Systematic of Incomplete fusion with strongly and weakly bound projectiles

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Introduction

Incomplete fusion (ICF) in which part of the projectile fuses with the target have been studied extensively using both strongly (^{12,13}C, ^{14}N, ^{16}O, ^{19}F, ^{20}Ne) and weakly bound (^{6,7}Li, ^{9}Be, ^{6,8}He) projectiles. In this talk, I will give overview of experimental techniques and available theoretical models for understanding ICF phenomenon. Also we have performed systematic studies [1, 2] of ICF, TF, α particle production and reaction cross sections based on available data and its dependence on reaction parameters which will be preseneted.

1. Comparison of ICF cross sections in strongly and weakly bound projectiles

A comparative study of ICF cross sections (σ_{ICF}) for various projectile-target systems as a function of incident beam energy was performed using the available data. A systematic behaviour of σ_{ICF} is observed for various projectile-target systems as a function of E_{red} as shown in Fig. 1. In general, σ_{ICF} for the WBP systems is higher than that for the SBP systems. The 1DBPM calculations for fusion with a factor 0.3 and 0.1 for WBP and SBP systems respectively are also shown in the figure. The onset of ICF in the SBP case occurs at relatively higher energy than ICF in WBP systems.

A quantitative assessment of the relative contribution of the ICF to the TF was made using the percentage ICF fraction ($F_{ICF}(\%)$) which is the ratio of σ_{ICF} and σ_{TF} cross sections. The $F_{ICF}(\%)$ also shows a systematic behaviour for different projectile-target systems. The increase of $F_{ICF}(\%)$ at sub-barrier energies in case of WBP is observed which may be attributed to the increased importance of ICF driven by breakup and transfer processes as compared to the CF processes. The $F_{ICF}(\%)$ is smaller in case of SBP and it shows a larger variation among values for different systems.

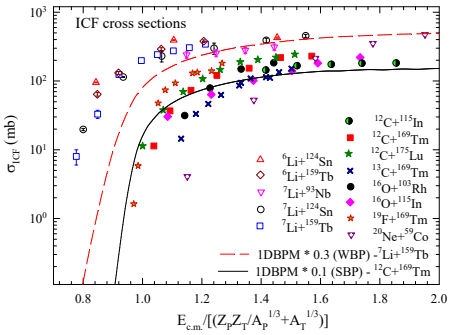

FIG. 1: ICF cross sections (σ_{ICF}) as a function of reduced energy for systems involving WBP and SBP. Dashed and solid lines are 1DBPM calculations multiplied by factors 0.3 and 0.1 for WBP and SBP, respectively.

2. Contribution of ICF in inclusive α production

Inclusive α production cross sections have been measured for reactions using SBP and WBP for several targets. The yield of evaporation α particles due to the CF contribution can be separated out using the statistical model predictions. The CF part has been estimated from the statistical model calculations using code PACE2 [3] and non-CF inclusive α production cross sections ($\sigma^{NCF}_{\alpha_{incl.}}$) have been determined. The plot of $\sigma^{NCF}_{\alpha_{incl}}$ with reduced energy E_{red} for various SBP systems is shown in Fig. 2. The plot also includes the data for residue measurements of $\Sigma\alpha xn$ channels asso-

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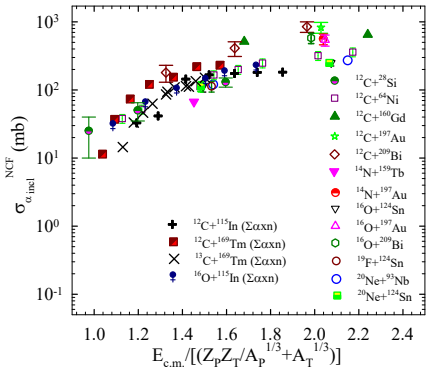

FIG. 2: Systematical behaviour of inclusive α production cross sections due to non-CF processes in reactions with SBP systems as a function of reduced energy is shown. The plot also includes the data for residue measurements using $\Sigma\alpha xn$ channels.

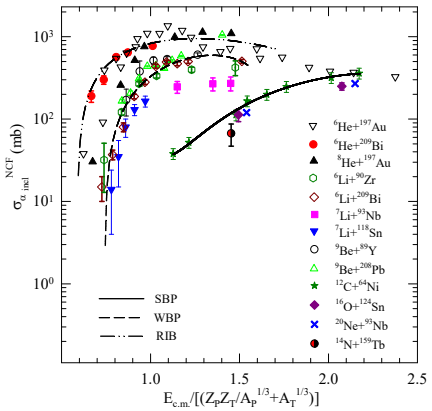

FIG. 3: Systematic comparison of inclusive α production cross sections due to non-CF processes for different nuclear systems in three categories: (i) SBP, (ii) stable WBP, and (iii) RIB. Lines are guide to an eye.

ciated with emission of one or more α particles. An increase in $\sigma^{NCF}_{\alpha_{incl}}$ with incident energy and a reasonable similarity in behaviour for different systems is observed. Similar plots of non-CF inclusive α cross sections along with ICF cross sections for WBP systems also show universal behaviour [1, 2].

3. Systematic of inclusive α production

We have compared the non-CF inclusive α cross sections ($\sigma^{NCF}_{\alpha_{incl}}$) in three different types of systems involving (i) SBP, (ii) stable WBP, and (iii) RIB and is shown in Fig. 3. There is a characteristic difference observed in $\sigma^{NCF}_{\alpha_{incl}}$ for these projectile systems analogous to those observed for the reaction cross sections [4] where larger values are seen for RIB compared to the values for stable WBP, which are in turn larger than the values for SBP. It can be seen that the energy values where the $\sigma^{NCF}_{\alpha_{incl}}$ saturate are much higher for SBP ($\approx 2V_B$) than the value for stable WBP and RIB ($\approx 1.2V_B$). The smaller binding energies coupled with extended radial shapes of the RIB contribute to larger values of σ_{ICF}, σ_{Reac} and $\sigma^{NCF}_{\alpha_{incl}}$.

Summary

We have done extensive study of ICF cross sections with systems involving strongly and weakly bound projectiles. The ICF cross sections with WBP systems are higher than that with SBP systems at all the energies. ICF cross sections with WBP increases at below barier energies, showing the importance of breakup channel. We have also shown strong corelation of ICF with measured inclusive α cross sections. The α production found to be larger for RIB compared to the values for stable WBP, which are in turn larger than the values for SBP. Many new studies with RIBs will be vital in extending these systematics.

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