Study of α-particle multiplicity in $^{16}O+^{196}Pt$ fusion-fission reaction

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Introduction

Study of dynamics of fusion-fission reaction is one of the interesting parts of heavy-ion-induced nuclear reaction. Extraction of fission time scales using different probes is of central importance for understanding the dynamics of fusion-fission process. In the past, extensive theoretical and experimental efforts have been made to understand the various aspects of the heavy ion induced fusion-fission reactions. Compelling evidences have been obtained from the earlier studies that the fission decay of hot nuclei is protracted process i.e. slowed down relative to the expectations of the standard statistical model, and large dynamical delays are required due to this hindrance [1]. Nuclear dissipation [2] is assumed to be responsible for this delay and more light particles are expected to be emitted during the fission process. These particles are emitted from various stages of the reaction process i.e. from compound nucleus (CN) (prescission) and from fully accelerated fission fragments (postscission). The multiplicities of various particles (neutrons, protons, alphas etc.) emitted during the decay of excited nucleus provide the information about these time scales and hence, help in understanding the fusion-fission dynamics.

One of neutron multiplicity measurements have been performed for the $^{16,18}O+^{194,198}Pt$ populating the CN $^{210,212,214,216}Rn$ and observed fission delay due to nuclear viscosity [3]. In order to have complete understanding for the dynamics of ^{212}Rn nucleus, we measured the charged particle multiplicity for $^{16}O+^{196}Pt$ system. Study of charged particles will give us more information about the emitter in comparison to neutrons as charged particles faces coulomb barrier and are more sensitive probe for understanding the dynamics of fusion-fission reactions [4]. In the present work, we are reporting some of the preliminary results of charged particle multiplicity.

Experimental Details

The experiment was performed at the 15 UD Pelletron facility at Inter University Accelerator Centre (IUAC), New Delhi, using General Purpose Scattering Chamber (GPSC). Enriched and self-supporting target of ^{196}Pt having thickness 1.8 mg/cm^2 was used in the experiment. Beam of ^{16}O with incident energy 98.4 MeV, was used to form ^{212}Rn. The charged particles (protons and alphas) were detected in coincidence with fission fragments, so as to extract the particle multiplicities for the reaction under study. In total, four detectors (16 crystals) of CsI(Tl) were used for the detection of protons and alpha particles. Two Multi-Wire Proportional Counters (MWPCs) were used for the detection of fission fragments. The MWPCs were kept at the folding angle to detect complimentary fission fragments. One MWPC detector was kept at an angle of 30^0 w.r.t beam whereas, the second was kept at an angle of 135^0 at a distance of 20.5 cm from the centre of target. Four CsI(Tl) detectors were kept at angles of 70^0, 90^0, 110^0 and 130^0 w.r.t the beam direction. All charged particle detectors, having four crystal each, were kept at a distance of 15.5 cm from the

centre of the target covering a solid angle of 16.6 msr for each CsI(Tl) detector.

In order to obtain the energies of the detected charged particles, CsI(Tl) detectors were calibrated using both offline and online techniques. The offline calibration was done using ^{241}Am and ^{229}Th sources. The online calibration was done using two reactions ^{12}C + ^{12}C at 30 MeV and ^{7}Li + ^{12}C at 20 MeV. From ^{12}C + ^{12}C reaction, α energies are in the range of 1.63 MeV to 18.5 MeV. Similarly, from ^{7}Li + ^{12}C reaction, α energies are in the range of 5.27 MeV to 16.19 MeV. Schematic diagram of the experimental setup is shown in Fig 1.

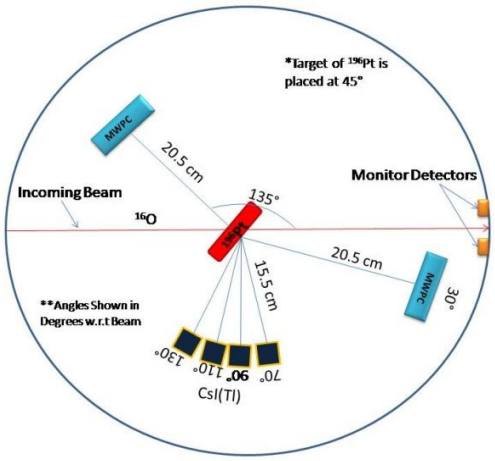

Fig 1. Schematic diagram for experimental setup.

Data Analysis and Results

Charged particles were identified using the Ballistic Deficit technique for the particle identification exploring the decay characteristics of CsI(Tl). 2-D spectrum of CsI(Tl) detector is shown in Fig 2. Various bands represent different particles as mentioned in the figure [5]. α- particles were further gated with anode of MWPC to obtain the spectrum of α in coincidence with fission fragments. α- particles were fitted using the moving source fitting expressions for charged particle emission [6]. Total contribution to α-particles from various sources such as CN, fragment 1, fragment 2, along with the experimental points is shown in the Fig 3.

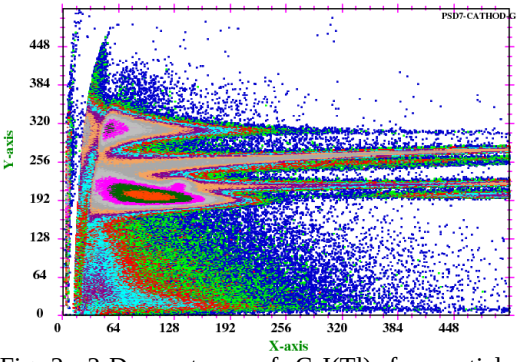

Fig 2. 2-D spectrum of CsI(Tl) for particle identification.

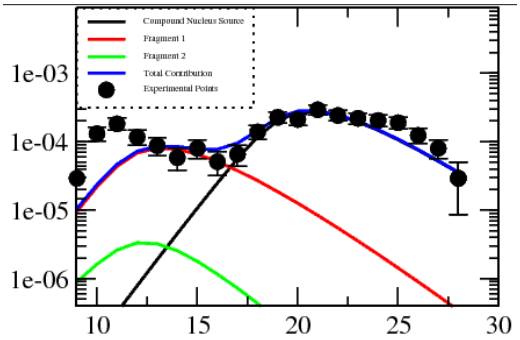

Fig 3. α- particle multiplicity spectrum along with the fits from moving source model. a) Solid line represents the total contribution, b) Red and Green line represents the Fragment 1 and fragment 2 contributions, c) Black curve represents the compound contribution.

Detailed analysis for this data is in progress. The data will also be analysed to extract the mass gated multiplicity of the charged particles.

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