Fusion, reaction and break-up cross sections of ^{6,7}Li+^{28}Si

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Introduction

The reaction dynamics of loosely bound projectiles with light mass target at near barrier energies is very important and not yet fully understood. So for such light systems with reduced Coulomb strength, the influence of breakup and other direct reactions (e.g. transfer) on fusion and elastic scattering is definitely interesting to probe the interplay of the different processes. The behaviour of the interaction potential for ^{6,7}Li+^{28}Si [1, 2] at near barrier energies was found almost energy independent and to be quite different compared to the observations with heavier targets. Recently, a simultaneous description of the elastic, fusion and reaction cross sections has been made by [3] for the same system. The so called breakup threshold anomaly is clearly observed for the ^{6}Li+^{28}Si system compared to ^{7}Li+^{28}Si. With this motivation, the effect of projectile breakup (BU) on elastic scattering and fusion for ^{6,7}Li+^{28}Si have been done in the projectile energy range of E/V_b= 0.9 - 3.0 by employing continuum discretized coupled-channels (CDCC) calculation. In this work the reaction cross section, fusion, elastic angular distribution predicted by CDCC are compared with the measured data [4–7].

CDCC calculation

Effect of breakup on elastic scattering

The effect of breakup on elastic scattering was investigated in the coupled channel framework (CDCC) using the code FRESCO. The details of the calculation was reported in [8]. The energy dependence of resulting effective potential (i.e., the bare potential plus the polarization potential due to BU values evaluated at average crossing radius R_{av} [8] are compared with those obtained by fitting the experimental elastic angular distributions [4, 7]. CDCC prediction for ^{6}Li follows the trend of experimental data, but that for ^{7}Li do not agree. However, CDCC calculation done by [9] is in agreement with our results. In a recent analysis in the phenomenological approach [3] for the same systems, the nuclear polarization potential is split into a volume (V_F, W_F) part for fusion and a surface part (V_{DR}, W_{DR}) for direct reaction to understand the energy dependence of the OM potential. However discrepancy is observed around the barrier when real and imaginary potential predicted by our CDCC calculation at the strong absorption radius R_{sa}(10.6 fm) [9] are compared with the sum of the potential V_{DR}+V_F, W_{DR}+W_F as reported by [3]. We have also done uncoupled calculation in FRESCO with single folding approach, using same potential for α+^{28}Si and d/t+^{28}Si, that was earlier used in case of BU coupling. The reaction cross section (σ_R) of ^{6}Li, ^{7}Li from CDCC are compared with previously extracted OM2 [8] potential as shown in Fig. 1 and Fig. 2. For these systems the two values are in good agreement at four higher energies but mismatch is found more around the barrier energies.

Effect of breakup on Fusion

The fusion cross section (σ_{fus}) for ^{6,7}Li+^{28}Si were estimated, subtracting BU cross section from reaction cross section predicted by CDCC. The estimated fusion for ^{6}Li and ^{7}Li from CDCC are plotted in Fig. 1 and Fig. 2 respectively, which are in good agreement with the measured data [6, 7] at higher energies E/V_b>1.5. However it over predicts the data at E/V_b<1.5. We have used

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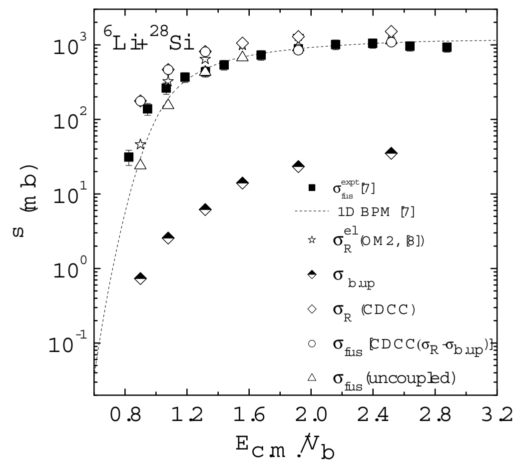

FIG. 1: Reaction, fusion and BU cross section (from CDCC) compared with measured data for ^{6}Li+^{28}Si.

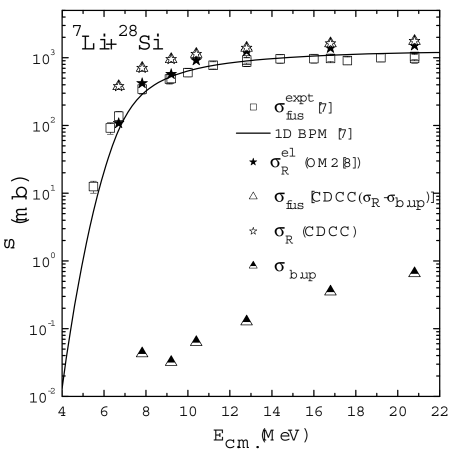

FIG. 2: Reaction, fusion and BU cross section (from CDCC) compared with measured data for ^{7}Li+^{28}Si.

the bare potential from FRESCO to estimate the σ_{fus} and it is found to obey the 1D BPM estimation [7] (Fig. 1). The σ_{BU} from CDCC are also plotted in the same graphs.

Results and Discussion

The CDCC calculation with coupling to BU channel describes well the elastic scattering data at higher energies for both ^{6}Li and ^{7}Li. But at lower energies, near the Coulomb barrier, the model predictions clearly underestimate the data. BU cross section of ^{6}Li is found to be larger than ^{7}Li. Although BU does not contribute significantly to the total reaction cross section at near-barrier energies, its influence is crucial for a good description of the elastic scattering data at higher energies. The total reaction cross sections are dominated by fusion at near and above barrier energies. The CDCC calculations suggest that there are other direct reaction processes (most likely nucleon transfer), which has larger contributions to the total reaction cross section than BU. In conclusion we may say that, the reaction mechanism for these two systems viz, ^{6,7}Li+^{28}Si is not well understand and further investigations are required. As for example, the coupling due to inelastic excitation of the target and coupled channel calculations with transfer channel needs to be performed to understand the mismatch at lower energies.

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