Final state interactions in $K\bar{K}$ pair production*

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Measurements of the $pp \to ppK^+K^-$ reaction at both COSY-11 and ANKE [1] have shown that the interaction of the K^- with the final protons is much stronger than that of the K^+ . Thus, if we define the ratio of the acceptance–corrected distributions in the Kp invariant masses $R_{Kp} = [d\sigma/dM(K^-p)]/[d\sigma/dM(K^+p)]$, then this shows a very strong preference for low values of $M(Kp)$ provided that the invariant mass of the K^+K^- is chosen to be away from the region of the ϕ peak. The three-particle invariant-mass distribution ratio R_{Kpp} shows same behaviour.

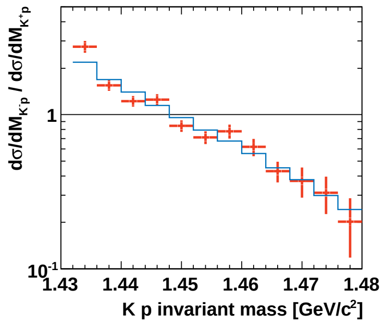

Fig. 1: Ratios of the differential cross sections for the $pp \to ppK^+K^-$ reaction at $Q_{K\bar{K}} = 51$ MeV away from the $\phi(1020)$ region. Experimental data (red) are compared to a Monte Carlo simulation (blue).

The magnitude and mass dependence of both the R_{Kp} and R_{Kpp} ratios can be described quantitatively at all the COSY-11 and ANKE energies by assuming that there are overlapping final state interactions (*fsi*) between the pp and both K^-p pairs. Within the framework of this simple *ansatz*, the only free parameter is an effective K^-p scattering length of $|a_{\bar{K}p}| = 1.5$ fm.

Although the above *ansatz* describes the vast bulk of all the available data, there is evidence of $K\bar{K}$ *fsi* at very low K^+K^- invariant masses for all beam energies. This is shown clearly in Fig. 2 where, to increase the limited statistics, the average of the ratio of the experimental data to the simulation involving just the K^-p and pp *fsi* is compared to fits that include both K^+K^- plus a charge exchange contribution, where a $K^0\bar{K}^0$ pair is converted into K^+K^- through a *fsi* [2].

Detailed investigation of this coupled channel effect allows to extract ratio of the B_0 and B_1 — the $pp \to ppK\bar{K}$ amplitudes for producing s-wave $K\bar{K}$ pairs in isospin-0 and 1 states, respectively. These amplitudes, which already include the *fsi* in the K^-p and pp channels, are then distorted through a *fsi* corresponding to elastic scattering. The subsequent fitting of the data is best achieved with $|B_1/B_0|^2 = 0.38^{+0.24}_{-0.14}$.

Since the antikaon is so strongly attracted to the proton, it is interesting to investigate its interaction with nuclei. For the simplest of nuclei, this is possible by using the $pp \to dK^+\bar{K}^0$ reaction, which has been recently reanalysed [3]. Similar effects to those observed in the $pp \to ppK^+K^-$ case are also seen here, with the strong tendency for the $\bar{K}^0d$ invariant mass to be lower than that of the K^+d system, as illustrated in Fig. 3.

The analysis is complicated for this reaction by the spin-parity requirement that even near threshold one of the final particles must be in a P-wave. The data show that this is overwhelmingly the K^+, with the $\bar{K}^0d$ being in an S-wave. Such a difference would come about through a strong $\bar{K}d$ attraction. A combined fit to the two data sets with the inclusion of final-state interactions in both the $K^+\bar{K}^0$ and $\bar{K}^0d$ systems has been done. The data is well discribed by the wide $a_0^+(980)$-resonance and $\bar{K}^0d$ *fsi* with typical value of $a_{\bar{K}d} \approx (-1.0 + i1.2)$ fm.

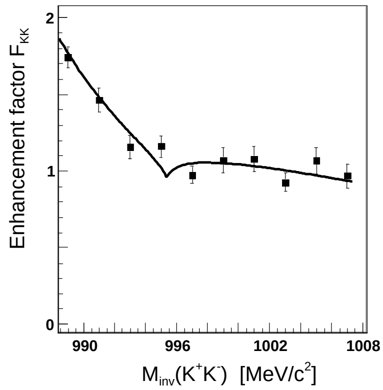

Fig. 2: Ratio of the K^+K^- invariant mass spectra from the $pp \to ppK^+K^-$ reaction to the simulation presented in Ref. [1]. The experimental points correspond to the weighted average of ANKE data taken at 2.65, 2.70, and 2.83 GeV. The solid curve includes both K^+K^- *fsi* and charge exchange $K^0\bar{K}^0 \to K^+K^-$ contributions.

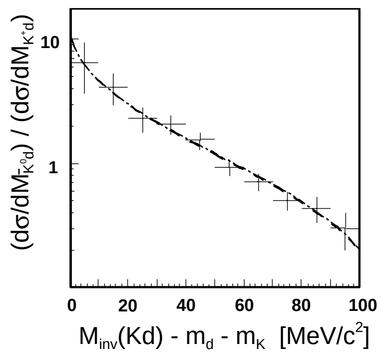

Fig. 3: Ratio of the differential cross section for the $pp \to dK^+\bar{K}^0$ reaction at an excess energy of 104.7 MeV in terms of the $\bar{K}^0d$ and K^+d invariant masses. The dashed curve represents the best fit to the data [3].

The natural continuation of the ANKE programme to study the antikaon-nucleon/nucleus interaction will be to measure the cross section for $pd \to {}^3\mathrm{He}K^+K^-$ to investigate the ${}^3\mathrm{He}K^-$ system.

References:

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[2] A. Dzyuba *et al.*, Phys. Lett. B **668** (2008) 315.
[3] A. Dzyuba *et al.*, Eur. Phys. J. A **38** (2008) 1.

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