Investigation of Break-up Fusion and its Dependency on Target Deformation at Energy 3-7 MeV/Nucleon

Pankaj K. Giri[1,*]
[1] *Department of Physics, Central University of Jharkhand, Ranchi- 835 222, INDIA*

Introduction

The study of the interaction between two heavy ions (HI) has been a subject of special interest in the nuclear physics. Various HI reactions such as pre-equilibrium (PEQ) emission, complete fusion (CF) and Fission may occurred, depending on the mass-asymmetry of target-projectile and energy. Further, its been observed that, at above the Coulomb barrier the most dominating fusion processes are (i) complete fusion (CF) and (ii) Break-up fusion/incomplete fusion (ICF) [1-6]. The the case of CF, projectile completely fuses with the target but in the case of ICF, a fraction of projectile fuses with the target nucleus. Several theoretical models have been proposed to explain the ICF dynamics such as Break-up Fusion (BUF) model, Sumrule model, Promptly Emitted Particles (PEP) model, Hot Spot model, and Fermi-jet model, etc but due to the complexity in ICF dynamic at energy below 10 MeV/Nucleon its still an active field of investigation among the nuclear physicist.

Present thesis work has been carried out with an objective to investigate the dynamics of complete and incomplete fusion in the HI collision at bombarding energy above the Coulomb barrier using four different experimental techniques namely; (i) Excitation Functions (EFs) Measurements, in which the enhancement in the measured cross-sections over their theoretical predictions (calculated from standard statistical models based on compound nucleus theory) indicates the presence of the ICF process. The measured EFs have been used to deduce the relative contributions of the CF and ICF reactions. (ii) Forward Recoil Range Distributions (FRRDs) Measurements: This method provides information about various degrees of linear momentum transfer from the projectile to the target. The FRRDs data can be used to extract the relative CF and ICF contributions. (iii) Angular Distributions (ADs) Measurements: Through this method, the contributions of ERs at different angles can be measured. This gives the information about the ejection of CF and ICF ERs at different angles. Schismatic of Experimental set-up is shown in Fig. 1. (iv) Transition intensity distributions (TIDs) measurements: This measurement gives the information about the TIDs of ERs populated via CF and ICF mode and their Feeding intensity patterns (FIPs).

The above measurements have been done through a series of experiments carried out using 15 UD Pelletron accelerator facility at inter University accelerator centre (IUAC), New Delhi, India. The measurements of EFs, FR-RDs and ADs of ERs have been carried out using the general purpose scattering chamber (GPSC) facility of IUAC. The stacked foil activation technique followed by offline -spectrometry has been employed in these measurements. Furthermore, the measurements of the TIDs of different ERs produced via CF and ICF channels have been done through a charged particle-γ-coincidence experiment. The experiment was carried out using the Gamma Detector Array (GDA) coupled with Charged Particle Detector Array (CPDA). Target were fabricated in the target lab of IUAC for all the experiments [7].

In the present work, EFs measurements have been done for ^{16}O + ^{148}Nd and ^{16}O + ^{142}Nd systems in the beam energy range ≈ 3–7 MeV/nucleon. Target fabri-

*Electronic address: pankajcuj@gmail.com

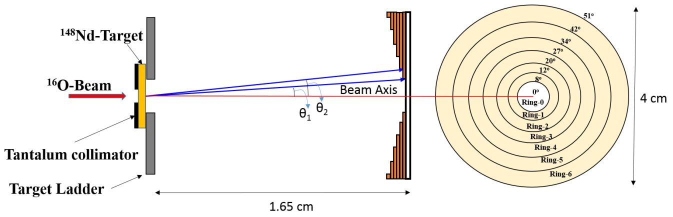

FIG. 1: Schematic of angular distribution measurement experimental set-up.

cation detail can seen in [7]. The measured EFs have been analyzed using statistical model code PACE4. During the analysis some of the αxn/αpxn channel's experimental cross-section (CS) found to be enhanced form the theoretical prediction, which indicates the presence of ICF mode in addition to CF. Further the estimated ICF fraction used to investigate the dependence of low energy ICF dynamics on existing entrance channel parameters viz., the mass-asymmetry (μ_{EC}^{AS}), Coulomb factor ($Z_P Z_T$) and α-Q value of the projectile. Further, the dependence of ICF dynamics on target deformation has also been investigated using the deformation parameter (β_2^T), deformation length ($\beta_2^T R^T$) and neutron excess of the target $(N - Z)^T$. Furthermore target deformation effect on CF hindrance above CB have been studied using Universal Fusion Function (UFF). The details of experimental methodology, analysis can be seen in [1, 2]. In the second set of experiments, the FRRDs of ERs in the system ^{16}O + ^{148}Nd have been measured at three different projectile energies $\approx$ 88, $\approx$92 and $\approx$96 MeV. The FRRDs results have been analyzed within the framework of the statistical model codes PACE-4 and CASCADE. The relative CF and ICF contributions of measured ERs compliments EFs data[3–5]. In addition to that, the measurements of ADs of various ERs populated in the same system ^{16}O + ^{148}Nd have also been done at beam energy $\approx$6 MeV/nucleon. From this measurement its been found that the ERs populated by the CF and ICF mode have angular range of 0^0-20^0 and 0^0-51^0 respectively. More details can be seen in [3]. Furthermore the transition intensity distributions and FIP of various -transitions for ERs formed via CF and ICF have been extracted from the particle-γ-coincidence measurement for the system ^{19}F+^{154}Sm at energy $\approx$5.2 MeV/Nucleon. The deduced TIDs have been analyzed to obtain information about the dependence of ICF dynamics on the deformation of the projectile and target. More details can be seen in [6].

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