

Measurement of fusion cross sections in ${}^7\text{Li} + {}^{205}\text{Tl}$ system

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Introduction

Recent studies on fusion with weakly bound stable projectiles (${}^6,{}^7\text{Li}$ and ${}^9\text{Be}$) on different targets have shown that the complete fusion (CF), where the entire projectile or all its fragments are captured in the target, is suppressed when compared to predictions based on coupled channels calculation at energies above the Coulomb barrier [1, 2]. In particular, experiments with ${}^6,{}^7\text{Li}$ and ${}^9\text{Be}$ projectiles on medium and heavy mass targets have given interesting conclusions on the systematics of CF suppression factor [2]. The suppression in CF involving these projectiles is found to be independent of target mass in many studies [3–5]. In general, the amount of suppression was found to be compensated in incomplete fusion (ICF) cross sections. In continuation of this activity, we have measured the CF and ICF cross sections for ${}^7\text{Li} + {}^{205}\text{Tl}$ system using online γ -ray measurement technique.

Experimental Details

The experiment was performed using ${}^7\text{Li}$ beam from 14UD BARC-TIFR Pelletron LINAC Facility, Mumbai at energies ranging from $E_{\text{beam}} = 24\text{--}29, 31, 32.5, 34, 38$ and 40 MeV. The target used was ${}^{205}\text{Tl}$ of 1 mg/cm^2 , evaporated on $25\text{ }\mu\text{g/cm}^2$ carbon backing. Prompt γ -ray transitions were detected using seven Compton suppressed High Purity Germanium (HPGe) Clover detectors

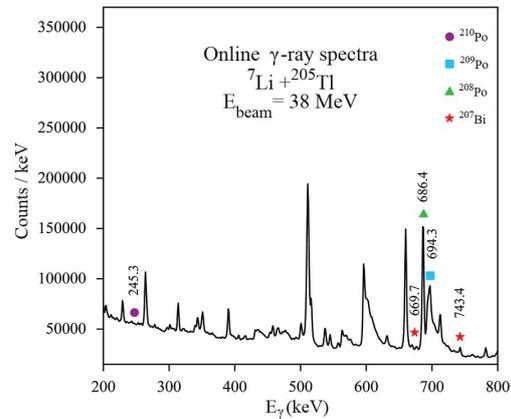


FIG. 1: γ -ray add-back spectrum from the clover detectors obtained in ${}^7\text{Li} + {}^{205}\text{Tl}$ reaction at $E_{\text{beam}} = 38$ MeV. The γ lines from the possible ERs are labeled.

surrounding the target chamber. In addition, two Si surface barrier detectors were placed at 25° and 35° for absolute normalisation purpose. The time stamped data were collected using a digital data acquisition system with a sampling rate of 100 MHz . Efficiency and energy calibration of the clover detectors were carried out using standard calibrated ${}^{152}\text{Eu}$ and ${}^{133}\text{Ba}$ γ -ray sources. Figure 1 shows the γ -ray add back spectrum measured in ${}^7\text{Li} + {}^{205}\text{Tl}$ reaction at $E_{\text{beam}} = 38$ MeV.

Results and Discussion

The cross sections for all the residues formed in CF and ICF were determined con-

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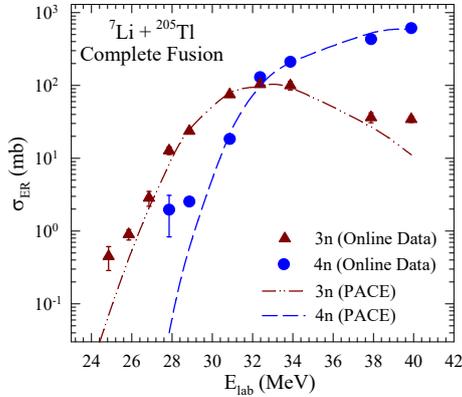


FIG. 2: Cross sections from online γ -ray measurement for 3n and 4n channels following CF are shown along with statistical model (PACE2) predictions.

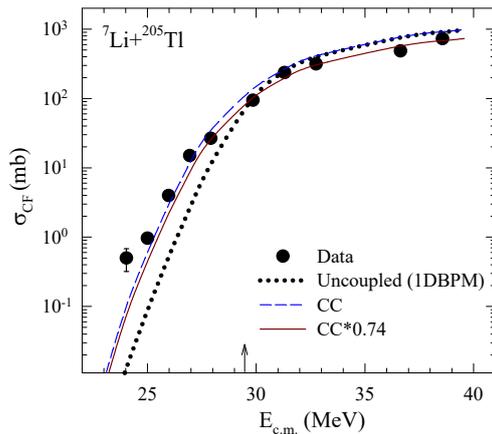


FIG. 3: Complete fusion cross section measured in ${}^7\text{Li}+{}^{205}\text{Tl}$ system are compared with coupled and uncoupled results from CCFULL calculations. Solid lines were obtained by multiplying the coupled results by a factor of 0.74.

sidering all the ground and metastable (\sim few μs life times) states. The residue cross sections for 3n and 4n channels are shown in Fig. 2 along with statistical model (PACE2) calculations, which shows a good agreement with the measured data. The CF cross sections were obtained from the cumulative sum of 3n and 4n cross sections.

We have performed the uncoupled and cou-

pled channel calculations using the code CC-FULL [6] and are shown in Fig. 3 by dotted and dashed lines, respectively. It was observed that at sub-barrier energies, the calculated fusion cross sections with the couplings (dashed lines) are enhanced compared to the uncoupled values. However, at above-barrier energies, the calculated values of fusion with or without couplings are higher than the measured ones.

Summary

Excitation function for the complete and incomplete fusion of ${}^7\text{Li}+{}^{205}\text{Tl}$ reaction were measured in the energy range $0.80 < V_B < 1.34$ by online γ -ray measurement technique. At above barrier energies, the measured CF cross sections were found to be suppressed by a factor of $26 \pm 4\%$ in comparison with the coupled channel calculations, which is in agreement with the literature data for the ${}^7\text{Li}$ projectile on various targets. The measured ICF accounts for the suppression in CF.

Acknowledgments

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