Few-body aspects of nuclear interaction in the alpha-induced break-up of deuteron at 13 and 15 MeV

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Introduction and Aim

To explore the few-body aspects of nuclear forces, nucleon-deuteron and alpha-deuteron systems are being studied [1-6], both experimentally and theoretically, since long ago. Among several theoretical frameworks, although Faddeev theoretical three-body calculations (FT) are expected to be best suited for examining and explaining the experimental kinematically complete three-body correlation cross sections, there have been several cases where discrepancies between experimental observations and theoretical predictions are of great significance. Although bound-state calculations on few-body systems sharply demand the existence of three-body nuclear forces (3BF), scattering state calculations when compared with experimental observations, point towards both assertive and negative results [1,3,5]. Very recently [1], studies on N-d systems, demanded 'unambiguous evidence for the missing' 3BF. In an aim to have an wider understanding on the discrepancies observed, the present study exploits two sets of existing data [2] on α-induced break-up of deuterons at 13 and 15 MeV in the light of single level R-matrix theory (RM) and a simple model [3] on three-body forces.

Data Analysis and Discussions

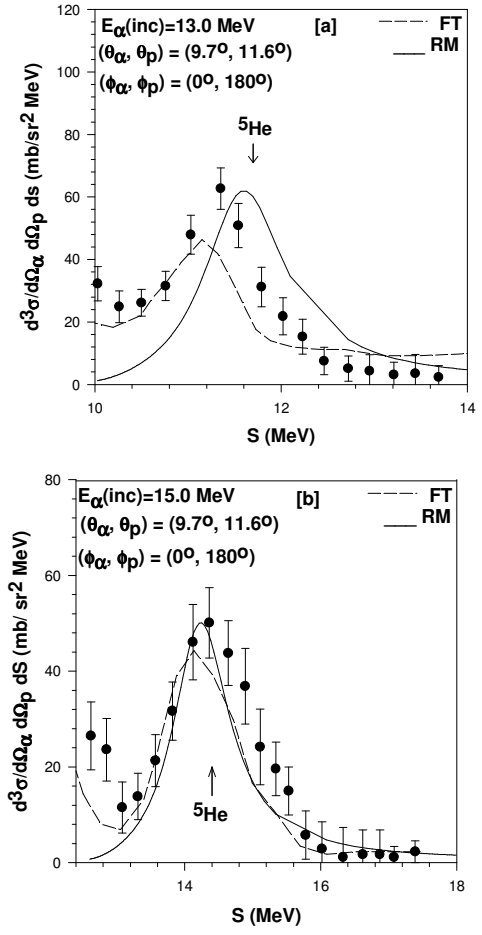
Based on R-matrix theory, three-body correlation cross sections were computed for the region of the experimental distributions where α-n FSI is kinematicalli predominant but with an overlap of the tail part of α-p FSI. The R-matrix parameters used are a=2.9 fm, γ^2= 6.9 MeV and E_0=4.3 MeV corresponding to $P_{3/2}$ channel of α-n system. Calculation on 3BF is based on a simple form [3] of three-body interaction, taking into consideration that three-body forces (3BF) are, in general, strongly angle dependent and that three-body interactions are likely to be favoured at low relative energies due to long time of escape from the nuclear interaction volume. To examine the probable signature of three-body forces, the 3BF calculations were performed focusing on the region of the phase space where c.m. kinetic energy of the neutron is minimum (≈0). The results of calculations are displayed in the following figures (Figs 1a,b & 2a,b). We summarize our observations as follows.

(i) So far as the reproduction of the peak positions of the α-n FSI spectra (Fig. 1a &1b) are concerned, the present calculation (RM) (solid line) yield better result than that due to FT (dashed line). However shapes (or widths) were not rightly reproduced in both the studies (RM & FT).

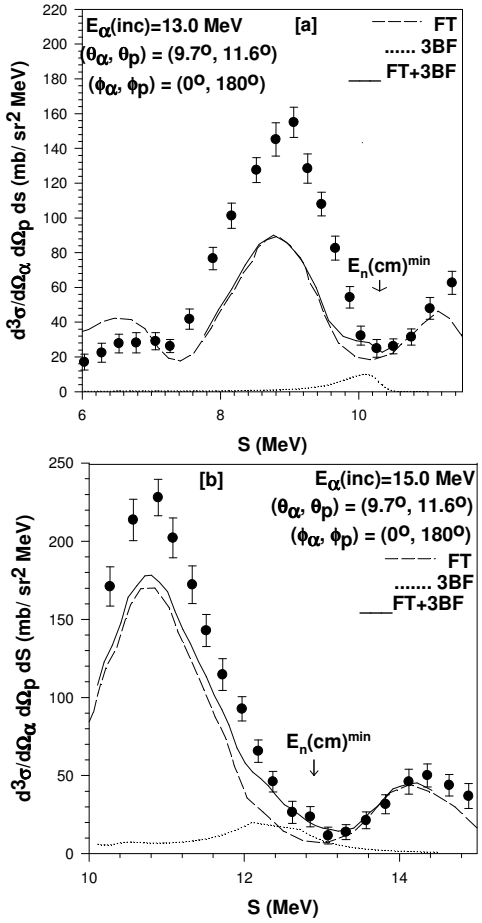
(ii) 3BF calculations (dotted line) (Fig. 2a & 2b) yield prominent bumps over the arc length where E_n(c.m.)≈0. When this is included with the existing FT, overall situation as to the reproduction of the spectral shape near the collinear region is improved to some extent (FT+3BF, as shown by solid lines in fig.2).

Conclusion

Remarkable improvement in the prediction of the peak positions of α-n FSI seems to indicate that interference among underlying pairwise interactions remains to be adequately described. Though improvement in fits are found due to inclusion of 3BF, no confirmatory conclusion



Figs .1a-1b. Three-body correlation cross-sections as a function of arc length (s) for the reaction d(α, αp)n for incident energies and correlated pairs of angles as mentioned in the figures. RM: R-matrix theoretical calculation; FT: existing Faddeev type calculation[2]. Experimental data are for ref [2].



Figs .2a-2b. Three-body correlation cross-sections as a function of arc length (s) for the reaction d(α, αp)n for incident energies and correlated pairs of angles as mentioned in the figures. 3BF: three-body force contribution; FT: existing Faddeev type calculation[2]. Experimental data are for ref [2].

may be drawn from the present study regarding the manifestation of the same in the data under consideration.

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