Understanding the role of incomplete fusion in ^{7}Li+^{159}Tb,^{197}Au reactions

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Introduction

Despite considerable efforts in last several decades, the fusion reactions with weakly bound nuclei at energies around the Coulomb barrier are not well understood. Due to the increased importance of breakup processes, the absorption from the breakup channel leading to incomplete fusion process has a significant contribution at these energies. The quantum mechanical calculations of individual CF and ICF cross-sections that take into account explicitly the breakup continuum effects, specially for weakly bound nuclei which dissociate into fragments of comparable masses are very scarce in the literature [1]. In our recent work, We have used breakup absorption model to simultaneously describe the measured cross sections of complete fusion (CF), incomplete fusion (ICF), and total fusion (TF) in ^{6,7}Li+^{209}Bi and ^{6,7}Li+^{198}Pt reactions [1]. In the present work, we perform breakup absorption model calculations for the available CF, ICF and TF data in ^{7}Li+^{159}Tb,^{197}Au [2, 3] reactions.

Calculation Details

The fusion cross sections are calculated by absorption model using the short-range imaginary (W_{SR}) potentials as described in Ref. [1]. The code FRESCO is used to solve the coupled equations using the Continuum Discretized Coupled Channels (CDCC) method. For the calculations, the real part of fragment-target potentials, $V_{\alpha-T}$ and V_{t-T} were taken from Refs. [4] and [5], respectively and these are listed in Table I. The radius parameter of imaginary part for the fragment-target potentials is optimized to get the better description of alpha/t capture data. The cross sections for the total fusion (σ_{TF}), complete fusion σ_{CF} along with α-capture ($\sigma_{\alpha-\mathrm{ICF}}$) and t-capture ($\sigma_{\mathrm{t}-\mathrm{ICF}}$) cross sections are evaluated explicitly from the calculated absorption cross sections.

TABLE I: Optical model potentials for fragment-target interaction used in the CDCC calculations.

System	V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_{SR} (MeV)	r_w (fm)	a_w (fm)
α+^{159}Tb	Sau	Paulo	Pot	25.0	0.60	0.40
t+^{159}Tb	161.7	0.95	0.72	25.0	0.69	0.40
α+^{197}Au	Sau	Paulo	Pot	25.0	0.60	0.40
t+^{197}Au	160.8	0.97	0.72	25.0	0.69	0.40

Results

In Figs. 1(a) and 2(a), We show TF, CF and ICF calculations with long dashed, short dashed and dotted lines respectively along with the measured data [2, 3] for ^{7}Li+^{159}Tb,^{197}Au reactions. The individual ICF calculations are also shown in Figs. 1 (b) and 2 (b). A satisfactory agreement for TF, CF and ICF cross-sections have been obtained for both the systems. However, $\sigma_{\mathrm{t}-\mathrm{ICF}}$ for the ^{7}Li+^{159}Tb system are under-predicted by the calculations, while it is well described for the ^{7}Li+^{197}Au system. The calculations presented here use the radius r_w parameter of the imaginary potential as a free parameter for the description of ICF, which is fixed from our earlier study. A better agreement for the individual ICF cross-sections for ^{7}Li+^{159}Tb system can be obtained by a suitable choice of this parameter.

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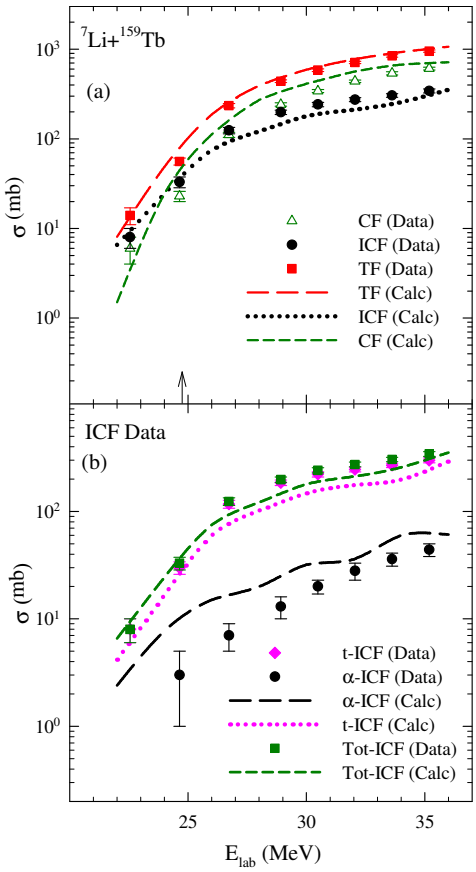

FIG. 1: The data of Complete Fusion (CF), Incomplete Fusion (ICF) and Total fusion (TF)=CF+ICF for ^{7}Li+^{159}Tb reaction from Ref. [2] is compared with the model calculations. The arrow indicate the position of Coulomb barrier.

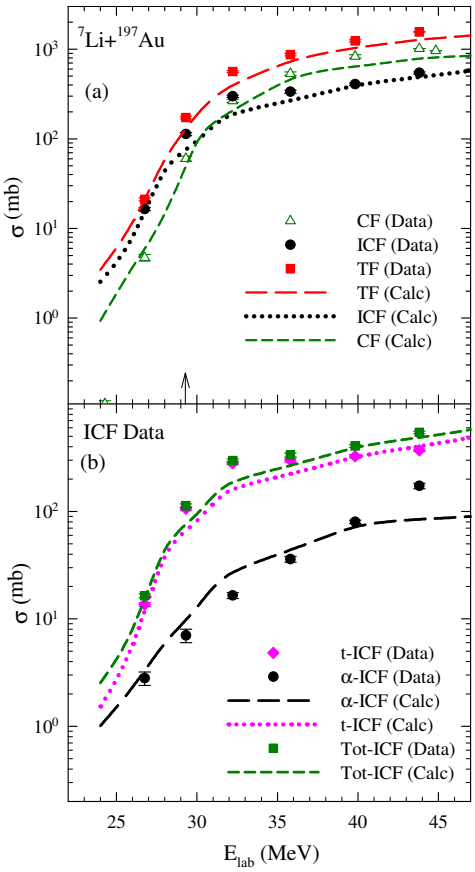

FIG. 2: Same as Fig. 1 but for ^{7}Li+^{197}Au reaction.

Summary and Conclusion

The cluster folding potentials in the real part along with short-range imaginary part were used in CDCC calculations to calculate the CF, ICF and TF cross-sections for ^{7}Li+^{159}Tb, ^{197}Au reactions. Overall a good description of CF, ICF and TF cross-sections along with individual α-ICF and t-ICF cross-sections is obtained with the present calculations. While the TF is calculated without any free parameter, the ICF cross sections can also be calculated in a reliable way by varying absorption using radius r_w parameter of the imaginary potential. The sensitivity of the r_w parameter for more accurate description of ICF components along with the simultaneous measurement of CF, ICF and TF data with ^{6,7}Li projectiles on various targets is essential.

References

[1] V. V. Parkar, V. Jha, S. Kailas, Phys. Rev. **C 94**, 024609 (2016).
[2] R. Broda *et al.*, Nucl. Phys. **A 248**, 356 (1975).
[3] C. S. Palshetkar *et al.*, Phys. Rev. **C 89**, 024607 (2014).
[4] L. C. Chamon *et al.*, Phys. Rev. **C 66**, 014610 (2002).
[5] F. D. Becchetti, G. W. Greenlees, Phys. Rev. **182**, 1190 (1969).