, u) \quad (3)$$

with ϵ_Λ^μ and β denoting, respectively, the photon polarization and the over-all normalization. In contrast to diffractive two-pion photoproduction (where the 2π system is an isospin one state), here both $I = 0$ and $I = 1$ isospin states can contribute to the invariant amplitude $A(s, t, u)$:

$$A(s, t, u) = \frac{1}{\sqrt{2}} [A_0(s, t, u) + A_1(s, t, u)] \quad (4)$$

Taking the ρ , ω and ϕ trajectories to dominate the s channel of $\pi\gamma \rightarrow K\bar{K}$ and the (degenerate) K and K_A trajectories for the t and u channels, we express the isoscalar and isovector amplitudes A_0 and A_1 in terms of dual resonance components

$$\begin{aligned} A_0 &= \tau C_\phi + (1-\tau) C_\omega \\ A_1 &= C_\rho \end{aligned} \quad (5)$$

with

$$\begin{aligned} C_v &= B(1-\alpha_v^s, -\alpha_K^t) + B(1-\alpha_v^s, -\alpha_K^u) + \eta B(-\alpha_K^t, -\alpha_K^u) \\ v &= \rho, \omega, \phi \end{aligned} \quad (6)$$

Because of its diffractive production, the $K\bar{K}$ system must have the same C parity as the incoming γ , which requires V to be anti-symmetric and hence C_v to be symmetric under t - u interchange. The parameters η and τ describe the relative coupling strengths of the trajectories for K, K_A and ω, ϕ , respectively. The relative weight and sign of $I = 0$ and $I = 1$ contributions to A follow from the absence of the t (or u) channel K pole in $\gamma P \rightarrow K^0 \bar{K}^0 P$.

The trajectories in (6) are given by

$$\alpha_\rho^s = 1 - m_\rho^2 + s + i(s - 4\mu^2) \frac{m_\rho \Gamma_\rho}{m_\rho^2 - 4\mu^2} \Theta(s - 4\mu^2) \quad (7a)$$

$$\alpha_{\omega}^s = 1 - m_{\omega}^2 + s + i(s - 9\mu^2) \frac{m_{\omega} \Gamma_{\omega}}{m_{\omega}^2 - 9\mu^2} \Theta(s - 9\mu^2) \quad (7b)$$

$$\alpha_{\phi}^s = 1 - m_{\phi}^2 + s + i(s - 4m_K^2) \frac{m_{\phi} \Gamma_{\phi}}{m_{\phi}^2 - 4m_K^2} \Theta(s - 4m_K^2) \quad (7c)$$

$$\alpha_K^t = -m_K^2 + t \quad (7d)$$

with masses and widths as quoted in Ref. 4). In the imaginary part of α_{ϕ}^s we have neglected the 3π decay mode of ϕ .

An estimate for the over-all normalization can be obtained from Ref. 3) : there the value β for two-pion photoproduction was found to be $\beta_{\pi\pi} = 4 \text{ GeV}^{-5}$. At the ρ pole, factorization and SU(3) then give ⁵⁾

$$\beta_{K^+K^-} = \beta_{\pi^+\pi^-} \frac{g_{\rho K^+K^-}}{g_{\rho \pi^+\pi^-}} = 1.4 \text{ GeV}^{-5} \quad (8)$$

Furthermore, we choose $\eta = 0$ analogous to Ref. 3), i.e., assume equal K and K_A trajectory coupling strengths. For τ , factorization and SU(3) (with ideal mixing) give

$$\tau = \frac{g_{\rho\gamma\phi}}{g_{\rho\gamma\rho}} \frac{g_{\phi K^+K^-}}{g_{\rho K^+K^-}} = \frac{2}{3} \quad (9)$$

With this set of parameters we find at $P_{\text{lab}} = 4 \text{ GeV}/c$ and for $M_{KK} \leq 1.7 \text{ GeV}$ that $\sigma(\gamma P \rightarrow K^+ K^- P) = 0.75 \mu\text{b}$; the experimental value ⁶⁾ for $3.5 \leq P_{\text{lab}} \leq 5.8 \text{ GeV}/c$ is $\sim 0.6 \mu\text{b}$. From the interval

