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NEW RESULTS IN THE PARTIAL WAVE ANALYSIS OF THE $K^-\omega$ SYSTEM IN THE REACTION $K^-p \to K^-\pi^+\pi^-\pi^0p$ * †

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ABSTRACT

Preliminary results are presented from the first large-statistics partial wave analysis of the $K^-\omega$ system produced in the reaction $K^-p \to K^-\pi^+\pi^-\pi^0p$ at 11GeV/c observed with the LASS spectrometer at SLAC. The analysis is based on the moments of the joint angular distributions of the decay to the $K^-\omega$ system, with subsequent ω decay to $\pi^+\pi^-\pi^0$. The resulting $J^P = 2^-, 2^+$and 3^- amplitudes exhibit resonant behavior, and are discussed in the context of the relevant Breit-Wigner fits.

1. Introduction

Although much has been learned about the spectroscopy of the strange meson sector from amplitude analysis of the $K\pi$, $K\eta$ and $K\pi\pi$ systems, the $K\omega$ system has the potential of providing useful information of a complementary nature, especially concerning states of unnatural spin-parity. For example, precise measurements of branching fractions (BF) to $K\omega$, together with results from the $K\rho$,$K\phi$ and $K^*\pi$ channels should provide precise checks of flavor SU(3) symmetry. In this regard, the present analysis constitutes the first high-statistics study of the $K\omega$ system, and yields the most accurate measurements to date of several such branching fractions.

2. Data and Results

Over 10^5 $K^-\omega p$ events have been reconstructed from the reaction $K^-p \to K^-\pi^+\pi^-\pi^0p$ at 11GeV/c observed with the Large Aperture Superconducting Solenoid

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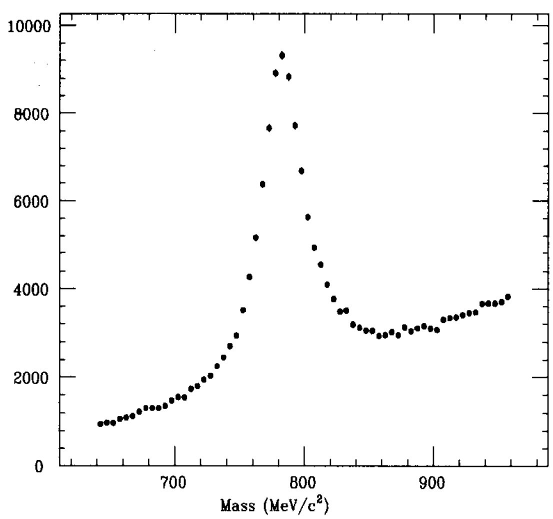

Figure 1: The $\pi^+\pi^-\pi^0$ mass

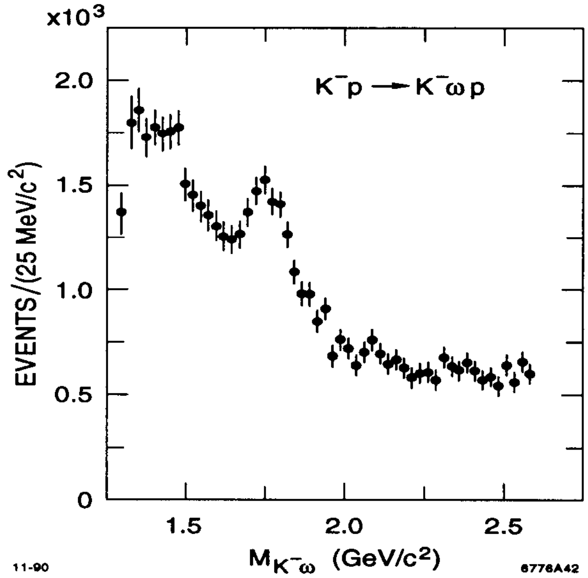

Figure 2: $K\pi^+\pi^-\pi^0$ mass

(LASS) spectrometer[1] at SLAC. Initially, events with 4 charged tracks and net charge zero from the primary vertex were chosen. These events were then subject to geometric and kinematic fits (MVFit). Four-constraint (4C) kinematic fits are used to exclude the $K^-\pi^+\pi^-p$ events; events with good 4C confidence level ($CL_{4C} > 10^{-10}$) are thus removed. Also, the events with bad 1C confidence level ($CL_{1C} < 10^{-2}$) are removed. Particle identification methods using the cylindrical chambers (dE/dx), a time of flight hodoscope and two threshold Cerenkov counters are applied to further purify the data sample. The 4-momentum transfer squared between the target proton and the recoil proton, $t' = |t_{p\to p}| - |t_{p\to p}|_{min}$ is restricted to $0.1 < t' < 2.0(\mathrm{GeV/c})^2$ to select events containing a peripherally produced $K^-\omega$ system; the lower cut-off is made since, for $t' \lesssim 0.08(\mathrm{GeV/c})^2$, the resulting slow proton almost always does not escape the target.

