Study of fusion barrier distributions from quasi-elastic scattering for ^{6,7}Li+ ^{209}Bi systems

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Introduction

Investigation of fusion barrier distributions have been extensively used as a tool to study projectile/target structure effects in heavy ion fusion reactions around the Coulomb barrier energies[1]. There are two complementary methods for fusion barrier distribution determination such as either by precise fusion excitation function measurement or by quasi-elastic scattering excitation function at backward angles [2]. The complementarity of fusion barrier distributions obtained from quasi-elastic scattering and fusion are due to the fact that the ratio of $d\sigma^{qel}/d\sigma^{R}(E)$ at 180°, is the the reflection coefficient $R_\circ$ for l=0 and the barrier penetration probability, $T_\circ$, related to fusion is unitary, that is $R^{qel}(E)+T^{fus}(E)=1$. If new reaction channels other than quasi-elastic scattering and fusion are present, the $T_\circ=1-R_\circ$, no more represents fusion barrier penetration probability rather total reaction transmission probability. In a recent work [3], it was suggested that the barrier distributions derived from quasi-elastic scattering at backward angles of very heavy target-projectile systems leads to information about the total reaction threshold distribution, instead of the usually accepted information about the fusion barrier because of appearance of deep inelastic scattering besides quasi-elastic scattering and fusion in these systems. Similar situation can also arise in case of reactions with loosely bound nuclei, where break up channel is dominant. There are very few measurements on quasi elastic barrier distribution involving weakly bound nuclei such as ^{6,7}Li, ^{9}Be [4, 5, 6]. In case of ^{9}Be on ^{208}Pb there is an indication of shift in central maxima of quasi-elastic barrier distribution towards lower energyside [4]. A systematic study of fusion barrier distributions obtained by fusion excitation function and quasi-elastic scattering for loosely bound projectile will be of interest. The experimental fusion barrier distributions for ^{6,7}Li+ ^{209}Bi systems are available in the literature [7], but there are no data from quasi-elastic scattering. In the present work, we have carried out fusion barrier measurement for ^{6,7}Li+ ^{209}Bi systems by quasi-elastic scattering at backward angle.

Experimental Details

The experiment was performed at the 14UD BARC-TIFR Pelletron, Mumbai, India. Beams of weakly bound stable nuclei ^{6}Li$^{(3+)}$ (break up threshold ∼1.42 MeV) and ^{7}Li$^{(3+)}$ (break up threshold ∼2.46 MeV) were bombarded on self supporting ^{209}Bi target of thickness around 1.2 mg/cm^2. Two detector telescopes were placed at 140^0 and at 160^0 with the thickness of ΔE = 15 μm and E=1.5 mm and ΔE = 25 μm and E= 2 mm respectively for quasi elastic scattering measurements. Measurements were carried out in the energy range from 22.0 to 38.0 MeV in steps of 1.0 MeV. For the purpose of Rutherford normalization two monitor (SSB) detectors were placed at 18^0. The bombarding energies were corrected for the energy loss in half the target thickness, ranging from 0.12 to 0.18MeV for ^{6}Li and 0.14 to 0.2MeV for ^{7}Li projectile.

Results and discussions

Fusion barrier distributions for ^{6,7}Li+ ^{209}Bi systems were obtained from quasi-elastic ex-

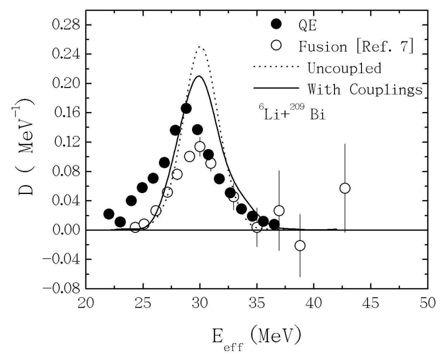

FIG. 1: Fusion barrier distributions in ^{6}Li+^{209}Bi reaction. Continuous curves are calculations.

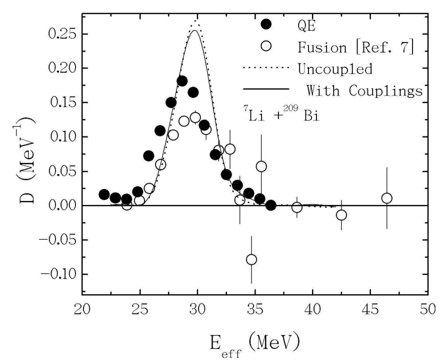

FIG. 2: Same as Fig. 2 for the reaction of ^{7}Li with ^{209}Bi.

citation function data at 160° following the procedure described in Ref.[1]. The barrier distributions thus obtained are compared with that obtained from fusion excitation function measurements [7] in Fig. 1 and Fig. 2. The predictions of coupled channel calculations using CCDEF code are also shown in Fig. 1 and Fig. 2. It is seen that the barrier distributions obtained from both the methods are consistent for energies above the peak energies of the barrier distributions obtained from fusion excitation function measurements for both the systems. But for energies, below the barrier peaks, the QE barrier distribution values are higher and extends to lower energies. This suggests, that the barrier distributions obtained from QE scattering represent 'total reaction threshold distribution' rather than

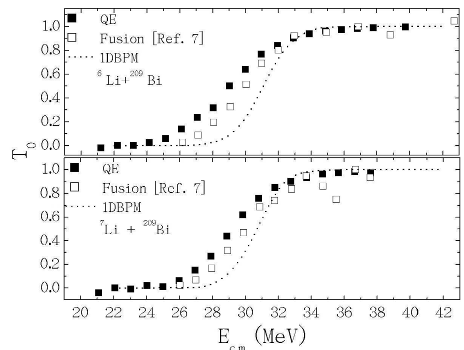

FIG. 3: Transmission coefficient ($T_\circ$) as a function of $E_{c.m.}$ in the reaction of ^{6,7}Li with ^{209}Bi.

fusion barrier distribution. Though the barrier distributions obtained from fusion excitation function measurement can be explained by multiplying with some factor to barrier distributions predicted by CCDEF but it can not explain QE barrier distributions. The QE barrier distributions can be better understood by plotting the transmission probability obtained from QE and fusion excitation function measurements as a function of energy as shown in Fig. 3 along with 1DBPM predictions. It is seen that, the $T_\circ$ values obtained from QE are higher and extends to lower energies suggesting the contributions of breakup in total reaction channel as in quasi-elastic analysis breakup channels are not included.

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