Investigation of fusion of ^{7}Li with ^{64}Ni around the Coulomb barrier

Md. Moin Shaikh[1],* Subinit Roy[1], S. Rajbanshi[1], A. Mukherjee[1], P. Basu[1], M. K. Pradhan[1], S. Pal[2], V. Nanal[2], A. Shrivastava[3], S. Saha[2], and R.G. Pillay[2]
[1] *Saha Institute of Nuclear Physics, 1/AF, Bidhan Nagar, Kolkata-700064, INDIA*
[2] *Tata Institute of Fundamental Research, Mumbai-400 005, INDIA and*
[3] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai-400 085, INDIA*
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1. Introduction

In fusion reactions with weakly bound projectiles having low breakup threshold, besides the *complete fusion* (CF) process there can be significant contribution from *incomplete fusion* (ICF) process [1]. In collisions with heavy targets, these two contributions could be separated experimentally. But for medium and low mass targets, the measurements of fusion cross sections provides the *total fusion* (TF=CF+ICF) cross sections [2, 3]. Recently, an attempt has been made to separate the CF component from the TF cross section measurement for ^{6}Li+^{64}Ni system [4]. The motivations were to investigate, in case of medium mass targets, the magnitude of suppression, if any, in CF cross section due to ICF process at above barrier energies and the origin of enhancements in TF and CF cross sections at below barrier energies. Continuing to investigate the collisions of other weakly bound projectiles, we have completed our measurement of fusion cross sections around the barrier energy for ^{7}Li on ^{64}Ni, the heaviest stable isotope of nickel. The data from the new measurement will be presented along with the analysis to separate the CF from the TF cross sections. A comparison with the fusion of ^{6}Li projectile and ^{64}Ni target will be shown.

2. Experiment and Analysis

The experiment was carried out at BARC-TIFR Pelletron Facility in Mumbai, India. The ^{7}Li beam with energies varying from 12 to 28 MeV was bombarded on a self-supporting target of ^{64}Ni of thickness 507 μg/cm^{2}. A monitor detector was placed at 30° for normalization purpose. The fusion cross sections were determined using the characteristic γ rays detection technique. To detect the γ rays, a clover detector was placed at 45° and a HPGe detector at 150° with respect to the beam direction. The fusion residue cross sections were estimated entirely from the measured transitions to the ground states of the residues. Several such transitions corresponding to each residue channel were recorded. The fusion cross section at each energy is the sum of the observed residue cross sections, obtained by summing over the γ-ray cross sections. To get an estimate of the direct ground state feeding contribution, which cannot be measured in γ-ray detection technique, a separate off-line measurement was done by detecting the characteristic X-rays from residues having reasonable electron capture lifetime.

3. Results and Discussions

The compound nucleus ^{71}Ga, produced in the fusion of ^{7}Li and ^{64}Ni, decays to form the residues ^{69}Ga($2n$), ^{68}Ga($3n$), ^{69}Zn(pn), ^{68}Zn($p2n$), ^{66}Cu(αn) and ^{65}Cu($\alpha 2n$) respectively by evaporating various particles. The residues produced through $2n$, $3n$ and pn evaporation channels are associated only with the CF process and the rest can be produced from CF as well as other reaction processes. The experimental fusion excitation functions of each residues and the summed TF cross sections are shown in Fig. 1. A comparison with the one dimensional barrier penetration (1DBPM) prediction is also shown in

*Electronic address: moin.shaikh@saha.ac.in

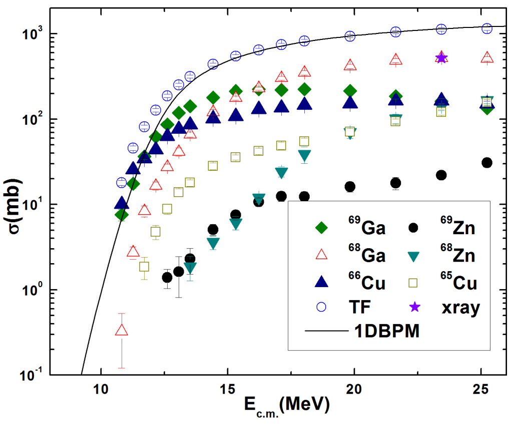

FIG. 1: The measured excitation functions of individual residue channels and that of TF are shown along with the 1DBPM prediction for the system ^{7}Li+^{64}Ni. The population cross section of ^{68}Ga at E_{lab}=26 MeV from off-line measurement is shown by a solid star.

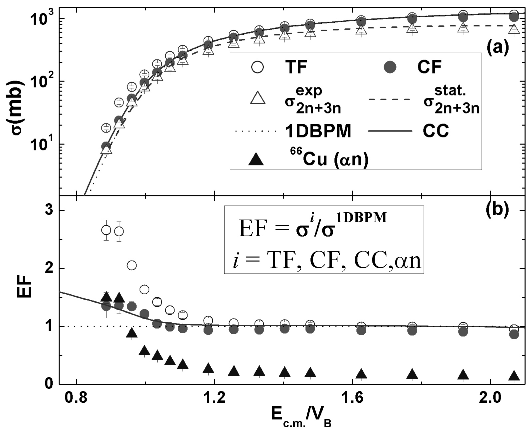

FIG. 2: a) The excitation functions of measured TF, derived CF, experimental $(2n+3n)$ for ^{7}Li+^{64}Ni. The 1DBPM and CC predictions and PACE prediction for $2n+3n$ channel cross section are shown by solid, dotted and dashed lines. b) Relative enhancement (EF) as a function of energy to Coulomb barrier ratio.

Fig. 1. A slightly modified Akyüz-Winther potential, with V_0 = 48.0 MeV, r_0 = 1.12 fm and a_0 = 0.66 fm, was used in the fusion cross section calculation with the code CCFULL [5]. The resultant barrier parameters, V_B, R_B and $\hbar\omega$, are 12.20 MeV, 9.19 fm and 3.41 MeV, respectively. A coupled channel (CC) calculation has been performed including the coupling to projectile and the target excitations. It is clear from the Fig. 1 that the TF excitation function is well reproduced by 1DBPM prediction at above barrier region. But the TF cross sections are significantly enhanced compared to 1DBPM and CC predictions at below barrier energies (Fig. 2a). The CF cross section, extracted using the $2n$ and $3n$ channels following the procedure described in Ref.[4], is found to be suppressed on an average by $\sim$7% at above barrier energies. The suppression factor ($\sim$ 0.93) of CF cross section for ^{7}Li+^{64}Ni system is much lower compared to that of the ^{6}Li+^{64}Ni ($\sim$ 0.87) [4]. This shows that, for a fixed target, the suppression decreases as the breakup threshold of the projectile increases. The below barrier enhancement of CF cross section is well reproduced by the CC calculation. This has been shown in Fig. 2b where the relative enhancement factor, EF, has been plotted as a function of energy. The large enhancement in TF at below the barrier is due to the large population of ^{66}Cu(αn), a channel that has contributions from CF, ICF and cluster transfer reactions.

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