Universal behaviour of complete fusion suppression factor for ^{9}Be projectile with different targets

V. Jha[1],* V. V. Parkar[1], H. Kumawat[1], S. K. Pandit[1], and S. Kailas[1]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*

Introduction

A number of fusion cross section measurements with weakly bound stable nuclei, ^{6}Li, ^{7}Li and ^{9}Be, on a range of targets have been performed in recent years. In such measurements a distinction is made between the complete fusion (CF) which refers to fusion of the whole projectile and the total fusion (TF), which also includes the fusion of only part of the projectile, namely the incomplete fusion (ICF). A large suppression of CF cross section is observed in these measurements at energies above the Coulomb barrier with respect to one dimensional barrier penetration model (1DBPM) calculations. This suppression is commensurate with the measured ICF cross section.

Recently, Gomes *et al.* [1], have attempted to give a universal description of fusion suppression factors in case of reactions involving ^{9}Be nucleus based on the ICF yield. The ICF was estimated using a simple empirical relation given by Hinde *et al.* [2]. It is claimed that the ICF component and hence the fusion suppression factors decrease for the light mass systems. The complete fusion data for the ^{9}Be + ^{89}Y [4] and ^{9}Be + ^{124}Sn [5] systems, both measured at BARC-TIFR pelletron, Mumbai are found not to follow this systematics. In order to investigate this inconsistency, we have attempted to make an assessment of ICF based on the more accurate calculations of breakup and transfer in reactions of ^{9}Be with different targets. The maximum contribution to ICF in case of ^{9}Be induced reactions, is expected from the ^{8}Be +n breakup and the one neutron stripping processes.

*Electronic address: vjha@barc.gov.in

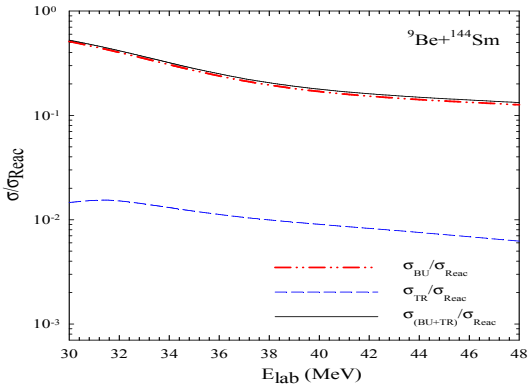

FIG. 1: ICF probability for the ^{9}Be + ^{144}Sm system as a function of beam energy.

Calculation

The breakup of the ^{9}Be in the ^{9}Be+^{28}Si, ^{64}Zn,^{144}Sm and ^{208}Pb reactions has been taken into account by performing the continuum discretized coupled channel (CDCC) calculations assuming a ^{8}Be +n cluster structure for the ^{9}Be nucleus. In our earlier study [3], we have shown that the ^{8}Be +n model gives a good description of ^{9}Be elastic scattering and breakup cross sections. In addition to the breakup, we have calculated the one neutron stripping cross sections using the Coupled Reaction Channels (CRC) calculations. Details of the continuum couplings are same as given in Ref. [3]. These calculations provide a good description of the elastic scattering and the reaction cross sections of the measured data for all the systems. The ratio of the summed breakup and transfer cross sections and the reactions cross sections, for two cases ^{9}Be + ^{144}Sm and ^{9}Be + ^{28}Si are shown in Fig. 1 and 2 respectively.

It is observed that the breakup is the dominant mechanism compared to transfer for both

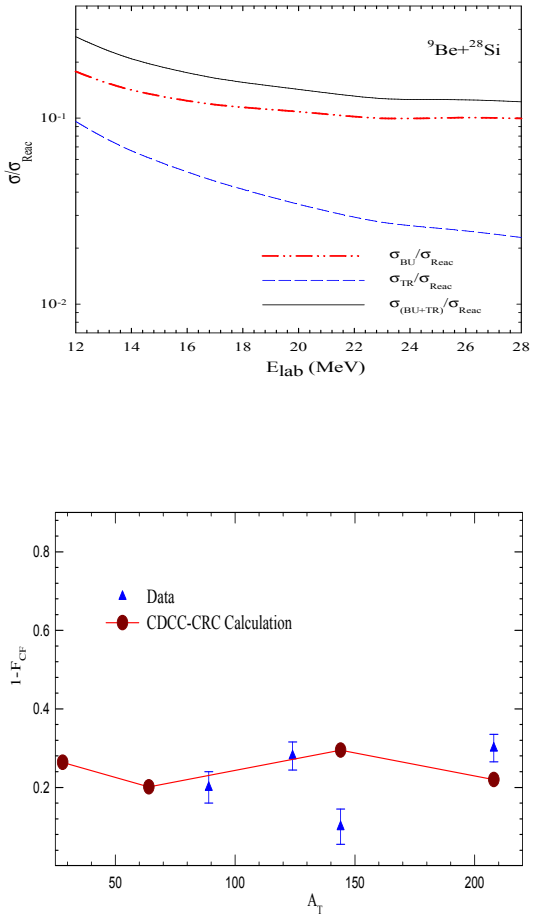

FIG. 3: The calculated ICF probability compared with the CF suppression factors derived from the measured data.

the systems. The breakup cross section remains constant over the energy range above the Coulomb barrier and increases at low energies. With the assumption that the fraction of non-capture breakup remains same for all the systems, these ratios can be taken as the ICF probability. In Fig. 3, we compare the ICF probability $(1 - F_{CF})$ which are derived from the experimental complete fusion suppression, with the calculated value of ratio at the higher energy for each system. The calculations have been normalized to the average suppression factor determined using the measured data for all the systems. We observe that the calculated ICF probabilty remains approximately constant from heavy to light target system, which is in contrast to empirical relation given in Ref. [2]. The extracted value of CF suppression factors from the present calculation are consistent with the experimental data for all the measured systems except for the ^{9}Be + ^{144}Sm system. Morever, the data measured at Mumbai pelletron are found fully consistent with the calculations, contrary to the claim in Ref. [1]. We would like to mention, that the universal behaviour of fusion suppression factors from heavy to light targets observed here for the ^{9}Be projectile, is also observed in experimental data of complete fusion with the other weakly bound nucleus ^{6}Li [6].

Summary

In summary, we have shown that the incomplete fusion probablity remains approximately constant for all the targets. Assuming that the ICF probability can be taken as a measure of CF suppression factor, we derive an important result that the CF suppression factor for ^{9}Be shows a universal behaviour irrespective of target chosen.

References

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