The $\pi^+\pi^-\pi^0$ mass spectrum shows a clear ω signal (Figure 1), with signal to background ratio about one to one in the signal region ($0.72 - 0.84$ GeV/c²). To remove the effect of the background, the events in the side-band regions ($0.64 - 0.70$ GeV/c² and $0.86 - 0.92$ GeV/c²) are given weight of -1 in the moments calculation, while those in the ω signal region are given $+1$. The uncorrected weighted moments, representing the joint decay moments of the $K^-\omega$ and subsequently ω into 3π's, are given by

$$H(LMlm) = \sum_i w_i [D^L_{Mm}(\Omega_1) D^l_{m0}(\Omega_2)]_i.$$

$0 \le L \le 6$
$0 \le M \le 2$
$l = 0,\ 2$
$-2 \le m \le 2$

Table 1: The double moments indices

The solid angle Ω_1 describes the ω direction in the $K^-\omega$ rest frame, Ω_2 describes the normal to the ω decay plane, and w_i is the above-mentioned weight for the ith event. This background subtraction procedure assumes that there is no interference between the ω and the non$-\omega$ 3π background contributing to the moments $H(LMlm)$, and that the background is a linear function of $\pi^+\pi^-\pi^0$ mass; this appears to be a good approximation in general. However, for the $H(0000)$ moment, which describes the $K^-\omega$ mass spectrum, the background is not well described by a linear function. For this moment, the background is parametrized by a quadratic function, and the ω lineshape is fitted to measure the signal contribution. The $K^-\omega$ mass spectrum reconstructed by this method is shown in Fig. 2.

To remove the background due to baryon resonance production, events with $M_{p\omega} < 2.28\text{GeV/c}^2$ or $M_{pK} < 2.0\text{GeV/c}^2$ are eliminated. Monte Carlo samples are used to compute the acceptance correction matrix $A^{LMlm}_{L'M'l'm'}$ in order to obtain the acceptance-corrected moments $H_c(LMlm) = (A^{LMlm}_{L'M'l'm'})^{-1} H(L'M'l'm')$. Using the expressions for the moments in terms of the ampliudes as in the paper by Martin and Nef,[2] a χ^2-minimization fit to the $H_c(LMlm)'$s is made to obtain the real and imaginary parts of the partial wave amplitudes. The range of the indices L, M, l, m, are shown in Table 1. The 1^+ wave is dominant in the $K^-\omega$ threshold region and also present in the $1.7 - 1.8\text{GeV/c}^2$ region; its structure is not well-understood at present and will not be discussed further in this preliminary report. Resonant structures are observed for the 2^- and 3^- waves in the $1.7 - 1.8\text{GeV/c}^2$ region, and for the 2^+ wave in the $1.4 - 1.5\text{GeV/c}^2$ region; these correspond to the production of $K_2(1770)$, $K_3^*(1780)$ and $K_2^*(1430)$, respectively. Breit-Wigner lineshape fitting has been performed for these waves.

Figure 3 shows the amplitudes of the 2^- waves. Models using one B-W resonance (solid curve) and two B-W resonances (dotted curves) with the same width value, which was determined from the 1 B-W fit, have been applied to simultaneously fit the three 2^- waves showing peaks, i.e. 2^-0^+P, 2^-0^+F and 2^-1^+F. The results of both fits are shown in Table 2.

The productions of $K_2^*(1430)$ and $K_3^*(1780)$ are compared with the other reactions ($K\eta p$,[3] $K\pi p$[4]) in the same experiment. Figures 4 and 5 show the intensities of the 2^+1^+D (or D_+) and 3^-1^+F (or F_+) waves in the various decay channels, corrected for the unseen decays. The solid curves represent the B-W resonance fits with the same

