Role of entrance channel parameters on incomplete fusion reaction dynamics

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In recent time the keen interest has been observed in the study of incomplete fusion (ICF) reactions and its dependence on various entrance channel parameters: projectile type/energy, angular momentum imparted to the system, alpha-Q-value of the projectile, mass asymmetry of the interacting partners etc. The fusion reaction proceeds for the energy of projectile capable of overcoming the fusion barrier resulting from the sum of repulsive Coulomb and attractive nuclear potentials. However, the breakup becomes an important process and influences the flux of fusion reactions. Further, the influence of the projectile breakup on fusion is not yet well understood, thus continues to be an active area of investigations. In view of the above facts, we have measured the excitation functions of several evaporated residues in the ^{16}O+^{115}In at energies 4-7 MeV/nucleon. The influence of various entrance channel parameters on ICF reaction dynamics has been studied.

The experiment for this study has been carried out at the Inter University Accelerator Centre (IUAC), New Delhi. The stack of six target catcher assembly has been irradiated for about 8 hours using ^{16}O-beam. The beam current was maintained at 30-35 nA. The overall estimated error in the present work is less than or equal to 17%.

In the present work, residues such as $^{129m,129g,128-126}$Ba, ^{127,125}Cs, $^{125,123-121}$Xe, ^{121,120m,120g,119}I and ^{118m,117,116m}Sb have been obtained by the identification of their characteristic γ-rays. The analysis of these residues has been carried out in the frame work of statistical model code PACE4 [1]. Some of the pxn and α-emitting channels have contribution from their higher charge isobar precursors, which is deducted to have independent yields of these residues. All CF channels were reproduced very well with this code while enhancement in α-emitting channels is observed due to ICF contribution. As a representative case, this can be seen in Fig.1. Total Fusion cross section i.e. (σ_{TF}=$\Sigma\sigma_{CF}$+$\Sigma\sigma_{ICF}$) is plotted along with ($\Sigma\sigma_{CF}$) and ($\Sigma\sigma_{ICF}$) in Fig.2. This figure clearly shows that ICF contribution is increases with projectile energy. Moreover, to see the effect of entrance

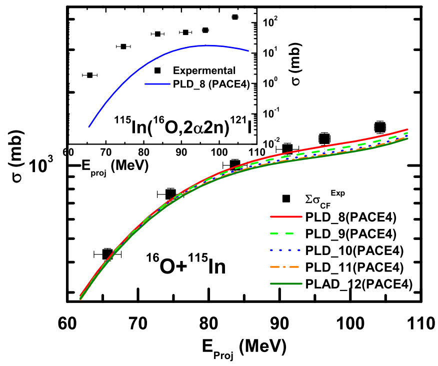

FIG. 1: Sum of all CF channels along with PACE4 calculations (K=8-12) has been plotted. K=8 value is found most suitable. In inset figure the typical representation of α-emitting channel is shown. The enhancement over the theoretical prediction may be attributed to ICF reaction processes.

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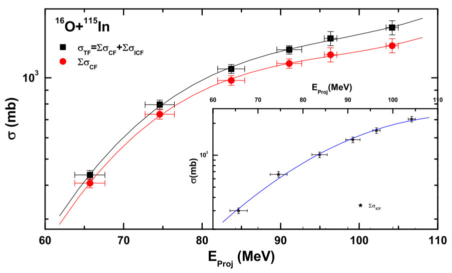

FIG. 2: σ_{TF}=$\Sigma\sigma_{CF}$+$\Sigma\sigma_{ICF}$ is plotted along with $\Sigma\sigma_{CF}$ and $\Sigma\sigma_{ICF}$. The separation between σ_{TF} and $\Sigma\sigma_{CF}$ increases due to the enhancement of ICF with the projectile energy. Solid lines are just to guide the eyes.

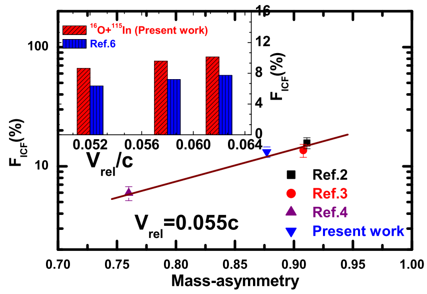

FIG. 3: The deduced percentage ICF fraction (F_{ICF}) as a function of mass asymmetry for different systems at a constant relative velocity (v_{rel}=0.055c) has been plotted. Solid line is just to guide the eyes. In inset figure the (F_{ICF}) for two different projectiles on the same target combinations at different relative velocities is also plotted.

channel parameters on ICF reaction dynamics, incomplete fusion fraction(F_{ICF}) has been extracted. In this sequence, F_{ICF} for different projectile-target combination [2–4] has been plotted against the mass-asymmetry at a constant relative velocity (v_{rel}=0.055c), as shown in Fig.3. As can be seen, in general, the data points suggest more ICF probability for more mass asymmetric than symmetric systems, which is in accordance with Morgenstern et al. [5]. However, in the inset of this figure we have plotted the ICF fraction for the systems ^{12}C+^{115}In [6] and ^{16}O+^{115}In (present work) against the relative velocity. In these two systems ^{12}C+^{115}In is more mass asymmetric than ^{16}O+^{115}In but ICF fraction is found more for the system ^{16}O+^{115}In. This different behaviour of ICF contribution can be explained in terms of α-Q-values of the projectiles. The α-Q-values of ^{16}O and ^{12}C are found to be -7.16 MeV and -7.37 MeV respectively. In inset of Fig.3, we can see for low α-Q-value of projectile the ICF contribution is found more. So, it may be worthy to note that along with mass asymmetry and projectile energy, projectile structure effect (which predominantly depends on the α-Q-value of the projectile) is also accountable for ICF reaction dynamics. The details of the work will be presented.

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