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Investigation of ^{18}O+^{182}W fusion reactions using microscopic nuclear potential with in the channel coupling approach

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Introduction

The fusion reactions of heavy nuclei have been thoroughly studied to comprehend the quantum tunnelling phenomenon in intricate many-body systems. One interesting phenomenon observed in this field is the sub-barrier fusion enhancement. A significant enhancement in the sub-barrier heavy ion fusion cross sections over the one-dimensional barrier penetration model (1-D BPM) predictions have been observed experimentally [1]. The measured fusion excitation functions have been attributable to the coupling between relative motion in the entrance channel with intrinsic degrees of freedom of the participating nuclei and nucleon transfer channels. Within the context of coupled channels (CC) calculations, the effect of nuclear vibration and deformation has been established [1, 2]. However, in most cases, the involvement of neutron transfer has appeared to be ambiguous. Further, various nuclear potentials have been proposed in the literature to explain the fusion cross-section over wide energy ranges. The nuclear component of nucleus-nucleus interactions can be approximated using the Woods-Saxon potential. The other well-known one is the double folding nuclear potential in which the ion-ion optical potential is obtained by averaging an effective nucleon-nucleon (NN) interaction over the matter densities of the two colliding nuclei [3]. Over recent decades, the widely used NN interactions are M3Y interactions. Recently, the Relativistic mean field formalism has been used to generate the effective NN interaction known as R3Y potential which is analogous to the M3Y potential [4] and references therein. Therefore, in the present work, the CC calculations have been performed using WS and R3Y NN interaction potential with neutron transfer channels for ^{18}O+^{182}W reaction.

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Theoretical Formalism

The Coupled Channel approach (CCFULL) is employed mainly for calculating mean angular momenta and the fusion cross-sections of the compound nucleus under the influence of coupling between relative motion and intrinsic degrees of freedom of the interacting nuclei. More details can be found in Ref. [2]. The crucial and sensitive ingredient of the coupled channel approach is the nucleus-nucleus interaction potential, which is taken from the Wood-Saxon approach.
It is worth mentioning that microscopic R3Y NN potential for the NL3* parameter set will be included in this investigation and can be determined by solving the RMF equations for mesons. Further details can be found in Refs.[3, 4]. The fusion cross-section of the compound nucleus assumes the coupling of all orders as discussed in the results.

Result and Discussions

The measured fusion cross-section for ^{18}O + ^{182}W reaction is analyzed using the coupled channel CCFULL code. The Woods-Saxon potential parameters V_0, r_0, and a_0 are 98.76 MeV, 1.15 fm and 0.73 fm respectively to reproduce the fusion cross-section at the above barrier energies [5]. The ℓ-values are obtained from the sharp cut-off model [6]. The channel coupling does not play an important role above the Coulomb barrier. Therefore, we first perform the one-dimensional barrier penetration model (1-D BPM) by ignoring nuclear

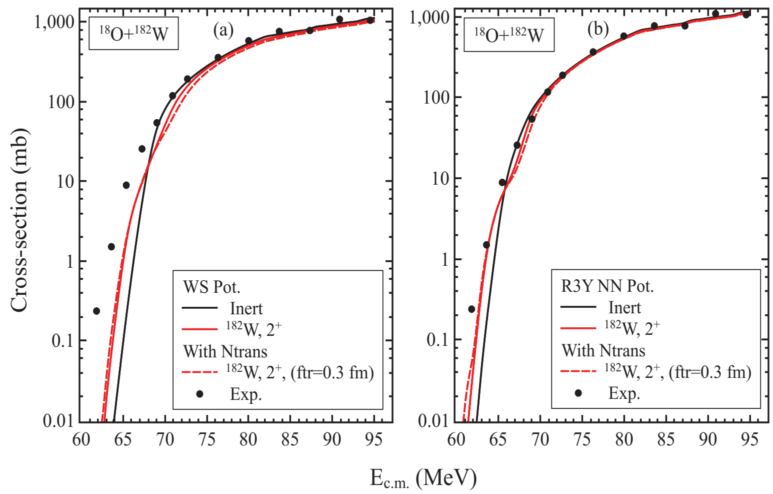

FIG. 1: (Color online) The fusion cross-sections estimated up to 2^+ excited state as a function of $E_{c.m.}$(MeV) for ^{18}O + ^{182}W reactions (a) WS potential (b) R3Y NN potential.

intrinsic excitations to reproduce the experimental fusion cross-sections at the above barrier energies. The solid black line represents the 1-D BPM calculations as shown in Fig.1. In coupled channel calculations, we have included the quadrupole deformation β_2= 0.265 and hexadecapole deformation β_4= -0.075 obtained from the relativistic mean-field formalism (RMF). The fusion cross-section obtained with the inclusion of at 2^+ state of the target nuclei is represented by a solid red line as shown in Fig.1. However, even with the inclusion of excitation channel 2^+, fusion hindrance at below barrier energy is still observed. We have obtained the microscopic R3Y nucleon-nucleon (NN) potential within the RMF approach and then fed this potential as an external potential to perform the coupled channel calculations. The Woods-Saxon potential parameters are tuned to R3Y NN potential in such a way as to obtain the same fusion cross-section. The fitted WS parameters for R3Y NN potential V_0, r_0, and a_0 are 98.76 MeV, 1.193 fm, and 0.73 fm respectively. This reaction has a $+ve$ Q-value of 1.414 MeV for the neutron stripping channel [5]. The coupling strength of 0.3 fm has been included in the CCFULL code. We have done the calculations by including the $2n$-transfer channel and the inelastic excitations. The dotted red line represents the data for the 2^+ channel as shown in fig.1. Our results show that within the inclusion of neutron transfer (Ntrans) with R3Y NN potential, theoretical calculations match well with the experimental data even at below barrier energies [5]. Further investigations are in progress.

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