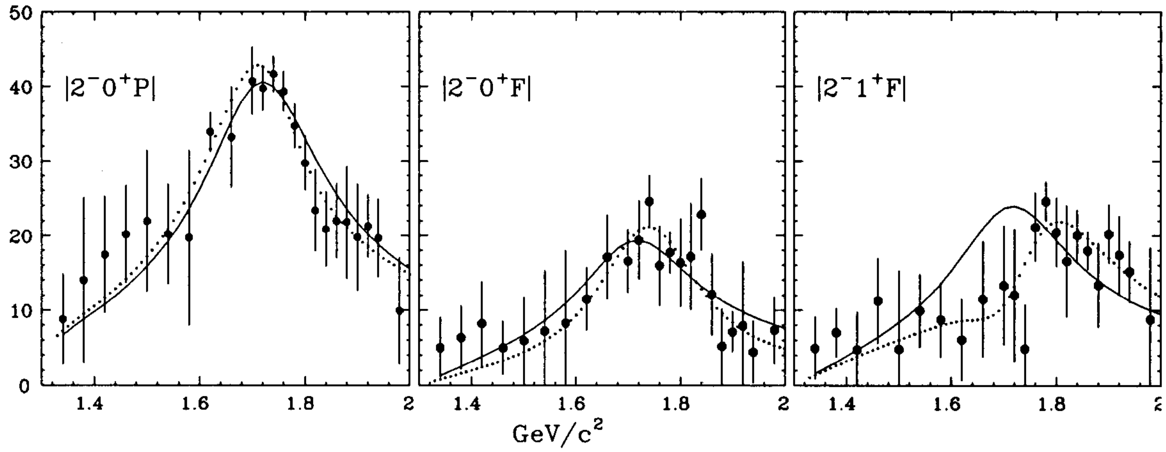

Figure 3: The 2^- wave amplitudes

Fit	Resonance	Mass (MeV/c^2)	Width (MeV/c^2)	χ^2/dof.
one B-W		1721 ± 9	212 ± 23	53.0/49
two B-W's	1	1731 ± 23	212 ± 23	23.6/43
	2	1770 ± 25		

Table 2: The Breit-Wigner fits to the 2^- waves

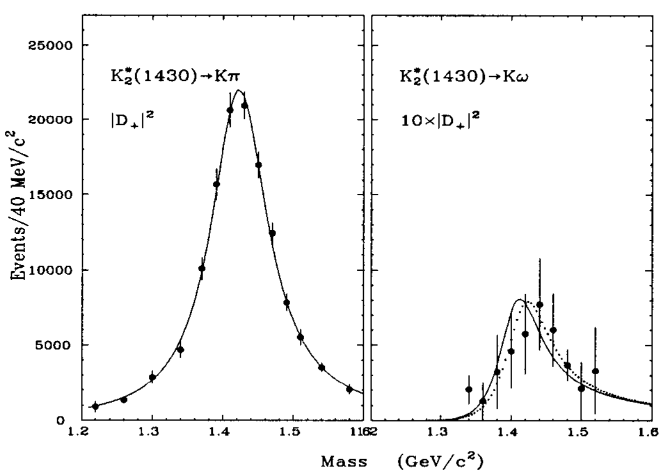

Figure 4: $K_2^*(1430)$ in $K\pi$, $K\omega$ channels

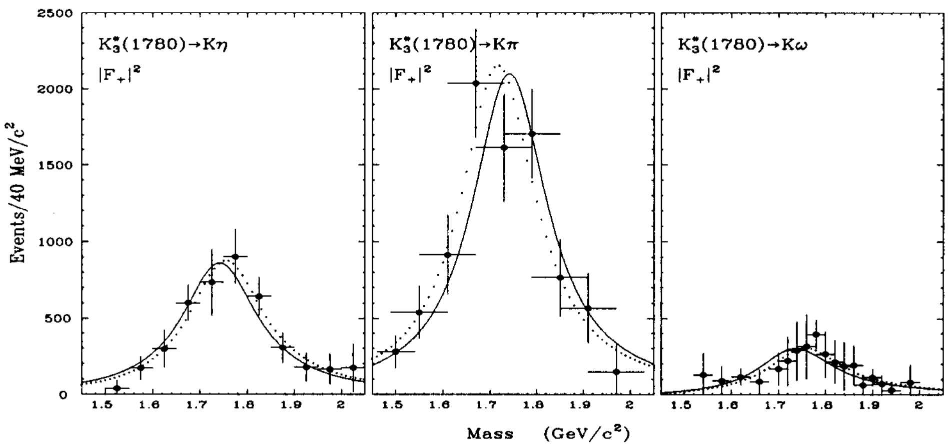

Figure 5: $K_3^*(1780)$ in $K\eta$, $K\pi$, $K\omega$ channels

mode	branching fractions (%)
$K_2^*(1430) \to K\omega$	1.8 ± 0.3
$K_3^*(1780) \to K\omega$	2.9 ± 0.4

Table 3: The branching fractions to the $K\omega$ channel

fitting parameters (mass, width and radius factor) for each channel, while the dotted curves show the B-W fits with free mass parameter for each channel. By comparing the peak values of the B-W fits, the branching fractions have been measured to give the following results:

$$\frac{\mathrm{BF}(K_2^*(1430) \to K\omega)}{\mathrm{BF}(K_2^*(1430) \to K\pi)} = 3.7 \pm 0.6\ \%$$

$$\frac{\mathrm{BF}(K_3^*(1780) \to K\omega)}{\mathrm{BF}(K_3^*(1780) \to K\pi)} = 15 \pm 2\ \%.$$

Then by using the corresponding PDG[5] values for the absolute branching fractions to $K\pi$, we obtained the absolute branching fractions to $K\omega$ channel as in Table 3.

3. Conclusion

A high-statistics study of the $K^-\omega$ system has been performed using a data sample at least 25 times larger than in any other experiment. Partial wave analysis using 22 partial waves with the $K^-\omega$ system spin up to 3 has revealed $K_3^*(1780)$ decay into $K\omega$ for the first time, and also a clear signal for $K_2^*(1430)$. Branching fractions are measured. The observed resonant structure of the 2^- wave has been studied.

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