Probing experimental landscape of fusion barrier widths through coupling strengths

Abhijit Bairagya¹, Saumyajit Biswas², B. Mukherjee¹, and A. Chakraborty^{1*}

Department of Physics, Siksha Bhavana,

Visva-Bharati, Santiniketan, West Bengal-731 235 and ²Department of Physics, Murshidabad College of Engineering and Technology, West Bengal-742 102

Introduction

Nuclear fusion and quasi-elastic scattering are the two proven ways for the measurements of barrier distributions that provide vital ingredients for unveiling the issues related to the associated nuclear reaction dynamics. As the orientation of the colliding deformed nuclei changes, the separation between the centres of the concerned target-projectile combination also changes, and as a result, the barrier also varies [1]. This effect is manifested in the corresponding barrier distribution. It is also to be noted here that the width and the structure of the barrier distribution varies with the variation of different target projectile combinations. The width of barrier distribution depends upon the coupling strength. The coupling strength for a system is found to be proportional to $Z_p Z_t \beta$ [2], where Z_p , Z_t represent respectively the projectile and target nuclear charges and, β denotes the average deformation parameter for the concerned colliding system. So, the influencing effect of nuclear deformation on reaction dynamics can be understood very well by probing the variation of barrier width with the parameter, $Z_p Z_t \beta$.

Methodology

In the present work, we have extracted the experimental barrier width (ΔB_{exp}) of a few target projectile combinations following the prescription as described in Ref. [3]. In this context, the required experimental data have been collected from the relevant nuclear data bases and the published works. We have se-

*Electronic address: anagha.chakraborty@ visva-bharati.ac.in

lected a series of systems with a fixed spherical projectile $({}^{16}O)$ and deformed targets. The combinations of a fixed deformed projectile (^{28}Si) with different spherical and deformed targets have also been considered. The extracted results have been tabulated in TA-BLES I, II & III. The Corresponding graphical representations have been made in Fig. 1 and Fig. 2, respectively.

TABLE I: The extracted data for the combinations of spherical projectile and deformed targets.

$Z_p Z_t \beta$	$\Delta B_{exp}(\text{MeV})$
16.384	7.091
17.841	9.524
22.209	11.114
24.166	15.669
25.843	18.374
29.017	23.449
	$\frac{Z_p Z_t \beta}{16.384} \\ 17.841 \\ 22.209 \\ 24.166 \\ 25.843 \\ 29.017 \\$

TABLE II: The extracted data for the combinations of deformed projectile and deformed targets.

System	$Z_p Z_t \beta$	$\Delta B_{exp}(\text{MeV})$
$^{28}Si + ^{64}Ni$ [8]	111.916	11.699
$^{28}Si + ^{58}Ni$ [8]	116.032	12.165
$^{28}Si + ^{68}Zn$ [9]	129.195	12.769
$^{28}Si + ^{92}Zr$ [10]	143.948	19.631
$^{28}Si + ^{115}In$ [10]	197.808	41.348
$^{28}Si + ^{150}Nd$ [11]	283.160	54.700
$^{28}Si + ^{154}Sm$ [10]	326.368	68.474

TABLE III: The extracted data for the combinations of deformed projectile and spherical targets.

System	$Z_p Z_t \beta$	$\Delta B_{exp}(\text{MeV})$
$^{28}Si + ^{90}Zr$ [12]	141.291	39.192
$^{28}Si + ^{124}Sn$ [10]	177.771	36.706
$^{28}Si + ^{142}Nd$ [11]	211.806	36.386
$^{28}Si + ^{208}Pb$ [10]	269.214	34.137



FIG. 1: The extracted variation profile of ΔB_{exp} vs $Z_p Z_t \beta$ for the combinations of the spherical projectile (¹⁶O) and deformed targets.



FIG. 2: the extracted variation profiles of ΔB_{exp} vs $Z_p Z_t \beta$ for the combinations of : deformed projectile (²⁸Si) and spherical targets ; deformed projectile(²⁸Si) and deformed targets.

Results and Discussions

For understanding the possible nuclear structure effects of the colliding nuclei on barrier distributions, we have studied the variation profiles of ΔB_{exp} with $Z_p Z_t \beta$. The effect of target deformation on ΔB_{exp} can clearly be seen in Fig. 1. As can be seen from the figure, the value of ΔB_{exp} continuously increases with the increasing value of $Z_p Z_t \beta$. So, there is a clear indication of the effect target deformation on barrier distribution as the projectile (¹⁶O) considered here is spherical. In Fig. 2, the said variation profiles for the deformed projectile (²⁸Si) and spherical targets (⁹⁰Zr, ¹²⁴Sn, ¹⁴²Nd, and ²⁰⁸Pb) as well as the & deformed projectile (²⁸Si) and deformed targets (⁶⁴Ni, ⁵⁸Ni, ⁶⁸Zn, ⁹²Zr, ¹¹⁵In, ¹⁵⁰Nd, and ¹⁵⁴Sm) are shown. The difference in the varying trends is found to be quite obvious for the considered two cases. This clearly demonstrates the influence of the deformations of the colliding partners in controlling the experimentally observed barrier widths. The detailed results along with the underlying issues of reaction dynamics would be presented during the symposium.

Acknowledgments

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