Probing experimental landscape of fusion barrier widths through coupling strengths

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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 selected 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 TABLES 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.

System	$Z_p Z_t \beta$	ΔB_{exp}(MeV)
$^{16}O +^{92} Zr$ [4]	16.384	7.091
$^{16}O +^{64} Ni$ [5]	17.841	9.524
$^{16}O +^{62} Ni$ [6]	22.209	11.114
$^{16}O +^{76} Ge$ [7]	24.166	15.669
$^{16}O +^{74} Ge$ [7]	25.843	18.374
$^{16}O +^{70} Ge$ [7]	29.017	23.449

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

System	$Z_p Z_t \beta$	ΔB_{exp}(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	$Z_p Z_t \beta$	ΔB_{exp}(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

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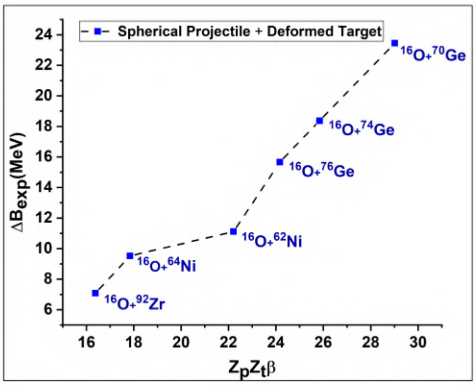

FIG. 1: The extracted variation profile of ΔB_{exp} vs $Z_pZ_t\beta$ for the combinations of the spherical projectile (^{16}O) and deformed targets.

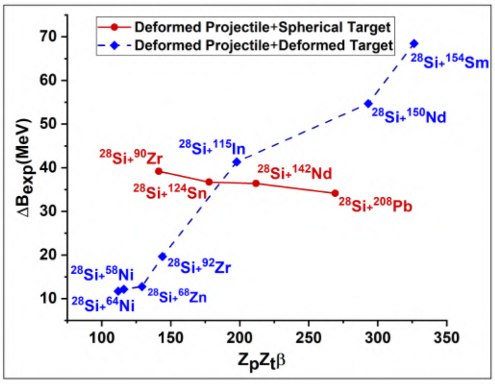

FIG. 2: the extracted variation profiles of ΔB_{exp} vs $Z_pZ_t\beta$ for the combinations of : deformed projectile (^{28}Si) and spherical targets ; deformed projectile(^{28}Si) and deformed targets.

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 $Z_pZ_t\beta$. 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 $Z_pZ_t\beta$. So, there is a clear indication of the effect target deformation on barrier distribution as the projectile (^{16}O) considered here is spherical. In Fig. 2, the said variation profiles for the deformed projectile (^{28}Si) and spherical targets (^{90}Zr, ^{124}Sn, ^{142}Nd, and ^{208}Pb) as well as the & deformed projectile (^{28}Si) and deformed targets (^{64}Ni, ^{58}Ni, ^{68}Zn, ^{92}Zr, ^{115}In, ^{150}Nd, and ^{154}Sm) 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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