ER excitation function for ^{16}O +^{194}Pt reaction

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Introduction

Heavy ion induced fusion-fission dynamics has been a topic of extensive theoretical as well as experimental study for the past few decades. The fused composite system after capture follows a long dynamical path, during which it equilibrates in all degrees of freedom and forms a compound nucleus (CN) or reseparates in to fission-like fragments. Experimental measurements using different probes such as pre-scission charged particles, neutron and GDR gamma-ray multiplicities revealed that the fission decay is slowed down relative to the expectations from the standard statistical models. This hindrance was interpreted in terms of a large scale mass diffusion process including the effects of nuclear viscosity [1]. The diffusion process leads to a reduction in the fission width and enhances the emission of particles and gamma rays before the system passes through the saddle point. The reduction in fission decay width leads to an increase in evaporation residue (ER) cross section. It is also reported that the experimental fusion cross sections in ~200 amu mass region is significantly reduced even for very asymmetric reactions, due to the onset of other non-compound nucleus processes. ERs are the unambiguous signatures of CN formation and can be used as a sensitive probe to study the statistical as well as dynamical aspects of fusion-fission process.

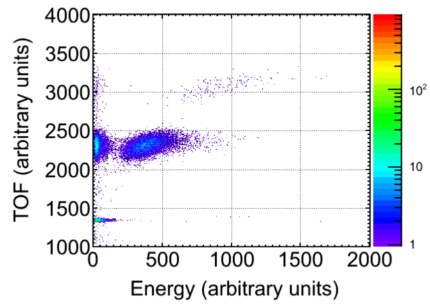

FIG. 1: Two-dimensional plot of energy versus TOF for the reaction ^{16}O +^{194}Pt at 96.0 MeV beam energy. ERs are seen at the centre, while scattered particles (which are very less in number) are seen on the top.

Experiment and Analysis

The experiment was performed at the 15UD Pelletron accelerator facility of Inter University Accelerator Centre (IUAC), New Delhi. Chopped ^{16}O beam with a pulse separation of 4 μs was used in the experiment to bombard the isotopically enriched ^{194}Pt (96.5% enrichment) target of thickness 300 μg/cm^2 on a 20 μg/cm^2 thick carbon foil. ER excitation function measurements were performed at laboratory beam energies 75.4, 79.5, 83.7, 87.8, 91.9, 96.0, 101.1 and 103.1 MeV. At the highest energy (103.1 MeV) we used the dc

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beam to compensate for the low beam current. At 101.1 MeV the contamination at the focal plane arising from the scattered particle was less than 1.5 %. At energies above 101.1 MeV, the possible contamination at the focal plane is expected to be even less as the scattering cross section is too low. The heavy ERs produced were separated from the intense beam background and transported to the focal plane using the first stage of the recoil mass separator HYRA [2]. The ERs reaching the focal plane were detected using a multi wire proportional counter followed by a two-dimensional position sensitive silicon detector. The slowly moving ERs, produced at the target chamber took about 3.5 to 4 μs to reach the focal plane, where they were detected. Hence, a time of flight (TOF) setup was formed by taking the start signal from the MWPC anode and stop signal from the RF. This TOF setup helped us to have a very clean separation of ERs from the beam-like and target-like contaminations. Fig. 1 shows the TOF versus energy of the particles reaching the focal plane. Particles with same TOF but almost zero energy can also be seen near to (left side) the ERs. These were also ERs which were not reaching the silicon detector kept behind the MWPC. ^{16}O +^{184}W reaction was used to measure the transmission efficiency of the separator. The transmission efficiency (η_{HYRA}) for ^{16}O +^{184}W reaction was calculated from the experimental ER [3] cross sections. The angular distribution of the major ERs (PACE3 calculations shows that xn-evaporation channels are the dominant decay channels in the energy range studied) from ^{16}O +^{194}Pt reaction was simulated using the semi-microscopic Monte Carlo code TERS [4], which in turn was used for obtaining η_{HYRA} for the present reaction. Statistical model calculations were performed using the fusion l-distribution obatined from CCFULL after reproducing the experimental fusion cross sections. Rotational couplings of the target nuclei were included in the coupled channels calculations. Standard statistical model calculations using Bohr-Wheeler fission widths (no nuclear dissipation effects) [5] underpredicted the ER cross sections at higher energies. However, calculations using Kramers' [6, 7] formula for fission width with dissipation coefficient $\beta = 5{\times}10^{-21}$sec^{-1} reproduced the experimental cross sections at all energies. Fig. 2 shows experimental ER excitation function along with the theoretical calculations. The present measurement provides further evidence for the effect of nuclear dissipation in 200 mass region.

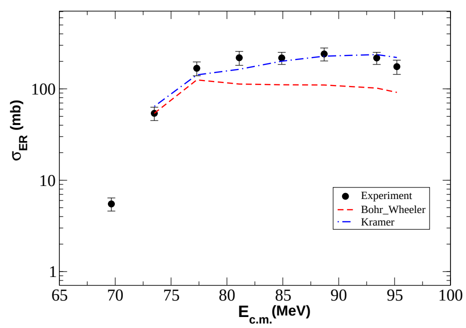

FIG. 2: Experimental ER excitation function compared with calculations using Bohr-Wheeler's and Kramers' fission widths.

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