ELECTROMAGNETIC PRODUCTION OF KAONS ON THE NUCLEON*

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Kaon photo- and electroproduction in all six isospin channels is investigated by means of an isobaric model. It is found that existing models can only partially describe the current experimental data. Moreover, the extracted coupling constants are mostly inconsistent with the prediction of SU(3) symmetry or the information from hadronic reactions. In order to further analyze this problem, we introduce a form factor at the hadronic vertices KNY (with $Y = \Lambda$ or Σ) and study its behavior qualitatively. Our result suggests the need of more accurate experiments, especially in the charged Σ and the neutral K^0 channels.

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The electromagnetic production of kaons has the potential to become a powerful tool in the investigation of reactions involving strangeness, a degree of freedom not available with pions and eta mesons. The main problem faced by phenomenological models over the last thirty years, apart from the limited energy region, is that there is little guidance as to which resonances to include in the model. Furthermore, the extracted Born coupling constants are inconsistent with the SU(3) prediction or those yielded by the kaon-nucleon or hyperon-nucleon scattering, and the χ^2 remains fairly large.

In previous studies [1, 2] we have investigated kaon photo- and electroproduction for the four $K\Sigma$ channels and found that the inclusion of the few available data for the reactions $\gamma p \to K^0\Sigma^+$ and $\gamma n \to K^+\Sigma^-$ in the fit can drastically reduce the leading coupling constants $g_{K\Lambda N}$ and $g_{K\Sigma N}$

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in the process. This result suggests the need to include a form factor at the hadronic vertices, since such a form factor is expected to reduce the divergent Born terms at higher energies. However, the presence of a form factor at the KNY vertices leads to the violation of gauge invariance, since different diagrams give different contributions of the form factor. There are several ways to remedy the situation, the simplest is to just multiply the whole amplitude with an overall form factor. Another possibility would involve minimal substitution which was motivated by Ohta [3].

In the present study we use the isobaric model developed in Ref. [1] with a slight modification in order to describe the elementary processes of photo- and electroproduction in all six isospin channels. To relate all production channels, we employ the isospin formalism and use some information on resonance decay widths [1]. Our model consists of the standard Born terms along with the intermediate K^*-exchange. Furthermore, we have incorporated the N^* resonances $S_{11}(1650)$ and $P_{11}(1710)$ for $K\Sigma$ and $K\Lambda$ productions, as well as the Δ resonances $S_{31}(1900)$ and $P_{31}(1910)$ for the $K\Sigma$ channels. Our choice of resonances was guided by our goal to draw qualitative conclusions about the behavior of coupling constants with a simple model that contains as few parameters as needed to achieve a reasonable χ^2.

TABLE I

The Born coupling constants from SU(3) prediction, fit to $K^+\Sigma^0$ data only (I) [6], fit to all $K\Sigma$ data (II) [1], fit to all $K\Sigma$ and $K\Lambda$ data (III), and fit to all data including the preliminary data [2] and using the hadronic form factor (IV).

	SU(3)	I	II	III	IV
$g_{K\Sigma N}/\sqrt{4\pi}$	1.09	2.72	0.13	0.53	1.13
$g_{K\Lambda N}/\sqrt{4\pi}$	−3.74	−1.84	0.51	−2.10	−3.09
Λ_c (GeV)	-	-	-	-	0.859
N	-	86	190	671	754
χ^2/N	-	3.15	5.30	7.18	5.94

To obtain a qualitative understanding of the amplitude with a hadronic form factor, we multiply the whole amplitude with a monopole form factor $F(\Lambda_c, t) = (\Lambda_c^2 - m_K^2)/(\Lambda_c^2 - t)$, where Λ_c represent the corresponding cut off parameter. The result of our analyses along with that of former studies are shown in Table . As shown in set IV of this Table, the impact of the hadronic form factor is to increase the leading Born coupling constants to values consistent with the SU(3) prediction and to reduce the χ^2/N significantly using the entire data set. In Fig. 1, we show the result for total

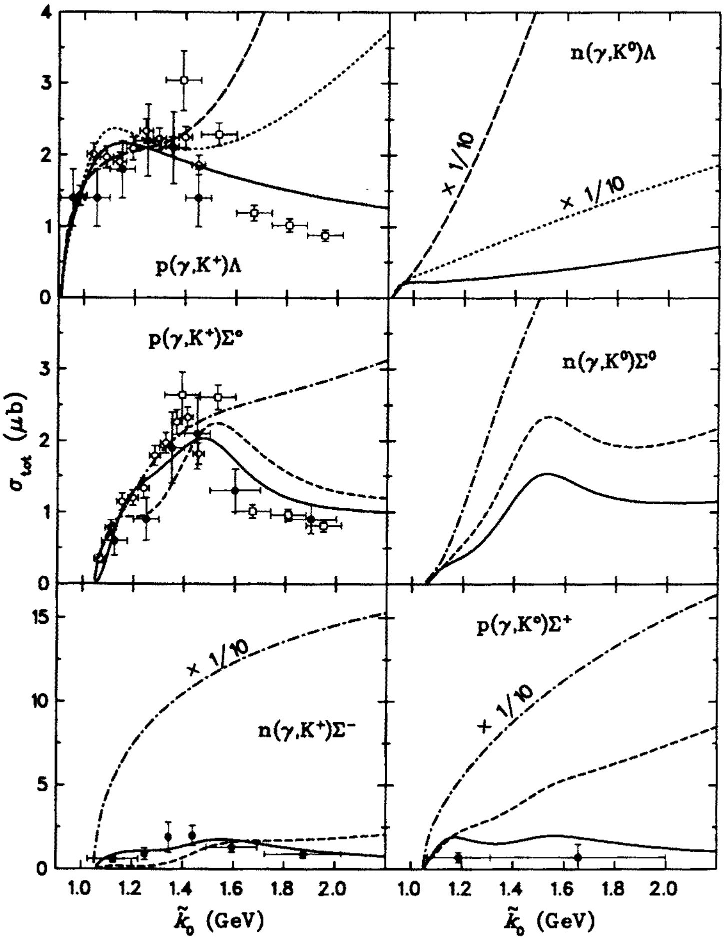

Fig. 1. Total cross section in kaon photoproduction. The dotted (dashed) curve in $K\Lambda$ represents the model from Ref. [5] ([4]). The dash-dotted (dashed) curve in $K\Sigma$ comes from set I (set II), while the solid curve fits all data in the $K\Lambda$ and $K\Sigma$ channels (set IV).

cross sections of photoproduction in all six isospin channels. Obviously, the hadronic form factor can successfully suppress the divergence of the cross section at higher energies, whereas the $K^+\Lambda$ channel models from Refs. [4, 5] overestimate the cross section already at photon energy about 1.5 GeV. Besides diverging at higher energies in the $K^+\Sigma^0$ channel, the model of Ref. [6] overpredicts experimental data in charged Σ channels by up to two orders of magnitude. Aside from the $n(\gamma, K^0)\Sigma^0$ channel, where no experimental data are available, Fig. 1 shows that a significant improvement to our former result [1] has been made by our present model. New and more accurate data, especially in the charged Σ and the $n(\gamma, K^0)\Lambda$, as well as the $n(\gamma, K^0)\Sigma^0$ channels are therefore needed to improve the model. In conclusion, we have investigated kaon photo- and electroproduction in all six isospin channels simultaneously and shown that the use of hadronic form factor can significantly improve the isobaric model, especially at higher energies.

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