EVIDENCE FOR DOUBLE ϕ PRODUCTION IN THE REACTION $K^-p \rightarrow \phi\phi\Lambda/\Sigma^0$
AT 18.5 GeV/c

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ABSTRACT

Evidence is found for the reaction $K^-p \rightarrow \phi\phi\Lambda/\Sigma^0$ at 18.5 GeV/c. The total cross section is estimated to be 190 ± 30 nb (130 ± 20 nb for $m(\phi\phi) < 2.7$ GeV). A comparison with the reaction $\pi^-p \rightarrow \phi\phi n$ at 16 and 23 GeV/c shows a suppression factor of the order of 4 going from K to π beams, which is much lower than that found for single ϕ production.

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We report the first measurement of the cross section for the reaction

at 18.5 GeV/c incident momentum.

Reaction (1) is of interest because it allows the comparison of $\phi\phi$ production via an OZI allowed process with existing data at neighbouring energies [1] on the reaction

Reaction (2) is expected to proceed through a violation of the OZI rule and it has been suggested that intermediate gluon bound states can exist with a large decay branching ratio into $\phi\phi$ [2]. The data come from an experiment performed using the CERN Ω' spectrometer [3]. Details of the apparatus, trigger conditions and data processing have been given in previous publications [4]. The total beam flux sensitivity is 12 events/nb.

The events belonging to reaction (1) were selected from the 791, 250 four-prong charge conserving events requiring the Cerenkov mass assignment to be compatible with the K mass. Due to the limited Ω' set-up used in the present experiment we were not able to detect the charged decay of the recoiling Λ which has a low momentum in reaction (1).

Assigning the kaon mass to all the charged particles and labelling the triggering one K_1^+ a strong ϕ signal (fig. 1(a)) is apparent in the $K_1^+ K_{1,2}^-$ mass spectrum (two entries per event). We have selected this ϕ (say ϕ_1) in the mass range

$$1.009 \leq m(K^+ K^-) \leq 1.030 \text{ GeV} \quad (3)$$

and then we have computed the missing mass to the $\phi_1 K^+ K^-$ system: at this point no evident Λ/Σ^0 signal is seen because of the large background. However, the scatter plot $m(K^+ K^-)$ vs. the missing mass to the $\phi_1 K^+ K^-$ system ($MM(\phi_1 K^+ K^-)$) (fig. 1(b)) shows an accumulation of events in the region of intersection of the Λ/Σ^0 band and the band of a second ϕ (say ϕ_2). Reaction (1) was then selected by using (3) to select ϕ_1 and ϕ_2 and

$$1.05 \leq MM(\phi\phi) \leq 1.25 \quad (4)$$

to define the Λ/Σ^0 region.

Since we are interested in forward $\phi\phi$ production we applied a further cut in the Van Hove plot for the three-body reaction (1) by requiring

$$\alpha = \arctan \frac{p_L^*(\phi_1) - p_L^*(\phi_2)}{\sqrt{3}p_L^*(\Lambda/\Sigma^0)} \geq 130^\circ \quad (5)$$

where p_L^* are the longitudinal centre of mass momenta. A final cut

$$t'_{p \rightarrow \Lambda/\Sigma^0} \leq 1.0 \text{ GeV}^2 \quad (6)$$

was also applied to the data.

Using the selection (4), fig. 2 shows the scatter plot $m(K_2^+, K_{2,1}^-)$ vs. $m(K_1^+, K_{1,2}^-)$ where two combinations per event enter in the plot. A strong ϕ_1 is evident together with an accumulation around the region of ϕ_2 . Fig. 3(a) (3(b)) shows the $\phi_1(\phi_2)$ signal when $\phi_2(\phi_1)$ was selected according to (3) and Λ/Σ^0 according to (4). Selecting only the two ϕ 's, fig. 3(c) shows the missing mass $MM(\phi\phi)$.

In order to compute the number of $\phi\phi$ events, the scatter plot $m(K_2^+, K_{2,1}^-)$ vs. $m(K_1^+, K_{1,2}^-)$ has been divided into nine regions corresponding to the three bands (0.988-1.009), (1.009-1.030) and (1.030-1.051)GeV on each axis. The numbers of events, N_i ($i = 1,9$), in these regions are shown in table 1. The estimation of the signal and background has been obtained using the formula

$$N_{\phi\phi} = N_5 - \frac{N_2 + N_4 + N_6 + N_8 - \frac{N_1 + N_3 + N_7 + N_9}{2}}{2}$$

This procedure gives 94 $\phi\phi$ events in sector 5 and corresponds to a 1:1 signal to background ratio. The resulting $\phi\phi$ mass spectrum for the total 186 events (including the 92 background events) is shown in fig. 4(a).

