Comment on "Hadronic ^{3}Heη production near threshold"

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Measurements of the differential and total cross sections for the $pd \to {}^3\mathrm{He}\eta$ reaction at five energies were recently reported [Phys. Rev. C **75**, 014004 (2007)] and comparisons with theoretical models were made. We point out that these comparisons involved a model based on ad hoc assumptions and hence the conclusions regarding the reaction mechanism as well as the role of the higher partial waves drawn in the above work are misleading. Revised conclusions based on better model calculations are presented.

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The $pd \to {}^3\mathrm{He}\eta$ reaction has been studied earlier near threshold [1] as well as at a few higher energies [2,3]. The strong role of the η nucleus final state interaction (FSI) near threshold was established first in [4] where the FSI was incorporated through an enhancement factor. Later on, using few body equations within the finite rank approximation to describe the η-^{3}He elastic scattering, a good agreement with the threshold data was found in [5] using a three-body reaction mechanism. However, this two-step model, where the η meson is produced via the $pp \to \pi d$ and $\pi N \to \eta N$ reactions could not reproduce the forward peaked angular distributions at high energies [6]. In [6], it was also shown that the claim in [7], that the two-step model is successful in reproducing the angular distributions as well as the total cross sections at high energies was based on ad hoc assumptions related to the intermediate off-shell pion. Besides, the author in [7] included the FSI in an approximate way. The purpose of this Comment is to point out the erroneous conclusions reached in [8] based on comparisons with the two step model of [7] as well as present and discuss the results on the role of the higher partial waves in the $\pi N \to \eta N$ scattering, which is an input for these calculations. Finally, we also compare our theoretical η^3He scattering length with the one deduced by the authors of [8].

In Fig. 1, we compare the data on the total cross sections for the $pd \to {}^3\mathrm{He}\eta$ reaction with our results obtained using the two-step model for the production mechanism [5,6]. This calculation incorporates an integral over all momenta of the intermediate off-shell particles in the two-step model, and includes the η^3He FSI through a solution of the few body equations in the FRA. The results are shown for the FSI calculated with two different parameter sets for the $\eta N \to \eta N$ scattering, corresponding to scattering lengths (0.75,0.27) fm

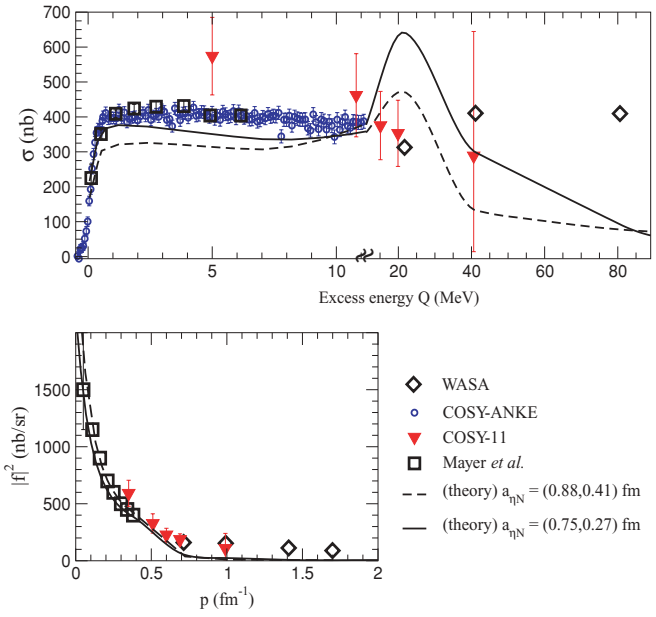

FIG. 1. (Color online) Comparison of the data on the $pd \to {}^3\mathrm{He}\eta$ reaction with a two step model calculation including the η^3He final state interaction in the s-wave and s, p, and d partial waves in the reaction mechanism. The scale in the upper plot has been broken at 11.2 MeV for clarity.

