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Analysis of fusion reactions induced by weakly bound nuclei on medium and heavy mass targets

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Keywords: weakly bound nuclei, coupling effects, break up effects, fusion reaction cross section

Abstract

Fusion cross section for reactions induced by weakly bound nuclei ^{6}He, ^{6,7}Li ^{9,11}Be and ^{10}B on targets lying in the mass region $64 \leqslant A \leqslant 238$ have been investigated at around Coulomb barrier energies within the coupled channel formalism. Specifically, the effects of coupling to low-lying excited states of reactants and those arises due to the breakup of projectile have been studied by using Broglia and Winther (BW91), Aage Winther (AW95) and fitted potential (FP) parameterization schemes. Among these the FP scheme is found to be most appropriate in the description of fusion excitation functions of various projectile-target combination. Further, it is observed that in the sub barrier energy region there is an enhancement in the fusion cross section due to coupling to excited states while there occurs fusion suppression at above barrier energies because of the breakup of the projectile.

1. Introduction

The advancement in radioactive ion beam facilities has made it possible to understand the dynamics of the reactions induced by weakly bound nuclei [1–5]. Particularly, the study of fusion reactions at near and sub barrier energies involving these nuclei have attracted considerable interest both on experimental and theoretical fronts [6–12]. These studies have shown that the magnitude of fusion cross section at energies slightly below the barrier and slightly above the barrier is much larger than that predicted from one dimensional barrier penetration model [2, 13–17]. One of the possible reasons for this enhancement in fusion cross section at around Coulomb barrier energies may be ascribed to the coupling to excited states of the projectile and the target [16–23]. However, a lot of ambiguities have been found in the extent of enhancement arising due to coupling of excited states by various authors [1]. One of the possible reasons for these ambiguous results, may be attributed to inadequate knowledge of the ion–ion interaction potential comprising of Coulomb, nuclear and centrifugal part. The nature of Coulomb and centrifugal parts of the ion–ion potential is well known while many ambiguities are associated with the nuclear part. Consequently, several approaches have been proposed to describe the nuclear part of the interaction potential [24–38]. These approaches, however lead to different values of barrier parameters for the same reactants, particularly when one of reactant is light. Thus, it is quite tempting to explore the cumulative effects of potential parameters in conjugation with the coupling to excited states of the reactants on fusion excitation functions. Hence in the present work we have investigated the fusion of weakly bound nuclei (^{6}He, ^{6,7}Li ^{9,11}Be and ^{10}B) with various targets within coupled channel approach using code CCFULL [39] and BW91, AW95 and FP potential parameters. A brief description of the potential parameterization schemes and the coupled channel formulation is presented in section (2). The results are discussed in section (3) and the conclusions are given in section (4).

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