The geometrical acceptance of our apparatus for reaction (1) (fig. 4(b)) was then computed, generating by Monte-Carlo this reaction according to the observed t' distribution. Each ϕ was allowed to decay isotropically in its centre of mass system and the four kaons were traced through the Ω' system taking into account the efficiency of the wire chambers. The triggering conditions were then imposed.

The $\phi\phi$ spectrum obtained by subtracting the background and weighting for the geometrical acceptance is shown in fig. 4(c) where an accumulation in the region around 2.2 GeV appears together with a long tail.

We have then computed the corrections for losses due to the cuts in the ϕ_1 , ϕ_2 and Λ/Σ^0 mass spectra, for absorption of K's in the target, the trigger efficiency and the ϕ branching ratio into K^+K^- . In order to estimate the background under the Λ/Σ^0 we have applied the same procedure as above (using formula (7)) to obtain the number of $\phi\phi$ events in side bands to the Λ/Σ^0 region. This leads to a final estimate of 70 $\phi\phi\Lambda/\Sigma^0$ events.

The total cross section for reaction (1) is

$$\sigma_{\text{tot}} = 190 \pm 30 \text{ nb}$$

while the events belonging to the region $m(\phi\phi) < 2.7 \text{ GeV}$ lead to a cross section of

$$\sigma_{m(\phi\phi) < 2.7} = 130 \pm 20 \text{ nb}$$

This last result has to be compared with $40 \pm 10 \text{ nb}$ at 16 GeV/c and $23 \pm 2 \text{ nb}$ at 23 GeV/c in the π -induced reaction (2). This gives a reduction factor of ~ 4 in going from a K^- to a π^- beam.

Single ϕ production by K and π beams has been compared at 6 GeV/c [5]. It is found that

$$\sigma(K^-p \rightarrow \phi\Lambda)/\sigma(\pi^-p \rightarrow \phi n) \sim 60$$

The same order of magnitude of suppression is found when comparing ω and ϕ production by a π beam [6].

In conclusion, our data show a suppression factor of about 4 in $\phi\phi$ production going from K to π beams, which is much lower than that found for single ϕ production.

REFERENCES

- [1] T. Armstrong et al., Nucl. Phys. B196 (1982) 176;
A. Etkin et al., Phys. Rev. Lett. 40 (1978) 422.
- [2] J.D. Bjorken, SLAC-PUB-2366 (1979).
- [3] Omega Prime Project Working Group, CERN/SPSC 77-70, SPSC/T 17 (1977).
- [4] T. Armstrong et al., Nucl. Instr. Meth. 175 (1980) 543;
T. Armstrong et al., Phys. Lett. 110B (1982) 77.
- [5] D.S. Ayres et al., Phys. Rev. Lett. 32 (1974) 1463.
- [6] S. Okubo, Phys. Rev. D16 (1977) 2336.

TABLE 1

Number of events observed in the 9 regions in which the scatter plot $m(K_2^+, K_{2,1}^-)$ vs. $m(K_1^+, K_{1,2}^-)$ was divided after having imposed the cuts (4), (5) and (6) (see text) to the data

$m(K_2^+, K_{2,1}^-) \text{ GeV}$	1.051	16 (3)	108 (6)	33 (9)	
	1.030	12 (2)	186 (5)	42 (8)	
	1.009	9 (1)	56 (4)	11 (7)	
		0.988	1.009	1.030	1.051
		$m(K_1^+, K_{1,2}^-) \text{ GeV}$			

FIGURE CAPTIONS

- Fig. 1 (a) Effective mass $K_1^+ K_{1,2}^-$ for the total four-prong charge conserving sample. Two combinations per event enter in the plot.
- (b) Scatter plot $m(K^+ K_{2,1}^-)$ vs. $MM(\phi_1 K^+ K^-)$.
- Fig. 2 Scatter plot of the mass $K_2^+ K_{2,1}^-$ against the mass $K_1^+ K_{1,2}^-$ for the four-prong charge conserving events which, when the four charged particles have a kaon mass assigned to them, have a missing mass lying in the Λ/Σ^0 mass region. $t'_{p \rightarrow \Lambda/\Sigma^0} < 1 \text{ GeV}^2$ and a cut in the forward sector of the Van-Hove plot (see text) are also applied.
- Fig. 3 (a) Effective mass $K_1^+ K^-$ for events in which the combination $K_2^+ K^-$ lies in the ϕ region. A missing Λ/Σ^0 is also required.
- (b) Effective mass $K_2^+ K^-$ for events in which the combination $K_1^+ K^-$ lies in the ϕ region. A missing Λ/Σ^0 is also required.
- (c) Missing mass to the $\phi\phi$ system.
- Fig. 4 (a) Effective mass $\phi\phi$. The shaded histogram shows the estimated background.
- (b) Acceptance as a function of the $\phi\phi$ mass
- (c) Effective mass $\phi\phi$ after having subtracted the background and weighted by the geometrical acceptance.

Fig. 1

Fig. 2

Fig. 3

Fig. 4