Study of fusion barrier distribution from quasielastic scattering for ^{6,7}Li + ^{197}Au systems

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Introduction

In reactions with weakly bound nuclei, the effect of breakup on fusion process has been extensively studied in recent years. The experimental study shows that breakup channel leads to suppression of complete fusion at above barrier energies due to loss of flux [1]. The fusion barrier distribution can provide a further insight into understanding the influence of coupling to the breakup channels. Experimentally, the fusion barrier distribution can be extracted by taking second derivative of the product ($E_{cm}\sigma_{fus}$) with respect to E_{cm}, where σ_{fus} is the measured fusion excitation function. Similar information could be obtained from the elastic and quasielastic (QEL) scattering because of the conservation of the reaction flux (i.e. $R+T= 1$), where R is the reflection probability and T is the transmission probability [2]. Thus, quasi-elastic scattering at backward angles is the counterpart of the fusion process and it is expected that the barrier distributions extracted from two processes, namely, QEL and fusion should be similar. While this is true for tightly bound reaction systems, in reactions involving weakly bound projectiles significant differences have been observed for QEL barrier distributions with and without inclusion of breakup processes [3-5]. Earlier we have reported breakup and fusion excitation function measurements in ^{6,7}Li + ^{197}Au systems [6]. In this paper we present the fusion barrier distribution from QEL at backward angles for the same systems, namely, ^{6,7}Li + ^{197}Au.

Experimental Details

The experiment was performed at Pelletron Linac Facility, Mumbai using ^{6,7}Li beams (4-10 pnA) in energy range 23 to 38 MeV on a self-supporting gold foil (~800 μg/cm^2). The QEL events were measured by two Si ΔE-E telescopes (33-1500 μm and 30-2000 μm), placed at 150^0 and 170^0 relative to the beam direction with an angular aperture of 1.1^0. Two monitor detectors placed at 30^0 and 40^0 with respect to the beam direction were used for normalization purpose. Measurements were carried out in fine steps of 0.5 MeV in the vicinity of the barrier and in steps of 1 MeV at energies away from the barrier. Figure 1 shows a typical ΔE-E spectrum for ^{6}Li beam of 29.5 MeV at 170^o, where different products are clearly separated. The energy spectrum of the alpha particles is found to be peaked at 4/6th of the projectile energy indicating that these particles are originating predominantly from projectile breakup.

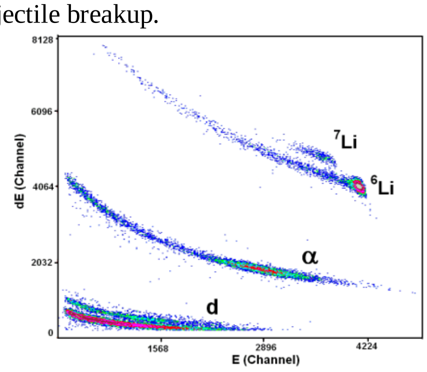

Figure 1: A typical ΔE-E spectrum at 170^o for ^{6}Li+^{197}Au at E_{lab}= 29.5MeV.

Data Analysis and Results

Figure 2a (3a) shows the measured QEL excitation function for ^{6}Li (^{7}Li). The QEL barrier distribution is extracted by taking the first derivative of the QEL cross section relative to the Rutherford cross section, that is, $-d(d\sigma_{QEL}/d\sigma_{Ruth})/dE$. Figure 2b (3b) shows the corresponding derived barrier distribution by using the point difference method with an energy interval of 2.0 MeV. It is evident that for both ^{6}Li and ^{7}Li, the barrier distribution extracted from QEL with and without alpha breakup is significantly different, with centroid shifted by 2.3 and 1.1 MeV, respectively. The fusion barrier distribution derived from the coupled channel calculations, performed using CCFULL [7] including couplings to first excited state of projectiles and inelastic state of target with deformation parameter β_2=0.1, is also shown (solid line) for comparison. This CCFULL calculation was able to explain the ^{6}Li and ^{7}Li complete fusion data at sub-barrier energies but found to overpredict the cross sections at above barrier energies [6]. It can be seen that the centroid of the barrier distribution extracted from QEL without including breakup alpha events is shifted towards lower energy as compared to the fusion barrier distribution predicted by CCFULL.

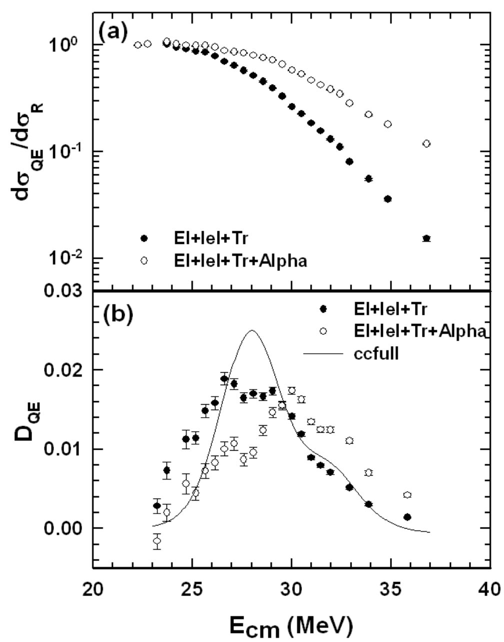

Figure 2: (a) Measured quasi elastic excitation function and (b) quasi elastic barrier distribution for the system ^{6}Li +^{197}Au.

Similar effect has also been observed in ^{9}Be + ^{208}Pb [3], ^{6,7}Li + ^{209}Pb [4] and ^{6,7}Li + ^{144}Sm [5]. Present results together with the published data imply that the experimental barrier distribution extracted from QEL is sensitive to the breakup of weakly bound projectiles and has a very little dependence on the target.

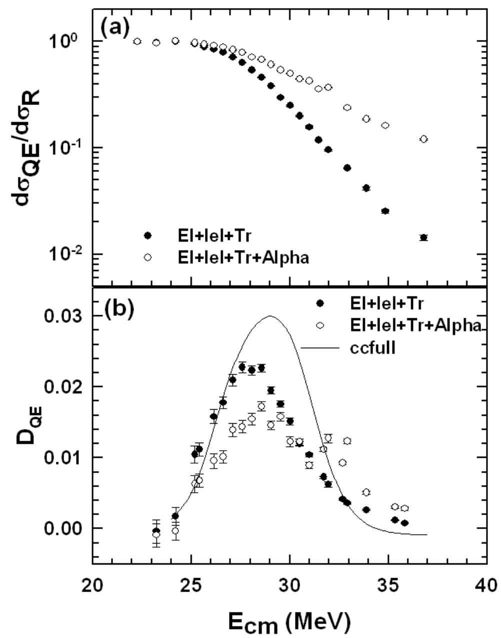

Figure 3: Same as figure 1 for the system ^{7}Li +^{197}Au.

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