$1.01 \leq M_{K^+K^-} \leq 1.03$ GeV alone we obtain $\sigma(\gamma P \rightarrow \phi P) \prod_{\phi \rightarrow K^+K^-} = 0.51 \mu b$, while the corresponding experimental value is found to be $0.21 \pm 0.06 \mu b$. This discrepancy is due to SU(3) breaking ⁷⁾ and can in a quark model description of vector meson dominance be related to the difference of total KW and πW cross-sections ; one there finds asymptotically

$$\tau^2 = \frac{2}{3} \frac{2\sigma_{tot}^{KW} - \sigma_{tot}^{\pi W}}{\sigma_{tot}^{\pi W}} \approx \frac{1}{2} \quad (10)$$

Using this value of τ , we obtain

$$\begin{aligned} \sigma(\gamma P \rightarrow K^+K^-P) &= .46 \mu b \quad (M_{K^+K^-} \leq 1.7 \text{ GeV}) \\ \sigma(\gamma P \rightarrow \phi P) &= .26 \mu b \quad (1.01 \leq M_{K^+K^-} \leq 1.03 \text{ GeV}) \end{aligned} \quad (11)$$

in fair agreement with the experimental results. It should be emphasized here, however, that the present statistics (47 events !) do not really allow for more than a very rough test of the employed determination of β and τ .

In Figure 2, we show (with the above [broken SU(3)] values for τ, η, β) the K^+K^- mass spectrum at $P_{lab}^* = 4$ GeV/c. It is seen that the ϕ spike in fact strongly dominates the spectrum, the higher peaks (ρ', ω', ϕ' , etc.) being of the order of 1%.

The proton-proton momentum transfer distribution for the ϕ band ($1.01 \leq M_{K^+K^-} \leq 1.03$) is shown in Fig. 3 together with the data ^{6), 8)-10)} for $\gamma P \rightarrow \phi P$; we have multiplied our predicted curve (calculated at $P_{lab}^* = 4$ GeV/c) by ⁴⁾ $1 + BR(\phi \rightarrow \text{all}/\phi \rightarrow K^+K^-) \simeq 2.11$ to account for the non K^+K^- decay modes of the ϕ . Our results are seen to be in complete agreement with the data. In the ϕ band the predicted slope A (defined as usual by $d\sigma/dt_{pp} \sim e^{At_{pp}}$) is $A \simeq 5 \text{ GeV}^{-2} \simeq a$, for $0 \leq |t_{pp}| \leq 0.6 \text{ GeV}^2$. It should be noted that in this model the ϕ

pole alone gives rise to the momentum transfer dependence $e^{at_{PP}}$. [cf. Eq. (1)] of the $PP \rho$ form factor, as is also the case for the ρ pole in two-pion photoproduction ³⁾. There, however, the momentum transfer dependence in the ρ band is appreciably modified by the strongly t_{PP} dependent pion exchange contribution ; the narrow ϕ width together with the weaker t_{PP} dependence of K exchange suppress such modifications here. It is possible to extend the additive quark model to non-forward directions and thus determine the diffractive slopes for the elastic scattering of vector mesons on nucleons ¹¹⁾ ; while this, together with vector meson dominance, in fact accounts for the observed ϕ slope, it does not agree with recent ρ slope data ¹²⁾. Multiperipheral graphs based on meson exchange ¹³⁾, on the other hand, lead to photoproduction slopes always larger than those for the corresponding elastic meson-nucleon process.

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FIGURE CAPTIONS

- Figure_1 Diffraction dissociation diagram.
- Figure_2 K^+K^- mass spectrum calculated for $P_{lab}^1 = 4 \text{ GeV/c}$.
- Figure_3 Proton-proton momentum transfer distribution for $P \rightarrow \emptyset P$:
 (a) for $P_{lab}^1 \leq 6.5 \text{ GeV/c}$;
 (b) for $P_{lab}^1 \geq 11.5 \text{ GeV/c}$.

FIG.1

$m_{K^+K^-}$ (GeV)

FIG.2

FIG.3a

FIG.3b