Study of some entrance channel effects in $^{16}O+^{55}Mn$ interactions

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Introduction

Heavy ions have been used as the projectile in nuclear reactions, after the advances in accelerator technology. This development has broadened and improved our understanding and knowledge of reaction dynamics & nuclear structure at energies near and above the Coulomb barrier. Due to complex nature of in-complete mass transfer and its indistinct dependence on various entrance channel parameters such as projectile type, energy, mass-asymmetry of the interacting nuclides, α-break-up energy (Q_α), input angular momentum (ℓ) imparted to the system, etc., the study of incomplete fusion reactions is still a dynamic region of research. Recent studies report that complete fusion (CF) and incomplete fusion (ICF) reactions are the most prevailing reaction mechanisms at these energies [1–4].

In extension to our previous work [5], in this paper the dependence of ICF on different entrance channel parameters have been presented and discussed.

Experimental Details

The experiment was performed at Inter University Accelerator Centre(IUAC), New Delhi, India by using the General Purpose Scattering Chamber (GPSC) facility. The experimental procedure, target preparation, data analysis etc. used in the present work are similar to those as presented elsewhere [5].

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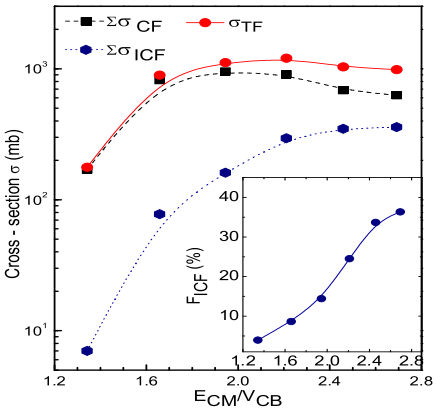

FIG. 1: The total fusion cross-section (σ_{TF}) plotted with the sum of the complete and incomplete fusion cross-section ($\sum\sigma_{CF}$ and $\sum\sigma_{ICF}$) are plotted as a function of reduced incident projectile energy. The probability of incomplete fusion fraction as a function of the normalized projectile energy is also shown in the inset. The lines are drawn to guide the eyes.

Results and Discussion

The values of $\sum\sigma_{ICF}$, $\sum\sigma_{CF}$ and σ_{TF} have been deduced by using the same remedy as in Ref. [3], and have been plotted in `Fig.1`, as a function of reduced projectile energy (E_{CM}/V_{CB}). To study the dependence of ICF on different entrance channel paprameters the incomplete fusion probability $\%F_{ICF}$ has also been obtained by using the formula, $F_{ICF}(\%) = (\sum\sigma_{ICF}/\sigma_{TF}) \times 100$, which is a measure of relative strength of ICF to the total fusion. The value of F_{ICF} has also been presented in inset of `Fig.1` and is found to increase with the increasing projectile energy. As inferred by Morgenstern

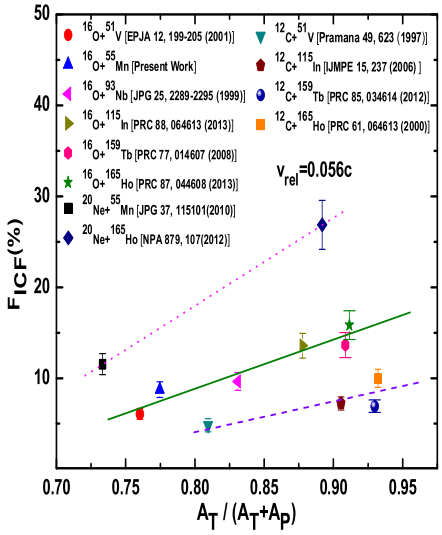

FIG. 2: The probability of ICF (%F_{ICF}) for the present system of ^{16}O+^{55}Mn is shown as a function of mass-asymmetry along with the previously studied systems. The lines are drawn to guide the eyes.

et al. [6], to test the variation of the ICF probability with the entrance channel mass asymmetry (μ = A_T/(A_T+A_P), the value of F_{ICF} in the present system ^{16}O+^{55}Mn has been compared with several other studied systems (as shown in Fig.2) at a constant relative velocity, υ_{rel}=0.056c. In general, the data points suggest more ICF probability for more mass-asymmetric systems than symmetric systems. However, different trends have been observed for three different projectiles viz. ^{12}C, ^{16}O and ^{20}Ne [F_{ICF}(^{20}Ne) > F_{ICF}(^{16}O) > F_{ICF}(^{12}C)]. This trend may be due to the projectile structure effects and may be due to the α-Q-value of the projectile, as suggested in the previous reports [1, 2]. To validate this aspect of α-Q-value, the F_{ICF} for the ^{20}Ne+^{55}Mn system [4] along with that of the present work at different relative velocities has been plotted in Fig.3. The calculated α-Q values for the projectile fragmentation are -4.73 MeV and -7.16 MeV for ^{20}Ne and ^{16}O projectiles, respectively. The higher α-Q value for ^{16}O translated into the smaller breakup probability for constituent α clusters, resulting in a smaller ICF fraction than for

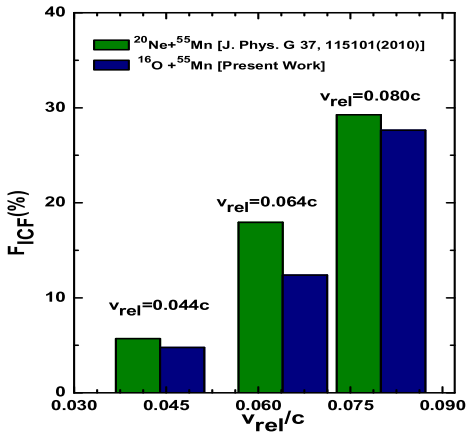

FIG. 3: Comparison of %F_{ICF} as a function of relative velocity (υ_{rel}/c) for the ^{16}O+^{55}Mn and ^{20}Ne+^{55}Mn systems.

^{20}Ne induced reactions. The obtained trend is found to be consistent with the previous studies [1, 2]. Hence, the α-Q value may be responsible for this projectile structure effect, shown in Fig.3.

Conclusions

In the present work the ICF reactions has been found to be influenced by projectile structure along with projectile energy and mass-asymmetry of interacting partners. The probability of ICF is found to increase with the increasing projectile energy and mass-asymmetry of the interacting partners. The fraction of ICF has been found to decrease for projectiles having large negative α-Q values. The details of the work will be presented.

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