Measurements of evaporation residue cross-sections for ^{48}Ti+^{124}Sn system

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Introduction

Sub-barrier fusion cross-sections are more than the predictions of the one-dimensional barrier penetration model (1-D BPM) [1, 2]. This enhancement in sub-barrier fusion cross-sections may be attributed to the couplings between various internal degrees of freedom such as static and dynamic deformation of the colliding nuclei, neck formation, and nucleon transfer channels [3–5]. Couplings with an intrinsic degree of freedom reduce the height of the barrier which in turn enhances the fusion cross-sections. So to understand the sub-barrier fusion enhancement phenomena and the role played by various types of couplings, we have measured the evaporation residue cross-sections for ^{48}Ti+^{124}Sn system.

Experimental details and data analysis

The experiment was performed using the HYRA (HYbrid Recoil mass Analyzer) [6] facility at IUAC, New Delhi. A ^{48}Ti pulsed beam was bombarded on ^{124}Sn target of thickness 100 μg/cm^2 having carbon backing of 20 μg/cm^2. ER cross-sections were measured in the energy range of 166 - 197.6 MeV. These energies are obtained after correcting energy loss of ∼ 16 MeV in carbon window foil, carbon backing and half thickness of the target. In the present experiment, the first stage of HYRA in the helium gas-filled mode was used with electromagnetic configurations Q_1Q_2-MD_1-Q_3-MD_2-Q_4Q_5, where MD represents magnetic dipoles and Q represents magnetic quadrupoles. During the whole experiment, helium gas pressure was maintained at 0.3 Torr. Total ER cross-section is given by

$$\sigma_{ER} \sim \sigma_{fusion} = \frac{Yield_{ER}}{Yield_{Mon}} \Omega_{Mon} \frac{d\sigma}{d\Omega} \frac{1}{\eta_{HYRA}} \quad (1)$$

Here σ_{ER} and σ_{fusion} correspond to ER cross-sections and fusion cross-sections. In these calculations, we considered σ_{ER} is equivalent to fusion cross-section because fission is nearly absent for this system. $Yield_{ER}$ is the yield of ER at the focal plane of HYRA, $Yield_{Mon}$ is the average yield of monitor detectors, $\frac{d\sigma}{d\Omega}$ is the Rutherford scattering cross-section, η_{HYRA} is the transmission efficiency of the HYRA. We have followed the same procedure as mentioned in reference [7] to calculate η_{HYRA}. ^{48}Ti+^{142}Ce was used as a calibration reaction to calculate the transmission efficiency because its cross-sections are already reported in the literature [8]. Experimentally obtained ER cross-sections are shown in Fig.1. Experimentally measured ER cross-sections are compared with the predictions of the One-dimensional barrier penetration model (1-D BPM). From Fig. 1 it is observed that 1-D BPM cross-sections underestimates the experimental sub-barrier fusion cross-sections. To understand this enhancement in sub-barrier fusion cross-sections we have performed the coupled channels calculations us-

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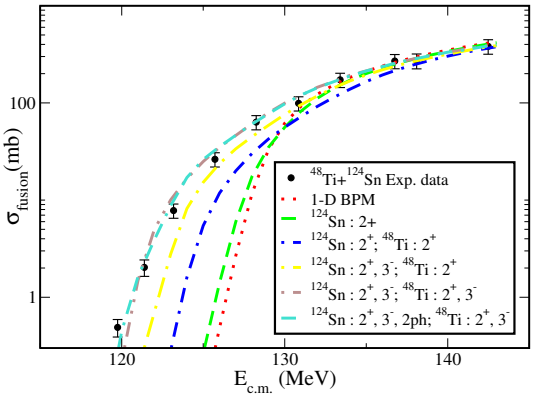

FIG. 1: Coupled-channels calculations by including various inelastic couplings for ^{48}Ti+^{124}Sn system.

ing the coupled-channel calculation code CCFULL [9] as shown in Fig.1. In these calculations, we have considered Akyuz-Winther parameterization of the Woods-Saxon form of nuclear potential with depth $V_0 = 77.78$ MeV, radius $r_0 = 1.18$ fm, and diffuseness $a_0 = 0.68$ fm were used. By including couplings of the 2^+, and 3^- states of both projectile and target along with 2-phonon couplings in the target, coupled-channel calculations were able to reproduce the fusion cross-sections as shown in Fig. 1.

Conclusion

ER cross-sections were measured in the energy range of $\sim$ 11 % above and $\sim$ 6 % below the Coulomb barrier. Experimental data was analyzed with the help of CCFULL code. By including the various types of couplings in both projectile and target nucleus, ER cross-sections were well reproduced in the measured energy range.

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