The K^- ^{3}He scattering length and the reaction $pd \to {}^3\mathrm{He}\, K^+K^-$ near threshold

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In a recent paper [1], we presented an estimation of the s-wave $K^-\alpha$ scattering length $A(K^-\alpha)$ obtained within the Multiple Scattering Approach. We further discussed the possibility of determining $A(K^-\alpha)$ from the $K^-\alpha$ invariant mass distribution measured in the reaction $dd{\to}\alpha K^+K^-$ near threshold. Here we show the results of similar calculations for $A(K^{-3}\mathrm{He})$ (see also Ref. [2].)

In Table 1 the predictions of $A(K^{-3}\mathrm{He})$ are given for different $\bar{K}N$ inputs. These are taken from a K-matrix fit (Set 1) [3], a constant scattering-length fit (Set 2) [4], and a chiral unitary approach (Set 3) [5].

Table 1: The K^- ^{3}He scattering length for different $\bar{K}N$ scattering lengths $a_I(\bar{K}N)$ $(I=0,1)$.

Ref.	$a_0(\bar{K}N)$[fm]	$a_1(\bar{K}N)$[fm]	$A(K^{-3}\mathrm{He})$[fm]
[3]	$-1.59+i0.76$	$0.26+i0.57$	$-1.50+i0.83$
[4]	$-1.03+i0.95$	$0.94+i0.72$	$-1.52+i1.80$
[5]	$-1.31+i1.24$	$0.26+i0.66$	$-1.66+i1.10$
[6]	$2.88+i1.12$	$0.43+i0.30$	$-3.93+i4.03$

We note that the $\bar{K}N$ scattering lengths described by Sets 1-3 correspond to their vacuum values. In order to demonstrate the sensitivity of our results to possible modifications of the $\bar{K}N$ scattering amplitudes in the presence of nuclear matter, we consider as Set 4 the strongly attractive in-medium solution found in Ref. [6] and given by

$$a_0^{\mathrm{eff}} = (2.9+i1.1)\,\mathrm{fm}\,,\quad a_1^{\mathrm{eff}} = (0.43+i0.30)\,\mathrm{fm}\,.$$

The results of our calculations are listed in the last column of Table 1. The values are very similar for Sets 1 and 3, being in the range $A(K^{-3}\mathrm{He}) = -(1.5\div 1.7)+i(0.83\div 1.1)$ fm. Set 2 gives a much larger imaginary part, with $A(K^{-3}\mathrm{He}) = -1.52+i1.80$ fm. The "exotic" Set 4 leads to a very large K^- ^{3}He scattering length, with a real part of -4 fm.

We now consider the K^- ^{3}He FSI effect in the reaction $pd \to K^+K^-$ ^{3}He near threshold. In Fig. 1 we present calculations of the K ^{3}He relative energy spectrum at an excess energy of 40 MeV. The solid line shows the calculations for pure phase space, *i.e.* for a constant production amplitude and neglecting FSI. All other lines in the figure represent the results obtained using the different sets of K^-N parameters given in Table 1. The predictions are normalized to the total $pd \to K^+K^-$ ^{3}He cross section of 9.3 nb. It is clear that the FSI can change significantly the K ^{3}He mass spectrum. The blue line corresponding to Set 4, which demonstrates a very pronounced deformation of the K^3He invariant mass spectrum in the region of small invariant masses, is in clear contradiction to the data.

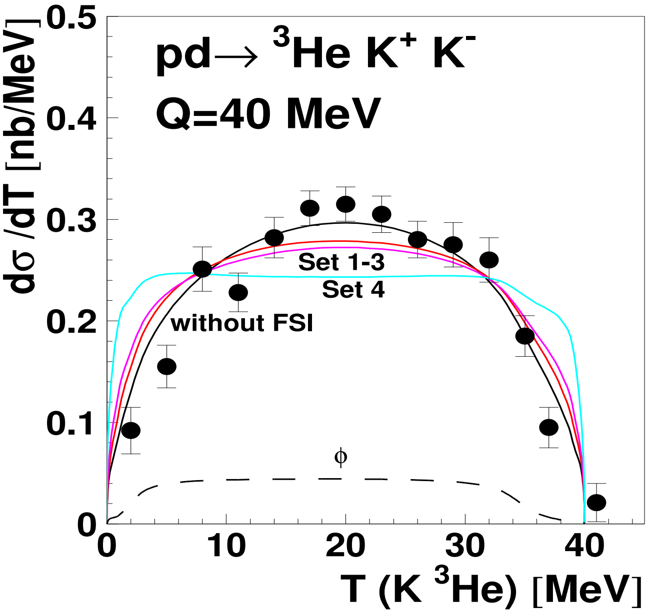

Fig. 1: Distribution of K^3He relative energies from the $pd \to {}^3\mathrm{He}\,K^+K^-$ reaction at 40 MeV. The MOMO experimental data are taken from Refs. [7, 8]. The model predictions (lines) are symmetric around $T = 20$ MeV since the MOMO experiment was insensitive to the signs of the kaon charges. The $\phi(1020)$ resonance, whose effects are shown by the dashed line, contributes about 15% to the total rate.

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