Comparison of fusion barrier distributions for ^{7}Li + ^{64}Ni and ^{6}Li + ^{64}Ni systems

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1. Introduction

Barrier distribution function in heavy ion collision at energies around the Coulomb barrier has evolved as an important observable to probe the interaction potential and the reaction dynamics in this energy regime [1]. It can be obtained from the measured fusion excitation function, $\sigma_{fus}(E)$, by taking the double derivative of the function $E\sigma_{fus}$ with respect to energy, E [2].

The studies of collisions involving weakly bound nuclei and the effect of weak binding on fusion and scattering processes are of current interest [3]. The coupling to the breakup channels and the threshold of breakup are found to affect the fusion process significantly, both at above and below barrier energies [4, 5]. Consequently, the investigation of influence of breakup channels in the barrier distribution function,derived from fusion excitation function, also becomes important.

In the fusion of weakly bound projectiles, two independent processes, namely, complete fusion (CF) and incomplete fusion (ICF) can occur. Total fusion (TF) is subsequently defined as TF = CF+ICF. However, to distinguish the CF and ICF events experimentally is very difficult, especially for lower mass targets with charged dominant particle emission channels. The measurement, therefore, provides the TF cross section. Studies of barrier distributions for fusion of weakly bound stable projectiles with heavy targets having distinguishable CF and ICF decay channels have been reported in Refs. [4, 6, 7].

The TF excitation functions for the systems ^{7}Li+^{64}Ni [8] with projectile breakup threshold 2.47 MeV and ^{6}Li+^{64}Ni [9] with projectile breakup threshold 1.47 MeV have previously been measured by our group. In the present work we report the comparison of the barrier distribution functions of the two systems, extracted from the measured TF cross sections.

2. Experiment and Analysis

The measurement of fusion excitation function 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 HPGe detector was used for the measurement of fusion excitation function using online characteristic γ-ray detection method. The detailed experimental setup and analysis procedure is discussed in Ref. [8].

3. Results and Discussions

The experimental TF excitation functions for both ^{7}Li+^{64}Ni [8] and ^{6}Li+^{64}Ni [9] systems are shown in Fig. 1 as a function of energy to Coulomb barrier ratio of each system. Both the excitation functions show almost similar behavior in the measured energy range. These excitation functions were used for extracting fusion barrier distribution, $D_{fus}(E_{c.m.})$ using point difference formula as,

$$D_{fus}(E_{c.m.}) = \frac{1}{\pi R_B^2}\frac{d^2(E_{c.m.}\sigma_{fus})}{dE_{c.m.}^2}, \qquad (1)$$

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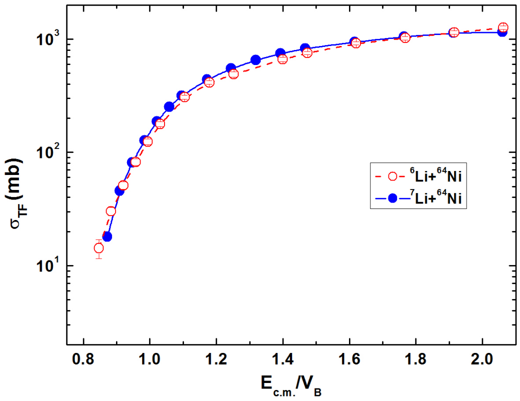

FIG. 1: The measured TF excitation function for the system ^{7}Li+^{64}Ni [8] in comparison with that of the system ^{6}Li+^{64}Ni [9] as a function of energy to Coulomb barrier ratio. The excitation function for ^{7}Li+^{64}Ni is shown by solid bullets, whereas ^{6}Li+^{64}Ni is shown by open circles. The lines are only guide to eye.

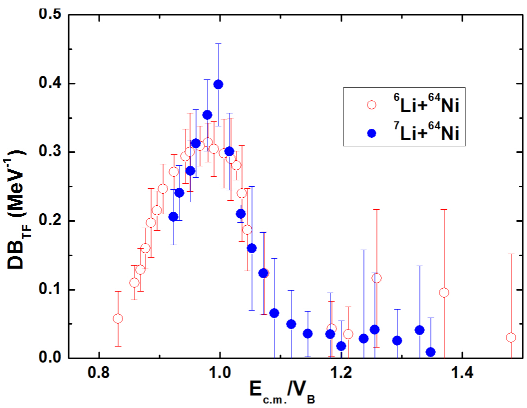

FIG. 2: The extracted barrier distributions for the systems ^{7}Li+^{64}Ni and ^{6}Li+^{64}Ni [10]. Solid bullets represent data for ^{7}Li+^{64}Ni and open circles represent the same for ^{6}Li+^{64}Ni system.

where $\sigma_{fus}(E_{c.m.})$ is the fusion cross section for a system at the projectile energy $E_{c.m.}$ in the centre of mass frame, R_B is the uncoupled barrier radius [2].

The barrier distributions extracted from the fusion excitation functions of the systems have been plotted in Fig. 2. The peaks of the distributions of ^{7}Li+^{64}Ni and ^{6}Li+^{64}Ni occur almost at the same energy. But the widths of the distributions are different. The barrier distribution of ^{6}Li+^{64}Ni is wider and extends further in the lower energy region. Although the data for ^{7}Li+^{64}Ni does not extend up to very low $E_{c.m.}/V_B$ values, it is quite clear that the distribution falls sharply after crossing the barrier energy. The observation corroborates with the slow fall off of the total fusion cross section of ^{6}Li+^{64}Ni compared to ^{7}Li+^{64}Ni below the Coulomb barrier energy.

Acknowledgments

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References

[1] M. Dasgupta, *et al.*, Ann. Rev. Part. Sci. **48**, 401 (1998).
[2] N. Rowley, G.R. Satchler and P.H. Stelson, Phys. Lett. B **254**, 25 (1991).
[3] L. F. Canto, *et al.*, Phys. Rep. **424**, 1 (2006).
[4] M. Dasgupta, *et al.*, Phys. Rev. C **70**, 024606 (2004).
[5] A. Mukherjee, *et al.*, Phys. Lett. B **636**, 91 (2006).
[6] M. Dasgupta, *et al.*, Phys. Rev. Lett. **82**, 1395 (1999)..
[7] M. Dasgupta, *et al.*, Phys. Rev. C **66**, 041602(R) (2002).
[8] Md. Moin Shaikh, *et al.*, Phys. Rev. C **93**, 044616 (2016).
[9] Md. Moin Shaikh, *et al.*, Phys. Rev. C **90**, 024615 (2014).
[10] Md. Moin Shaikh, *et al.*, Phys. Rev. C **91**, 034615 (2015).