# Role of Entrance Channel Parameters on α -Break up in Heavy Ion Induced Reactions

Rajesh K. Sahoo[1], Dharmendra Singh[1*], Amritraj Mahato[1], Nitin Sharma[1], Lupteindu Chhura[1], Rahul Mahato[1], Pankaj K. Giri[1†], Sneha B. Linda[1], Harish Kumar[2], Suhail A. Tali[2], Rahbar Ali[3], Sushil Kumar[4], Nabendu Kumar Deb[5], M. Afzal Ansari[2], R. Kumar[4], S. Muralithar[4], and R.P. Singh[4]

*[1]Department of Physics, Central University of Jharkhand, Ranchi - 835222 INDIA*
*[2]Department of Physics, Aligarh Muslim University, Aligarh - 202002, INDIA*
*[3]Department of Physics, G. F. (P. G.) College, Shahjahanpur - 242001, INDIA*
*[4]Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA*
*[5]Department of Physics, Gauhati University, Guwahati, Assam - 781014, INDIA*
*· * Email: dsinghcuj@gmail.com*

## Introduction

In recent years, multiple attempts have been made to understand the dynamical aspects of incomplete fusion (ICF) which is associated with heavy-ion (HI) induced reactions [1-3]. Generally, complete fusion (CF) is anticipated as a dominant contributor to total fusion (TF) cross-section in HI-induced fusion reaction but current findings demonstrated that the ICF has a significant contribution to TF cross-section at energy above the coulomb barrier [1-5]. Hence, it is crucial to establish a unified and coherent framework for understanding the transfer of energy, mass, linear, and angular momentum in nuclear reactions through a comprehensive description of both CF and ICF [6]. From recent investigations [1-5], it is now well established that various entrance channel parameters are required to explain the gross features of ICF dynamics. Further, projectile structure i.e., (α-clustered and non-α clustered) is the important parameter that has a significant impact on ICF dynamics requires in-depth research. Therefore, the systematic study of projectile structure along with various entrance channel parameters like (i) coulomb factor, (ii) projectile Energy, (iii) α -Q value of the projectile, (iv) mass asymmetry, (v) input angular momentum, etc. are required to probe the ICF dynamics.

## Experimental Procedure

Measurements were performed using the 15UD Pelletron accelerator facility at the Inter-University Accelerator Centre (IUAC), New Delhi, India. Excitation functions (EFs) of evaporation residues (ERs) populated in the $^{18}$O projectile $^{154}$Sm target have been measured using stack foil activation technique followed by offline γ-ray spectroscopy. A single stack consisting of seven samarium foils (thickness ≈ 400-600 μg/cm$^2$) backed by thick aluminum foils (1.0-1.5 mg/cm$^2$) was bombarded with the $^{18}$O ion beam energy 103 MeV in GPSC (General Purpose Scattering-Chamber) at IUAC, New Delhi. After irradiations, the γ-ray activities were recorded using HPGe detector coupled to PC-based software CANDLE [7]. A standard $^{152}$Eu γ–ray source was employed to pre-calibrate the detectors for energy and efficiency measurements. To measure the beam flux and to monitor the stability of the beam current during irradiation, a Faraday cup was installed behind the stack. From the characteristic γ-rays, the ERs populated via CF and ICF channels were identified and confirmed through their respective decay profiles.

## Analysis and Result

In the present work, EFs of nine ERs populated via CF and/or ICF channels have been measured, out of which two ERs were shown in our previous work [8]. The experimental cross sections of the ERs populated in the $^{18}$O+$^{154}$Sm system are compared with statistical model code PACE-4 [9] which utilizes the Monte Carlo simulation procedure to de-excite the compound nucleus (CN) formed via CF. From the analysis of data, it has been observed that the experimental cross-section of the ERs produced via xn/pxn

† Present Affiliation- *UGC-DAE Consortium for Scientific Research, Kolkata Centre, Kolkata 700098, India*

