Determination of the K^+K^- scattering length from the low-energy ppK^+K^- system produced at COSY-11

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The near threshold production of K^+K^- pairs in proton-proton collisions has been investigated at the cooler synchrotron COSY below and above the threshold for the ϕ meson. The experimental excitation function determined for the $pp \to ppK^+K^-$ reaction differs from the theoretical expectations including proton-proton final state interaction. The discrepancy may be assigned to the influence of K^+K^- or pK^- interaction. Indeed, as shown by authors of reference [1, 2] the inclusion of the pK^-–FSI reproduces the experimental data for the excess energies down to the point at Q = 28 MeV. However, the inclusion of pp and pK^- final state interaction is still not sufficient to describe the data very close to threshold. The discrepancy may be due to the influence of the K^+K^- interaction, which was neglected in the calculations. This encouraged us to preform a generalized Dalitz plot analysis of data measured by COSY-11 at excess energy of Q = 10 MeV and Q = 28 MeV in view of K^+K^- final state interaction [3]. The raw data (represented by black points in Figs. 1(a) and 1(b)) were first binned into intervals of ΔM = 2.5 MeV/c^2 width for the measurement at Q = 10 MeV and intervals of ΔM = 7 MeV/c^2 for the data at Q = 28 MeV, and then for each bin corrected for the acceptance and detection efficiency of the COSY-11 facility [4]. The resulting Goldhaber plots are presented together with the raw distributions in Figs. 1(a) and 1(b). Figures 1(c) and 1(d) show corresponding distributions simulated with Monte Carlo method taking into account the pp and pK^- interaction according to the factorization ansatz proposed by the ANKE collaboration [1]. In order to estimate the strength of the K^+K^- interaction, the derived cross sections were compared to results of simulations generated with various parameters of the K^+K^- interaction taking into account strong final state interaction in the pp and pK^- subsystems. In the simulations we assumed that the overall enhancement factor, originating from final state interaction in the ppK^+K^- system, can be factorised into enhancements in the pp, K^+K^- and two pK^- subsystems:

$$F_{FSI} \;=\; F_{pp}(k_1)\cdot F_{p_1K^-}(k_2)\cdot F_{p_2K^-}(k_3)\cdot F_{K^+K^-}(k_4)\;. \quad (1)$$

where k_j stands for the relative momentum of particles in the rest frame of the appropiate pair. The pK^-– and K^+K^-–FSI was calculated in the scattering length approximation [1]. Using this parametrization we compared the experimental event distributions to the results of Monte Carlo simulations treating the K^+K^- scattering length $a_{K^+K^-}$ as an unknown parameter, which has to be determined. In order to estimate the real and imaginary part of $a_{K^+K^-}$ we constructed the Poisson likelihood χ^2 statistic derived from the maximum likelihood method [5, 6]:

$$\chi^2\left(a_{K^+K^-},\alpha\right) = 2\cdot\sum_i\left[\alpha N_i^s - N_i^e + N_i^e\ln\left(\frac{N_i^e}{\alpha N_i^s}\right)\right]\,, \quad (2)$$

where N_i^e denotes the number of events in the i^{th} bin of the experimental Goldhaber plot, N_i^s stands for the content of the same bin in the simulated distributions, and α is the normalization factor. The data collected at both excess energies have been analysed simultaneously.

The best fit to the experimental data corresponds to $|Re(a_{K^+K^-})| = 0.5\,^{+4}_{-0.5}$ fm and $Im(a_{K^+K^-}) = 3\,\pm\,3$ fm. The final state interaction enhancement factor $F_{K^+K^-}$ in the scattering length approximation is symmetrical with respect to the sign of $Re(a_{K^+K^-})$, therefore only its absolute value can be determined.

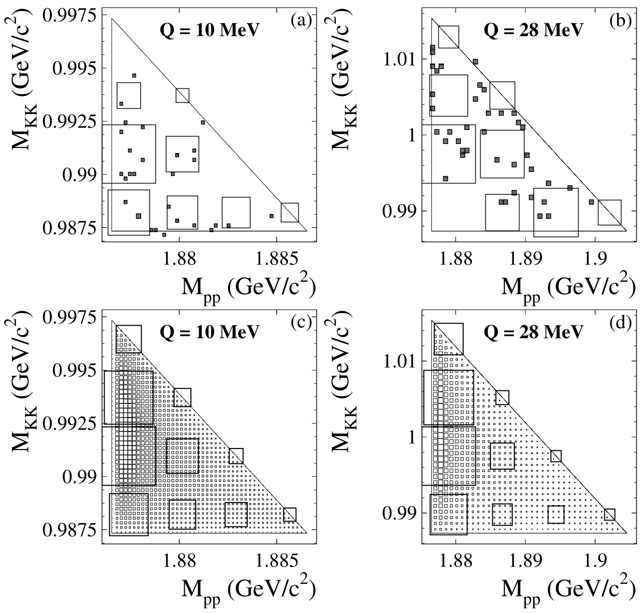

Fig. 1: Goldhaber plots for the $pp \to ppK^+K^-$ reaction. The solid lines of the triangles show the kinematically allowed boundaries. Raw data are shown in Figs. (a) and (b) as black points. The superimposed squares represent the same distributions but binned into intervals of ΔM = 2.5 MeV/c^2 (ΔM = 7 MeV/c^2) widths for an excess energy of Q = 10 MeV (28 MeV), respectively. The size of the square is proportional to the number of entries in a given interval. In Figs. (c) and (d) Monte Carlo results are presented. In the simulated distributions both the pp and the pK^-–FSI are taken into account.

References:

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