Effects of deformation on the sub-barrier fusion cross section induced by ^{16,18}O on Ni, Sn

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Introduction

Fusion reactions are influenced by the internal structure like deformation of the interacting nuclei [1]. It has been shown both experimentally and theoretically that the subbarrier fusion cross section of a nuclei in the ground state around Coulomb barrier energies is strongly enhanced by the quadrupole and/or hexadecapole deformation. Theoretical models are used to take the fusion barrier information from the fusion differentials cross sections which are obtained from the experiments and the base of all such models is nucleus-neucleus interaction potentials.

In this paper, twelve different versions of proximity potentials are used to study the fusion cross section in the sub-barrier region for the systems induced by spherical nuclei ^{16}O and ^{18}O on slightly deformed nuclei, ^{62} Ni and ^{116}Sn, within the theoretical approach.

Using these proximity potentials, the interaction barrier heights, fusion barrier radii and the curvatures of the barrier are determined for the three different reactions of ^{16}O+^{62}Ni [2], ^{16}O+^{116}Sn [3] and ^{18}O+^{116}Sn respectively. Applying these different parameters, the experimental fusion barriers, wherever applicable, are also investigated to see how well the barriers are reproduced, alongwith the equivalent calculation using a multidimensional barrier penetration model (BPM) [using CCFULL code [4]]. The quadrupole and hexadecapole deformation parameters considered here are ^{62}Ni ($\beta_2 = 0.093, \beta_4 = -0.008$)[5] and ^{116}Sn ($\beta_2 = 0.003, \beta_4 = -0.008$) as given in the Refs [5, 6] .

Interaction Potential

The nuclear part of the interaction potential, $\mathrm{V_N(r)}$, are calculated here using potentials, viz., Bass 77, Bass 80, Prox 77, Prox 88, modProx 88, Prox 00, Prox 00DP, Prox 10, Ngô, CW 76, BW 91 and AW 95 [7–14]. The Coulomb potential $\mathrm{V_C(r)}$ are approximately given by,[10]

$$V_C = \begin{cases} \dfrac{Z_P Z_T e^2}{2r_c}\left(3 - \dfrac{r^2}{r_c^2}\right), & \text{if } r \leq r_c \\ \dfrac{Z_P Z_T e^2}{r}, & \text{if } r > r_c \end{cases}$$

where Z_P, Z_T are the atomic numbers of the projectile and target respectively. Here, the size of the projectile is assumed to be much smaller than the radius of the target, r_c. Here r is the internuclear distance between the projectile and the target.

The total interaction potential between projectile and target is, therefore, the sum of the centrifugal term, the long range Coulomb repulsive force and short range nuclear attractive force written as

$$\mathrm{V = V_C(r) + V_N(r) + \frac{\hbar^2 l(l+1)}{2\mu r^2}}$$

where l is the angular momentum quantum number, and μ is the reduced mass of the system.

In this paper, the total interaction potential is extracted by taking into account the Coulomb corrections for the majority of the potentials, except BW 91 where both the Coulomb and nuclear corrections [15] are considered.

Fusion cross-section

In order to calculate the fusion cross-sections, the model derived by Wong [16] is

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*Electronic address: `nd_globe@yahoo.co.in` used here. The fusion cross-section are calculated by the BPM model under the parabolic approximation, which is given by $\sigma_f(E,\theta)$ as shown in ref.[16]

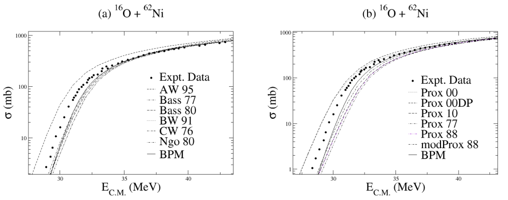

FIG. 1: The fusion cross section of ^{16}O+ ^{62}Ni with relative to centre of mass energy. The experimental data is obtained from ref. [2]

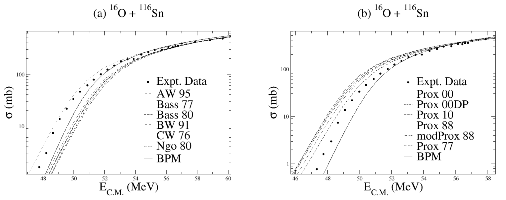

FIG. 2: The fusion cross section of ^{16}O+ ^{116}Sn with relative to centre of mass energy. The experimental data is obtained from ref. [3]

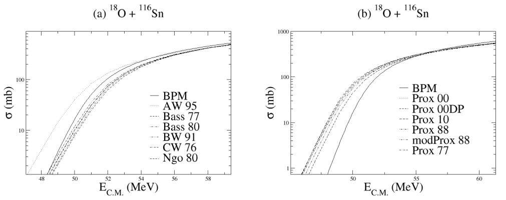

FIG. 3: The fusion cross section of ^{18}O+ ^{116}Sn with relative to centre of mass energy. The experimental data is not available for this system.

Results and Conclusion

From the studies performed on fusion barriers of the mentioned reactions, it is found that the the effect of deformation of the target and its orientation, with its collision axis, are more pronounced on the AW 95, Bass 80, BW 91, Prox 00 and Prox00DP potentials than the rest. It is seen from calculations, the improvement for the majority of nuclear interaction potentials both at below and at above barrier energies as compared to experimental results, wherever available. Although the fusion cross-sections by Prox 10 and Prox 00 potentials showed good agreement, but overall, by Prox 10, Prox 88, Prox 00, Prox 00DP, BW 95, CW 76, Ngô 80 and AW 95 potentials, it seems to be in stronger agreement with the experimental data. The deviation of fusion cross-sections from the experimental data shows that both Coulomb and nuclear corrections are needed for these potentials. Similarly, the fusion cross sections as a function of centre of mass energy was calculated for the ^{18}O+^{116}Sn. To know its correct form, experimental data is required. The inelastic effect for these three systems will also be considered here which will be presented in the conference as the work is under progress for this paper.

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