Investigation of fusion-fission dynamics using ER-gated neutron multiplicity and charged particles multiplicity as probes

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Introduction

Pre-scission neutron multiplicities are one of the most potent probes for studying the nuclear viscosity. The presence of Kramer's predicted dissipation is well established by comparing the experimental results with standard statistical models [1-4]. In our recent measurement of fission-gated neutron multiplicity [5], we observed that the excitation energy dependent nuclear dissipation is required to explain the observed neutron multiplicity whereas no nuclear dissipation (even lowering of Finite Rotating Liquid Drop Model (FRLDM) fission barrier) is required to explain the evaporation residue (ER) cross-sections [6].These observations indicated that a statistical model, which can explain the fission gated neutron multiplicity and ER cross-sections on same footing is still missing. In theoretical studies, it has been proposed that inclusion of energy and deformation dependence of various parameters is necessary to obtain a unified statistical model. The development of this model requires precise experimental data sensitive to the nuclear dissipation in both pre and post saddle regions. The pre saddle dissipation can be quantized using ER gated neutron multiplicity whereas fission gated charged particles multiplicities are most sensitive probe for post saddle dissipation [7].

With this motivation, we have proposed the measurement of ER-gated neutron multiplicity and fission-gated charged particles multiplicity for ^{19}F + ^{194,196,198}Pt reactions using NAND facility at IUAC, New Delhi. In the present work, we are reporting the predicated values of ER gated neutron multiplicity and fission gated charged particles multiplicity using statistical model calculations.

Experimental Set-up

The proposed experiment of ER-gated neutron multiplicity measurement will be carried out using National Array of Neutron Detectors (NAND) facility at excitation energy range from 50-100 MeV. The evaporation residue produced in the reactions will be detected using annular shaped PPAC detector placed inside the target chamber. The neutrons emitted from compound nucleus will be detected, in coincidence with evaporation residue, using neutron detectors. The second experiment proposed for the measurement of fission-gated charge particles multiplicity measurements will be performed using scattering chamber of NAND or General Purpose Scattering Chamber (GSPC) facility. The fission fragments will be detected using two Multi-Wire Proportional Counters (MWPCs) kept at folding angles to detect the complementary fission fragments. The charged particles (protons and α- particles) will be detected in coincidence with fission fragments using four CSI(Tl) detectors (each detector contains 4 crystals).

Statistical Model Calculations

The theoretical model used for the calculations assumes that the compound nucleus can decay either through the emission of light particles (neutron, proton, α-particles, γ-rays) or can undergo fission. The decay widths of light particles and GDR γ-rays are obtained from the

Weisskopf formula whereas the fission width is obtained using integral form of Bohr-Wheeler and Kramer (including dissipation as a free parameter)formula. The fission barrier is determined from the potential obtained from Sierk's model [8]. Since the compound nuclei populated in present study has either neutron shell closure or are close to the shell closed nuclei hence it is important to include the shell correction in calculations. An excitation energy dependent shell correction is taken into account for fission barrier. The level density is taken from work of Ignatyuk *et al.* [9]. The experimentally obtained fusion cross-section is fitted using CCDEF code and the generated spin distribution obtained from CCDEF is provided as an input for the statistical model calculations.

Results and Discussion

The calculation for pre-scission charged particles multiplicity is performed using BW fission width. The predicted values of pre-scission proton and α multiplicities as a function of excitation energy are shown in Fig. 1. Since it is well established that the nuclear dissipation enhances the neutron and charged particles multiplicities, the BW predicted charged particles multiplicities provide the lower limit of the multiplicities.

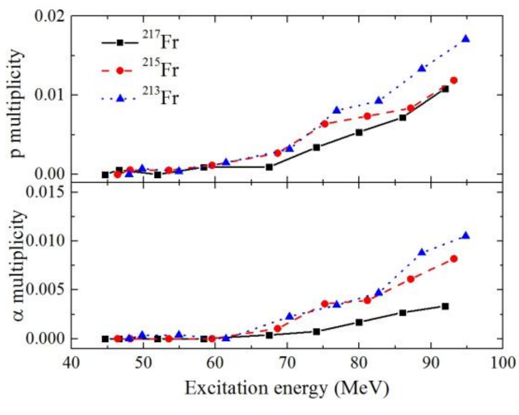

Fig. 1: The predicted values of pre-scission proton and α-particle multiplicities as a function of excitation energy for BW fission width.

Fig. 2 shows BW predicated values of ER gated neutron multiplicity, which provides the upper limit to the values.

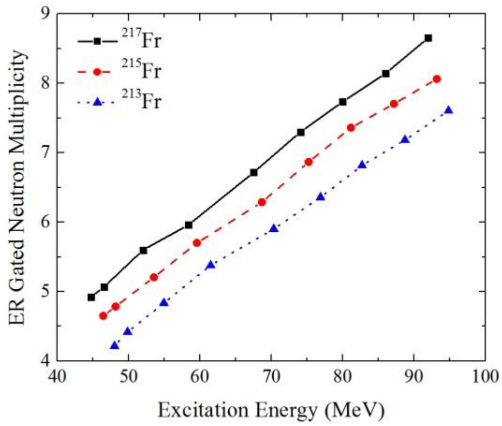

Fig. 2: The predicted values of ER-gated neutron multiplicity as a function of excitation energy for BW fission width.

These calculations will be helpful for planning the experiment. The experimental measurement will be performed soon and the experimental results will be compared with the theoretical predictions to understand the role of nuclear dissipation in pre and post saddle regime of fusion-fission dynamics.

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