Measurement of fusion and quasi-elastic barrier distributions of ^{6}Li+^{64}Ni

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1. Introduction

The measurement of fusion and quasi-elastic barrier distributions is an important tool to investigate the influence of different reaction mechanisms at energies around the Coulomb barrier [1]. The coupling of reaction channels with the elastic channel split the nominal barrier for fusion into a distribution of barriers. Consequently, the fusion cross sections at sub- and near-barrier energies are modified in comparison with the one-dimensional barrier penetration model (1-DBPM) predictions. Barrier distribution can be derived from the fusion excitation function [2] and also from the back-angle quasi-elastic excitation function [3]. Besides carrying the signature of coupling effects, the barrier distribution can also be used to probe the optical potentials [4].
In this context, we report here the measurement of fusion and quasi-elastic excitation functions and extraction of barrier distributions for weakly bound ^{6}Li colliding with ^{64}Ni at energies around the Coulomb barrier. Comparison of the extracted data with the model predictions for ^{6}Li+^{64}Ni will also be presented.

2. Experiment and Analysis

The experiment was carried out at 14UD BARC-TIFR Pelletron Facility in Mumbai, India. A self-supporting target of ^{64}Ni of thickness 507 μg/cm^2 was bombarded with ^{6}Li beam at laboratory energies varying from 11 to 28 MeV in small steps (V_B^{lab} ∼13.8 MeV). A monitor detector was placed at 30° for normalization purpose. Another Silicon surface barrier detector was positioned at 150° with respect to the beam direction to measure the quasi-elastic excitation function. The fusion cross sections were measured using the characteristic γ rays detection technique with an HPGe detector placed at 45° with respect to the beam direction. The data were recorded and analyzed using the software LAMPS [5]. The fusion residue cross sections were determined entirely from the measured ground state transitions of the residues. Several ground state transitions corresponding to each residue channels were recorded. The fusion cross section at each energy is the sum of the observed residue cross sections obtained by summing over associated characteristic γ-ray cross sections. The experimental fusion excitation function was compared with the 1-DBPM prediction in Fig. 1(a). An Akyüz-Winther potential with strength V_0 = 41.47 MeV, radius parameter r_0 = 1.17 fm and diffuseness a_0 = 0.60 fm was used in the calculation with the code CCFULL [6]. The resultant V_B and R_B are 12.41 MeV and 9.1 fm respectively. The measured quasi-elastic excitation function is presented in Fig. 1(b). The solid line in Fig. 1(b) represents the prediction of Continuum Discretized Coupled Channel (CDCC) calculation using the code FRESCO [7] while the dashed curve represents the cross sections in no coupling condition.

3. Results and Discussions

The barrier distributions extracted from the excitation functions of Fig. 1 are shown in

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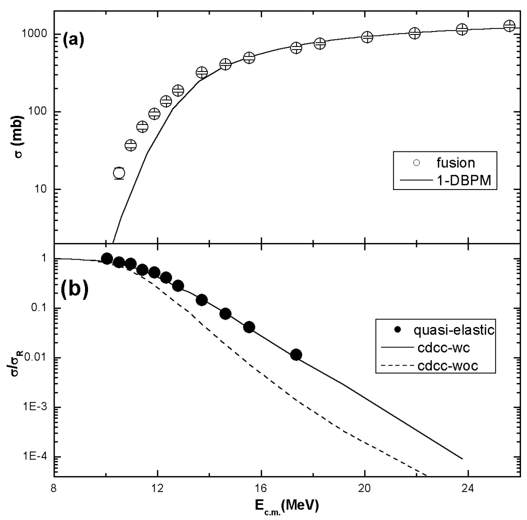

FIG. 1: Fusion (a) and Quasi-elastic (b) excitation functions. In (a) the solid line is 1-DBPM prediction and in (b) the solid (dashed) line shows the model prediction with (without) continuum coupling.

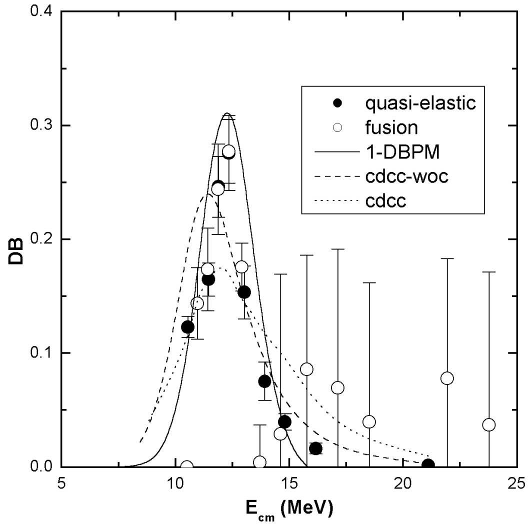

FIG. 2: Barrier distribution for ^{6}Li+^{64}Ni.

Fig. 2. It is observed that both the distributions, fusion (open circle) and quasi-elastic (solid circle), peak at $\sim E_{cm}$=12.41 MeV, close to the Coulomb barrier of the system. But beyond 15 MeV there is a hint of a second peak in the fusion barrier distribution, although experimental errors are quite high in this region. In Fig. 2 the solid line gives the barrier distribution from 1-DBPM calculation. The dotted line shows the prediction of CDCC calculation when the coupling to the $\alpha+d$ continuum of ^{6}Li was included. The dashed curve indicates the distribution in the no coupling condition. The location of the peak in no coupling condition shifts to lower energy region. Coupling to the continuum definitely improves the fit in terms of the location of the peak. The coupling also generates a better match to the barrier distribution at the higher energy region. However, the magnitude of the barrier distribution around the peak position has come down significantly due to the coupling to the breakup continuum alone. The effect of coupling to transfer following breakup, an important channel for ^{6}Li projectile, is being investigated using CDCC-CRC method.

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References

[1] M. Dasgupta *et al.* Annu. Rev. Nucl. Part. Sci. **48**, 401 (1998).
[2] N. Rowley, G.R. Satchler and P.H. Stelson, Phys. Lett. B **254**, 25 (1991).
[3] H. Timmers *et al.* NPA**584**,190(1995).
[4] K. Zerva *et al.* Phys. Rev. C **82**, 044607 (2010).
[5] LAMPS: Linux Advanced Multiparameter System; A. Chatterjee (private communication).
[6] K. Hagino, N. Rowley, A. Kruppa, Comp. Phys. Com. **123**, 143 (1999).
[7] I. J. Thompson, FRESCO (Version RES2.9, (2011)), Comput. Phys. Rep. **7**, 167 (1988).