Exploring the accurate Woods-Saxon Potential

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Recently Sharma and Nandi [1] demonstrated the coexistence of atomic and the nuclear phenomenon on the elastically scattered projectile ions while approaching the Coulomb barrier. Here the projectile ion x-ray energies were measured as a function of ion beam energies for three systems ^{12}C(^{56}Fe,^{56}Fe), ^{12}C(^{58}Ni,^{58}Ni) and ^{12}C(^{63}Cu,^{63}Cu) and observed unusual resonance like structures as the beam energy approaching the fusion barrier energies according Bass model [2]. We expected the resonance near to interaction barrier as this technique resembled quasi-elastic (QEL) scattering experiment [3]. To resolve this anomaly, we planned to examine the fusion and interaction barriers in a greater detail. Only the fusion barrier analysis is discussed here.

Various semi-empirical models for fusion barrier such as Bass [2], Christen and Winther (CW) [4], Broglia and Winther (BW) [5], Aage Winther (AW) [6], Siwek-Wilezyniska and Wilezyniski model (Poland) [7], Skyrme model [8] and São Paulo optical potential (SPP) [9] are used. Besides we have formulated another model on the basis of experimental results for about 30 different systems. These models take nuclear potential of different forms namely: exponential or Woods Saxon potential each having three parameters: depth (V_0), radius (r_0) and diffuseness (a_0). In this work, we have examined the predictive powers of all the models with respect to the fusion barrier (B_{fu}). The model predictions have been compared with experimental data of 60 different systems as shown in Fig 1. The agreement between the experiment and theory have been assessed by the average of the difference between the model prediction and experimental data. A similar study has also been done for radius parameter r_0. On the basis of these two analyses, the best model turns out to be the BW model [5]. To test these parameters, we have used them in calculating fusion cross sections for many reactions and compared the cross sections to their experimental values. Two reactions ^{19}F+^{181}Ta [10] and ^{16}O+^{208}Pb [11] have been shown in Fig 2. The fusion cross sections are calculated using the CCFULL [12] code. Above the barrier, the BW parameters explain the data very well without any further adjustments on the parameters to match the measured data. In the case of ^{16}O+^{208}Pb, at deep sub-barrier energies, fusion hindrance has to be accounted for through a damping factor using the CCFULLYPE code [11](Fig 2(b)). Similar test for many more reactions is in progress to validate the potential parameters in greater detail. We believe, this study will be useful for experiments aiming to form superheavy elements.

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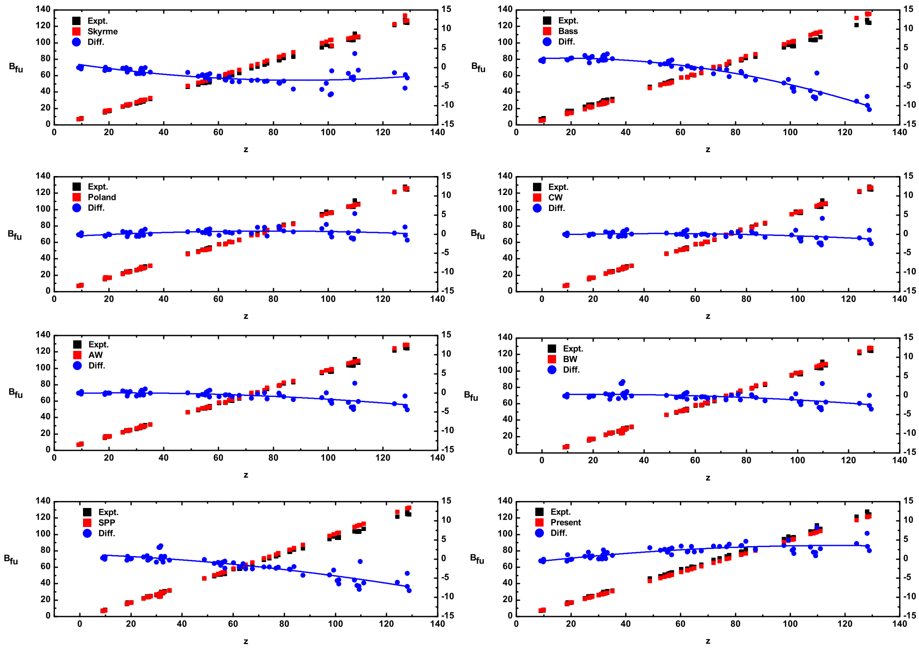

FIG. 1: Model prediction and experimental B_{fu} vs z plot and their difference. Here, $z = \frac{Z_p Z_t}{A_p^{\frac{1}{3}} + A_t^{\frac{1}{3}}}$, where Z_p,Z_t are the atomic number for projectile and target and A_p and A_t are the mass number for projectile and target, respectively. The blue curve is the polynomial fit.

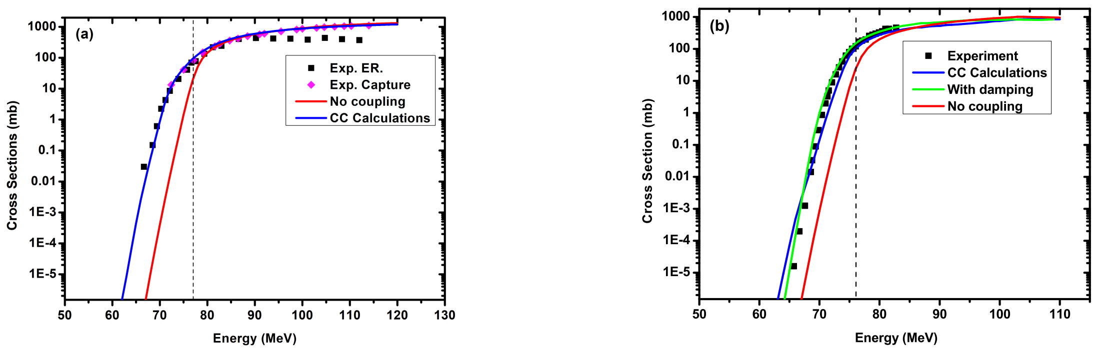

FIG. 2: Total fusion cross section vs Energy(in center of mass frame) plot for (a)^{19}F+^{181}Ta and (b)^{16}O+^{208}Pb. The dotted line represents the fusion barrier energy for the system.

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