Study of deformation effects on the sub-barrier fusion cross section in ^{13}C + ^{157}Gd and ^{18}O + ^{160}Dy

Harun Al Rashid,* Nabendu Kumar Deb, Kushal Kalita
Department of Physics, Gauhati University, Guwahati - 781014, Assam, INDIA

Introduction

Understanding the dynamics of heavy ion fusion reactions and the interplay of nuclear structure has been a subject of intensive study during last few decades [1]. Entrance channel properties such as deformation and mass asymmetry affect the formation of compound nucleus (CN) system or a multinuclear system [2]. Both experimentally and theoretically it has been shown that sub-barrier fusion cross section of nuclei in the ground state is strongly affected by the quadrupole and/or hexadecapole deformation and orientation of the target [3]. Going with experimental data, it is useful to investigate nuclear potentials as given in Refs [4–10] to observe how this parameterized potentials reproduce experimental fusion barriers. These proximity potentials are used to study the fusion cross-section near barrier for the reactions ^{13}C + ^{157}Gd and ^{18}O + ^{160}Dy. Using this potentials, the interaction barrier height, position and curvature are calculated which are then used to find the cross sections. Fusion cross sections are also calculated using multi-dimensional BPM with the help of CCFULL code [11]. The quadrupole and hexadecapole parameters considered here are taken from Refs [12, 13]. Our theoretical results are compared with the experimental data for the reactions ^{12}C + ^{159}Tb and ^{16}O + ^{159}Tb [14, 15].

Methodology

Using potentials as referred in [4–10], the nuclear part of the interacting potentials V_N(r) are calculated. The total interaction potential is the sum of the nuclear potential, Coulomb potential, V_C(r) and centrifugal term reads as

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

Here l is the total angular momentum quantum number, and μ is the reduced mass of the system. Coulomb potential is given as

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

where Z_P, Z_T are the atomic numbers of the projectile and target respectively. Here r is the inter-nuclear separation. The fusion barrier heights and position for different potentials are calculated using these above conditions. Fusion cross-section is calculated under parabolic approximation of BPM model given by Wong [2].

Results and Discussions

In fig. 1, the theoretical cross section for ^{13}C + ^{157}Gd is found to be slightly deviated from the experimental data of ^{12}C + ^{159}Tb. However, experimental cross-section of ^{16}O + ^{159}Tb agrees with theoretical cross-section of ^{18}O + ^{160}Dy as shown in fig. 2. Deformation as well as orientation of target affects the cross-section. It is therefore needed to correct the Coulomb and nuclear interactions.

Conclusion

Theoretical investigation of deformation on orientation is carried out as mentioned systems and compared with some experimental data. However, we are extending our work

*Electronic address: `rashidharunal5@gmail.com`

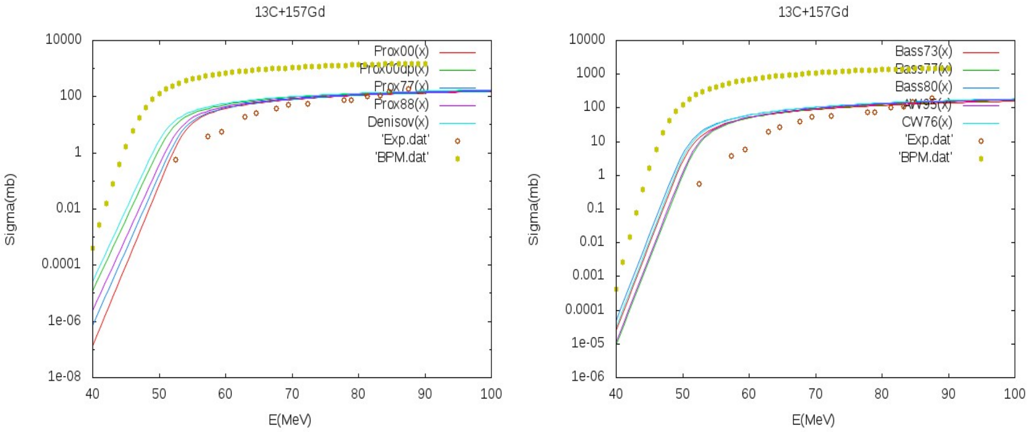

FIG. 1: Fusion cross section for ^{13}C + ^{157}Gd.

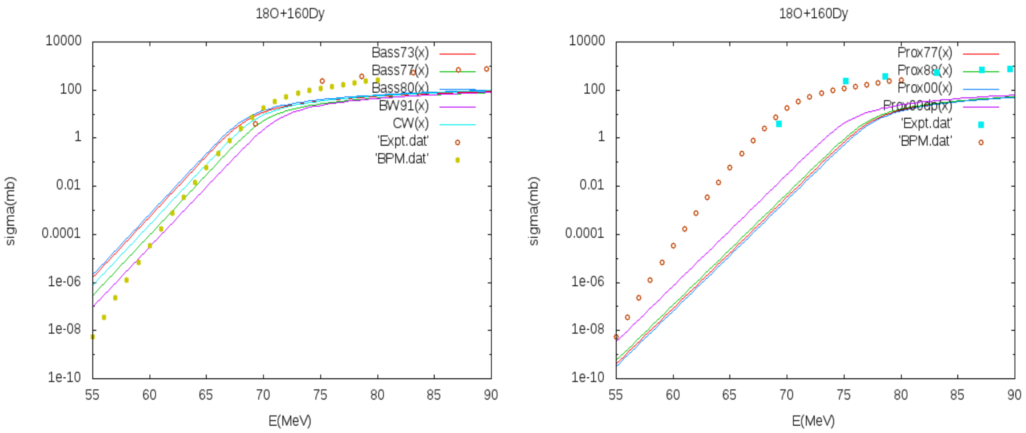

FIG. 2: Fusion cross section for ^{18}O + ^{160}Dy.

considering double-folding and Skyrme potentials to get clear picture of fusion mechanism as well as transfer processes.

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