Study of incomplete fusion dynamics by using particle gamma coincidence technique for the system $^{19}F + ^{154}Sm$

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Introduction

Study of incomplete fusion of heavy ions with different targets has been a growing interest at energies above Coulomb barrier. It has been observed that at projectile energies slightly above the Coulomb barrier, both the complete fusion (CF) and incomplete fusion (ICF) may be considered as dominant reaction mechanisms. Efforts are in progress to have better understanding of ICF processes. Britt and Quinton [1] first observed the production of forward peaked 'fast' alpha-particles in the break-up of the projectiles ^{12}C, ^{14}N and ^{16}O at energy 10.5 MeV/nucleon. Advances in the understanding of ICF dynamics took place after the charged particle-γ-coincidence measurements by Inamura et al. [2]. Semi-classical theory of heavy ion (HI) interaction categorize the CF and ICF processes on the basis of driving input angular momentum imparted in the system. In complete fusion (CF) process the driving input angular momentum, imparted in the system. In case of complete fusion reaction the projectile completely fuses with the target nucleus and the highly excited nuclear system decays by evaporating low energy nucleons and α-particles. In the incomplete fusion reaction, only a part of projectile fuses with the target nucleus, while remaining part moves in the forward direction [3-5]. The excited composite system decays by emission of particles and / or γ-rays. Some earlier studies have been carried out with different targets using alpha cluster structure projectile. However, the experimental data for the study of ICF dynamics using non alpha cluster structure projectile with deformed target nuclei (A>150) are not available in the literature. To the best of our knowledge these measurements have been reported for the first time.

Experimental Details

In order to understand the CF and ICF dynamics, an experiment have been carried out by using Gamma Detector Array (GDA) coupled with Charged Particle Detector Array (CPDA) for the system $^{19}F + ^{154}Sm$@100 MeV at Inter University Accelerator, New Delhi, India. A self-supporting ≈3.1 mg/cm^2 thick target of ^{154}Sm (enrichment ≈98.69%) prepared with a rolling technique has been used. GDA consists of 12 Compton suppressed n-type high purity germanium detectors at angles 45^0, 99^0, 153^0 with respect to the beam direction and there are 4 detectors at each of these angles. The CPDA is a group of 14 Phoswich detectors. In the CPDA scattering chamber, seven CPD were placed on top and seven on bottom of the chamber. All 14 detectors of CPDA are divided into three angular segments. There are 4 detectors at 'forward angles (F)' (10^0-60^0), 4 detectors at 'backward angles (B)' (120^0-170^0) and 6 detectors 'sideways (S)' i. e. between 60^0-120^0. In the present experiment two groups of α-particles are expected to be detected by forward angle (F) CPDs: (i) the fusion-evaporation (CF) α-particles of average energy Eα-CF≈18 MeV and (ii) the ICF 'fast' α-particles of energy Eα-ICF≈25 MeV. In front of the each four forward cone CPDs, aluminum absorbers of appropriate thickness were used to stop 'evaporation' α-particles (Eα-CF≈18 MeV). Hence, only 'fast' α-particles' with energy greater than 16 MeV have been detected in the forward cone.

Analysis and Results

In the present experiment the multiplicity of charged particles and α-particles detected in the CPDA are recorded. The multiplicity of charged particles and alpha-particles are taken to define the charged particle-γ-coincidence. Figs. 1(a) and (b) shows the typical charged particle and α-multiplicity spectra obtained from the reaction of 100 MeV ^{19}F-ion beam on ^{154}Sm.

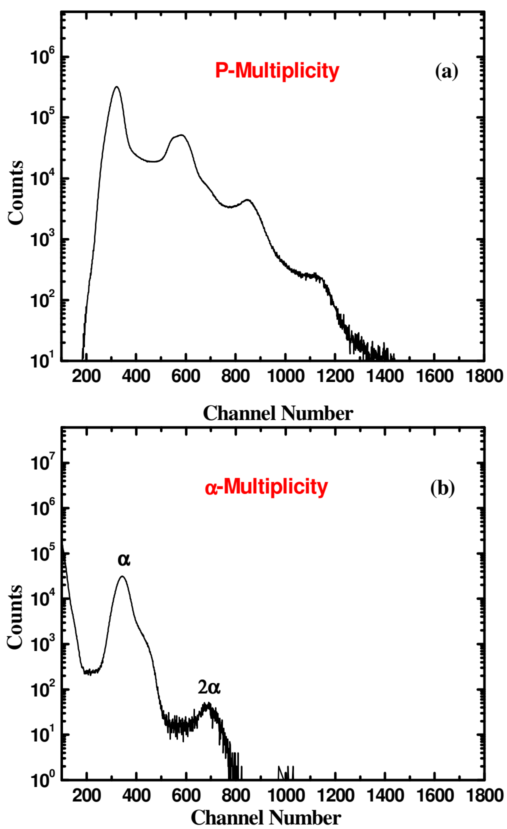

Fig. 1 (a) Charged particle multiplicity spectra and **(b)** α-particle multiplicity spectra obtained from the ^{19}F + ^{154}Sm system at 100MeV.

The preliminary data analysis has been done during the experiment by using software CANDLE. The four evaporation residues (ERs) ^{168}Lu(5n) , ^{167}Lu (6n), ^{166}Tm(α3n) and ^{165}Tm (α4n) are indentified from the gamma rays spectra. The evaporation residues ^{168}Lu and ^{167}Lu produced though the emission of 5 and 6 neutrons from the compound nucleus, respectively. These residues produced only through complete fusion of ^{19}F with ^{154}Sm. The evaporation residues ^{166}Tm produced though the emission of one α and 3 neutrons, while ^{165}Tm produced though the emission of one α and 4 neutrons. These ERs may be populated through the ICF process. The analysis of the experimental data is still in progress. The Final results will be presented in Symposium.

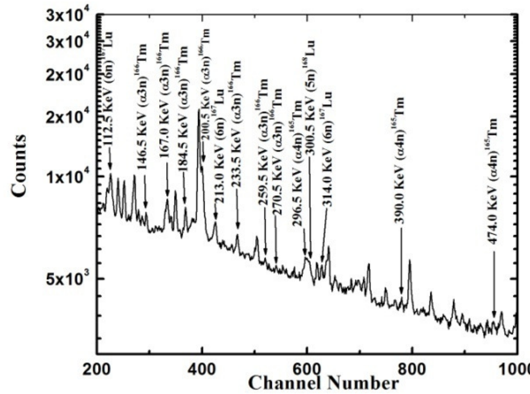

Fig. 2 Gamma ray energy spectra observed from ^{19}F + ^{154}Sm system at 100MeV.

Acknowledgements

The authors are thankful to Director, Inter University Accelerator Centre (IUAC), New Delhi, India for providing the experimental facilities to carry out the present work. The authors are also thankful to the operational staff of Pelletron, IUAC, New Delhi, India for providing the good co-operation during the course of this experiment. D. Singh is thankful to the Department of Science and Technology (DST), New Delhi, India for providing financial support through SERC-Fast Track Scheme for Young Scientist (SR/FTP/PS-005/2011).

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