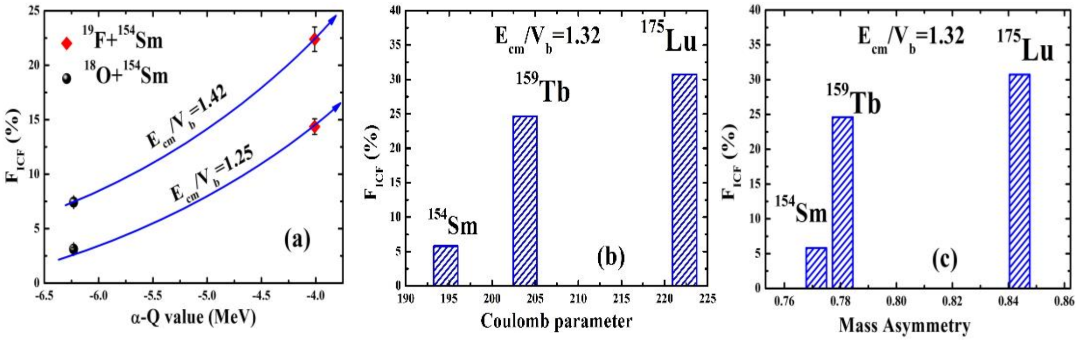


**Fig.1.** A comparison of ICF fraction ($F_{ICF}$) as a function of (a) α-Q value of the $^{18}O$ and $^{19}F$ projectile in interaction with $^{154}sm$ target, (b) Coulomb parameter and (c) Mass asymmetry in $^{18}O$ interaction with $^{154}Sm$,$^{159}Tb$ and $^{175}Lu$ targets.

channels show good agreement with PACE-4 prediction which confirmed their production via CF process only. On the other hand, the ERs produced via α emission channels shows significant enhancement in cross-section as compared to PACE-4 prediction. This enhancement serves as a signature of ICF along with CF because the ICF process is not taken into account PACE-4 predictions. To understand the effect of projectile structure (α and non-α clustered) on ICF dynamics, the present system has been analyzed with a previously reported $^{19}F+^{154}Sm$ system [2]. Fig. 1(a) represents the ICF fraction ($F_{ICF}$) of both the systems as a function of the α-Q value of the projectile at the normalized condition of $E_{cm}/V_b$=1.42 and 1.25. Since the α-Q value of $^{19}F$ (≈ 4.01 MeV) is lower than $^{18}O$ (≈ 6.18 MeV), $F_{ICF}$ should be higher for the $^{19}F$ projectile than the $^{18}O$ projectile. Figure 1(a) shows that $F_{ICF}$ for the $^{19}F$-induced reaction is significantly higher than for the $^{18}O$-induced reaction and this value increases with an increase in beam energy for the particular projectile. This outcome illustrates that projectile structure and projectile energy dominantly influence the ICF dynamics. Further to explore the effect of other entrance channel parameters i.e., Coulomb parameter ($(Z_PZ_T/(A_P)^{1/3}+(A_T)^{1/3})$ and Mass asymmetry ($(A_P-A_T)/(A_P+A_T)$) on ICF dynamics, a systematic study has been carried out in present work. The experimentally measured $F_{ICF}$ at normalization parameter $E_{cm}/V_b$=1.32 has been plotted as a function of coulomb parameter and mass asymmetry for present system $^{18}O+^{154}Sm$ along with some earlier measurements [3] and shown in Fig. 1(b), (c). It can be observed from these figures that $F_{ICF}$ increases with an increase in coulomb parameter and mass asymmetry for $^{18}O$ projectile-induced reaction. Consequently, a strong impact of different entrance channel parameters on ICF dynamics is observed in the current work.

## Acknowledgments

The authors are thankful to the Director, AUC Convener, Target Lab in charge and Mr. Abhilash S. R., Target Lab and operational staff of Pelletron accelerator at IUAC New Delhi for providing the necessary facility during the present experiment. Authors are also grateful to the Head, Department of Physics, Central University of Jharkhand, Ranchi for his motivation and assistance.

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