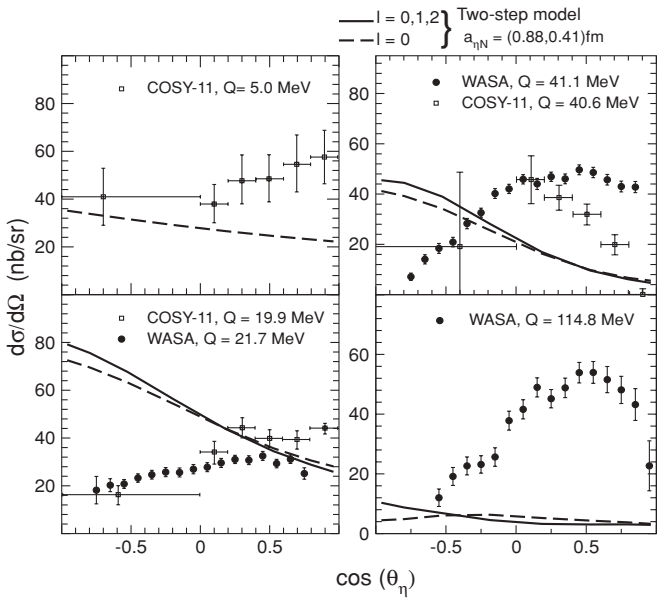

FIG. 2. Role of the higher partial waves in the angular distributions for the $pd \to {}^3\mathrm{He}\eta$ reaction (as explained in the text) at various energies calculated within the two step model with FSI included.

and (0.88,0.41) fm. This model reproduces the data of Mayer *et al*.. [1] as well as that of the COSY-ANKE experiment [9] at very low energies, close to threshold. The model is however unable to reproduce the data away from threshold in Fig. 1.

In Fig. 2, we show the predictions of this model for the angular distributions calculated with the s-wave alone and with higher partial waves for the intermediate $\pi N \to \eta N$ process. The theoretical angular distribution at threshold ($T_p = 891$ MeV) is isotropic (see Fig. 4 in [5]). However, the present two step model soon leads to a backward peaked cross section already at an excess energy of $Q = 5$ MeV. The forward peaked distributions at high energies cannot be reproduced even after the inclusion of the higher partial waves. The shifting of the peak to the forward hemisphere with energy, as shown in [6], can arise if we restrict the propagation of the intermediate pion to small angles (less than 10°). Such a constraint is, however, ad hoc and unjustified. Besides, the magnitude of the cross section gets highly underestimated in such a situation as can be seen in Fig. 4 of [6].

Finally, the η^3He scattering lengths, calculated from the η^3He t-matrix in [5], are $a_{\eta 3\mathrm{He}} = (1.99, 5.99)$ fm and (2.14, 5.71) fm for $a_{\eta N} = (0.75, 0.27)$ fm and (0.88, 0.41) fm, respectively, in comparison with the one reported in [8], viz., $a_{\eta\,3\mathrm{He}} = (4.2 \pm 0.5, 0.4 \pm 1.9)$ fm obtained from a fit to data. Our scattering lengths were obtained from the zero energy values of the few body η^3He t-matrix (with s-waves only) which was also used in calculating the FSI of the $pd \to {}^3\mathrm{He}\eta$ reaction. Though recent values of $|a_{\eta\,3\mathrm{He}}| = 4.3 \pm 0.5$ fm [10] and $a_{\eta\,3\mathrm{He}} = (10.7 \pm 0.8, 1.5 \pm 2.6)$ fm [9] are larger than our theoretical prediction, in agreement with the findings in [9], evidence for a quasibound state very close to threshold was found in another of our works [11] using the above η^3He t-matrix corresponding to an η^3He scattering length of (2.14, 5.71) fm.

To summarize, though the existing two-step model calculations of [5,6], do reproduce the close to threshold, $pd \to {}^3\mathrm{He}\eta$ total cross section data of Mayer [1] and the COSY-ANKE experiment [9], they are unable to reproduce the forward peaked angular distributions at high energies. Hence any conclusions in [8] about the success of the two-step model, based on a comparison with the theoretical work in [7] should be taken with caution.

[1] B. Mayer *et al*., Phys. Rev. C **53**, 2068 (1996); J. Berger *et al*., Phys. Rev. Lett. **61**, 919 (1988).
[2] R. Bilger *et al*., Phys. Rev. C **65**, 044608 (2002).
[3] M. Betigeri *et al*., Phys. Lett. **B472**, 267 (2000).
[4] G. Fäldt and C. Wilkin, Nucl. Phys. **A587**, 769 (1995).
[5] K. P. Khemchandani, N. G. Kelkar, and B. K. Jain, Nucl. Phys. **A708**, 312 (2002).
[6] K. P. Khemchandani, N. G. Kelkar, and B. K. Jain, Phys. Rev. C **68**, 064610 (2003).
[7] M. Stenmark, Phys. Rev. C **67**, 034906 (2003).
[8] H. -H. Adam *et al*., Phys. Rev. C **75**, 014004 (2007).
[9] T. Mersmann *et al*., Phys. Rev. Lett. **98**, 242301 (2007).
[10] J. Smyrski *et al*., Phys. Lett. **B649**, 258 (2007).
[11] N. G. Kelkar, K. P. Khemchandani, and B. K. Jain, J. Phys. G **32**, L19 (2006).