Simultaneous description of CF, ICF and TF data of ^{6,7}Li+^{209}Bi reaction using new ICF model

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Introduction

The systematic behavior of the fusion suppression factors and ICF probability as a function of target mass is not well understood, despite the CF experimental data being available for a number of projectile-target systems. In our recent paper [1], a new method was proposed to calculate the ICF probability which is based on absorption cross sections obtained from the CDCC calculations. In continuation of this work, we have also carried out similar calculations for ^{6,7}Li+^{209}Bi where the experimental data of CF and ICF is available [2]. In the recent paper by Marta *et al.* [3], the semi-classical model calculations were attempted to understand CF and ICF data for ^{6,7}Li+^{209}Bi, which was not explaining the data quite well. Here, we have demonstrated the use of quantum mechanical treatment for simultaneous explanation of CF, ICF and TF over a large energy range.

Calculation Details

The code FRESCO is used for these calculations. The fragment-target potentials $V_{\alpha-T}$ was taken from Sau-Paulo potential [4], while V_{d-T} and V_{t-T} were taken from Refs. [5] and [6] respectively. In the calculations presented here, the fusion cross sections are first calculated by including the short-range imaginary (W_{SR}) potentials in the coordinates of both projectile fragments relative to the target. The CDCC calculations with the breakup couplings only are performed with three choices of optical potentials, where W_{SR} is used for (i) both the projectile fragments relative to the target (Pot. A), (ii) the α-T part only (Pot. B), and (iii) the t(d)-T part only (Pot. C). However, in all these calculations, an additional W_{SR} without any real part is also present in the center of mass of the whole projectile for the projectile-target radial motion. The potentials used are given in Table

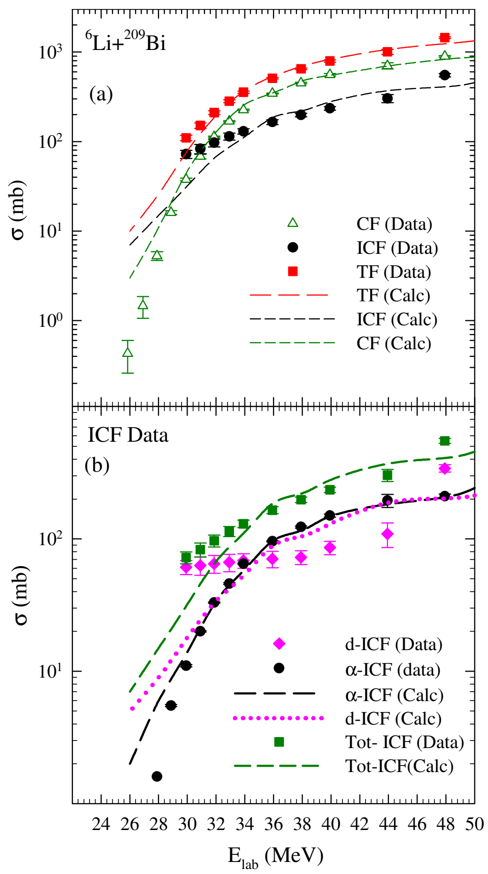

FIG. 1: The data of Complete Fusion (CF), Incomplete Fusion (ICF) and total fusion (TF)=CF+ICF for ^{6}Li+^{209}Bi reaction from Ref. [2] is compared with the model calculations.

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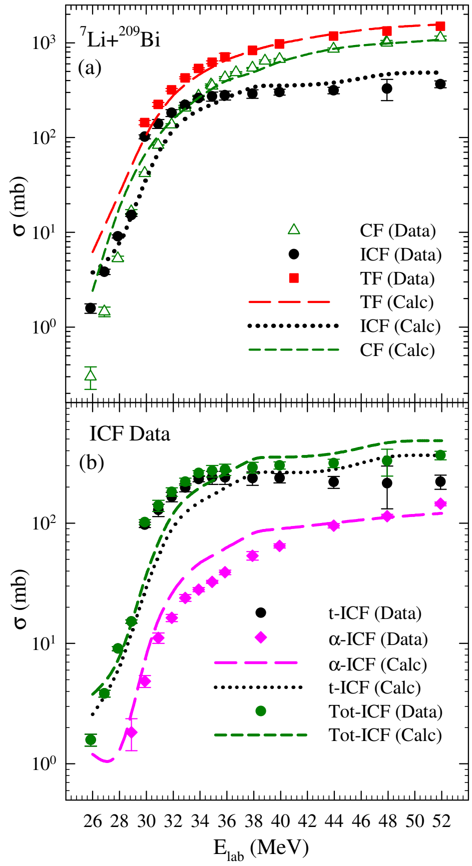

FIG. 2: Same as Fig. 1 but for ^{7}Li+^{209}Bi reaction.

I. The radius parameter of imaginary part is optimized to get the better description of ICF alpha/d/t capture data. The absorption cross sections in three cases represent cross sections for (i) Total fusion (σ_{TF}), (ii) σ_{CF}+σ_{α}, and (iii) σ_{CF}+$\sigma_{t/d}$, respectively. These three calculations together are used to estimate the $\sigma_{ICF\alpha}$ and $\sigma_{ICFt/d}$ explicitly.

Results

In Figs. 1(a) and 2(a), we have plotted TF, CF and ICF calculations with long dashed, short dashed and dotted lines respectively along with the measured data from Ref. [2]. The individual ICF calculations are also shown in Figs. 1 (b) and 2 (b). The calculated CF is the subtraction of ICF from TF

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_0 (MeV)	r_0 (fm)	a_0 (fm)
α+^{209}Bi	Sau	Paulo	Pot	10.0	0.65	0.40
d+^{209}Bi	96.5	0.97	0.74	10.0	0.75	0.40
t+^{209}Bi	160.8	0.97	0.72	10.0	0.85	0.40

cross-sections. As can be seen from Figs. 1 (b) and 2 (b), the alpha capture data is nicely explained by calculations but not d/t capture data. This is because of the fact that the long lived residue from t or d-capture followed by neutron evaporation path, i.e. ^{209}Po was not measured, which has significant contribution in t/d ICF. From the calculations, it can be seen that the cross-section of d and α capture in ^{6}Li+^{209}Bi is of similar order, while in the case of ^{7}Li+^{209}Bi, t-capture cross-section is higher than α capture which is also observed in data. The suppression factors obtained in CF data with ^{6,7}Li projectiles in various measurements is also explained in present calculations.

Summary and Conclusion

This is the first time, that using quantum mechanical treatment CF, ICF and TF calculations were performed for ^{6,7}Li+^{209}Bi reaction. The similar calculations are in progress for other systems where complete data on CF, ICF and TF is available with ^{6,7}Li projectiles.

References

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