Effect of entrance channel parameters on incomplete fusion reaction dynamics at low energies

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Introduction

In the study of heavy ion interactions, incomplete fusion (ICF) has been in extensive discussion in the recent years because near the barrier energies a significant contribution of ICF has been observed, where complete fusion (CF) is supposed to be dominant. The ICF has been observed to be governed by different entrance channel parameters [1-4] which is not systematically understood and thus needs more comprehensive and detailed study. The motivation of the present work is to have a systematic study of ICF reactions and their dependence on various entrance channel parameters. The probability of incomplete fusion for $^{16}O+^{51}V$ interaction has been studied in the energy range 4-7 MeV/A. The variation of incomplete fusion fraction with the projectile energy, relative velocity (V_{rel}) and α-Q value has been investigated. The results have been compared with the available data for the same projectile target system and for $^{20}Ne+^{51}V$, $^{12}C+^{51}V$ systems. A strong projectile structure effect has been observed on incomplete fusion reactions. Further the ICF probability is found to be more for the system which has small negative α-Q value.

Moreover, at low projectile energies approaching from coulomb barrier to slightly above, the influence of the projectile breakup on fusion is not yet well understood. Also for the study of ICF reactions, different type of systematics are used to explain the role of ICF reaction but these reaction can't be explain by a tool. Thus the recent study motivated to study the effect of different systematics like projectile structure, mass-asymmetry, α-Q value of the reaction, relative velocity, Coulomb effect and the effect of two multiple entrance channel parameter etc. on incomplete fusion (ICF) at low bombarding energies.

In extension to our earlier work [6], in this paper the sensitivity of ICF to different entrance channel parameters is investigated. The comparison of probability of fusion incompleteness (F_{ICF}(%)) as a function of various entrance channel parameters for the present system with the other available systems are planned to be presented and discussed.

Experimental Details

This experiment was performed at 15UD Inter-University Accelerator Centre (IUAC), New Delhi (INDIA) by using the General Purpose Scattering Chamber (GPSC) facility. The experimental procedure, target preparation and description of data analysis used in this paper are similar to the earlier papers [5, 6].

Results and Discussion

In the present work, sensitivity of ICF on entrance channel parameters has been studied. For this purpose, the experimentally measured cross-section for α and 2α-emitting channels (refered to in our earlier work [5]) have been calculated and plotted as a function of incident projectile energy. The sum of experimentally measured cross-sections for all identified α and 2 α-emitting channels is compared with the estimated theoretical predictions of ALICE-91 and is presented in fig.1. Since the statistical model code ALICE-91 does not take into account the ICF, the observed enhancement in experimental values over the theoretical predicti-

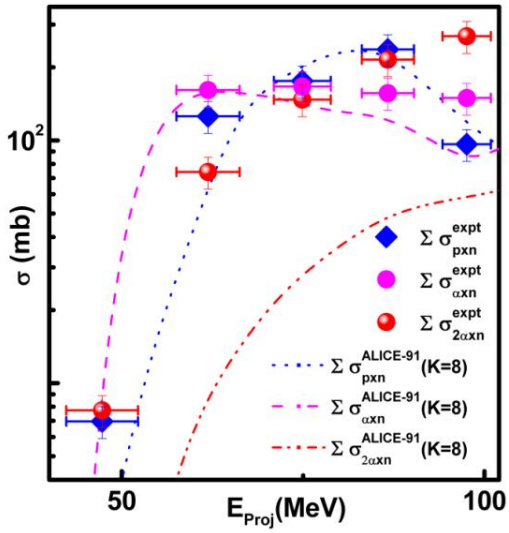

Fig. 1: The sum of experimentally measured excitation function (EFs) of all pxn, αxn and 2αxn channels is compared with that predicted by the code ALICE-91 at level density parameter K=8

-ons for α and 2α-emitting channels point towards the contribution coming from ICF of the projectile for these residues. Consequently for better understanding the contribution of ICF to the total fusion cross-section (σ_{TF}), the incomplete fusion cross-section has been calculated using the same recipe adopted in our earlier reports. Moreover to have conclusive information, the sensitivity of ICF on entrance channel parameters, ICF fraction has been studied in terms of mass-asymmetry, α-Q-value, relative velocity, coulomb effect (Z_PZ_T) and the degree of fusion incompleteness. From the results strong energy dependence of ICF is observed. The ICF fraction is found to increase with incident projectile energy. Further, according to Morgensterns et. al [6] mass-asymmetry systematics, ICF contributes significantly at higher relative velocity ($\geq 0.06c$) and ICF fraction should increase with the mass-asymmetry of the system. The ICF fraction for present system along with recently studied systems are compared as function of mass asymmetry at constant relative velocity v_{rel}= 0.051c. It is observed that more mass asymmetric system shows more probability of incomplete fusion which support Morgenstern et al. study [6]. However for different projectiles (^{12}C & ^{16}O) the different increasing trends have been observed. These different trends for different projectiles may be due to projectile structure effects and may be attributed due to the α-Q value of the projectiles.

To have more conclusive information and to ensure the validity of this aspect of α-Q-value, F_{ICF}(%) for four different projectile target systems (with same target and different projectiles) at same relative (v_{rel}) velocity has been investigated. It is found that the ICF fraction decreases with large negative α-Q-value of the projectile. Nevertheless this trend is not found to be true in case of neutron rich projectile systems and hence more and more data is needed with neutron rich projectiles. The information with neutron rich projectiles may definitely provide an important input parameter to understand the complex ICF dynamics at low incident energies. In general it can be concluded that the ICF fraction strongly depends on entrance channel parameter and a single entrance channel parameter is not able to explain the ICF dynamics completely.

Conclusions

In the present study of ICF reactions, strong dependence of entrance channel parameters is observed. During the analysis it has been found that with the large negative α-Q-value, the ICF fraction decreases but we can't say this in the case of neutron rich projectile. Furthermore a single entrance channel parameter is not sufficient to have complete information of ICF reactions. The detail of the work will be presented at time of symposium.

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