Fission dynamics at energies far above the Coulomb barrier

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(Dated: September 27, 2019)

1. Introduction

Though extensive amount of works have been carried out over several decades, a comprehensive understanding of the nuclear fission process, in particular it's complex dynamics, is yet to be achieved. To understand the fusion-fission dynamics, fission fragment mass and folding angle distributions are two very useful observables. The folding angle distribution provides the information about the linear momentum and energy transfer. As the fragment folding angle depends on the recoil velocity of the fissioning nuclei, the reactions with different momentum transfer (e.g; compound nuclear fission, transfer fission etc.) leading to different recoil velocity can be separated from the measured fission fragment folding angle distribution. At near barrier energies, transfer is the most dominant reaction channel among the direct reaction channels and fission fragment folding angle distribution technique has been successfully applied to separate transfer fission from only fusion fission [1, 2].

As most of the earlier studies were concentrated at near barrier energies, the experimental data at higher energies are scarce, thus, our understanding of fission dynamics are not well developed for the higher energy and angular momentum range. Measurements in this regime is particularly important for proper understanding of the processes intermediate between deep in-elastic and fusion fission (e.g; quasi-fission). In the present work, we have systematically investigated the fission fragment folding angle and mass distributions for the α-clustered projectile, ^{20}Ne with several pre-actinide and actinide targets.

2. Experiment and Analysis

The experiment was carried out at the General Purpose Scattering Chamber (GPSC) facility at the K-130 cyclotron at VECC, Kolkata. ^{20}Ne beams of energies 145 to 192 MeV with small energy steps was bombarded on ^{238}U, ^{209}Bi, ^{208}Pb, ^{197}Au and ^{181}Ta targets. The fission fragments were detected using two large area position sensitive multiwire proportional counters (MWPC) [3]. The detectors were operated at a low pressure of 3 torr. The position and the energy loss in the detector of the fission fragments along with their flight time has been recorded on event by event basis and the mass distributions have been obtained using time-of-flight difference technique.

3. Results and Discussions

The folding angle and mass distributions have been extracted for all the systems at all measured energies. A representative folding angle and mass distribution for the system ^{20}Ne+^{209}Bi at the incident energy of 180 MeV is shown in Fig. 1. The figure indicates two distinct peaks in the folding angle distribution, the first and the prominent one is consistent with the calculated folding angle from Viola's systematics for compound nuclear fission (CNF) [4]. The second peak at higher

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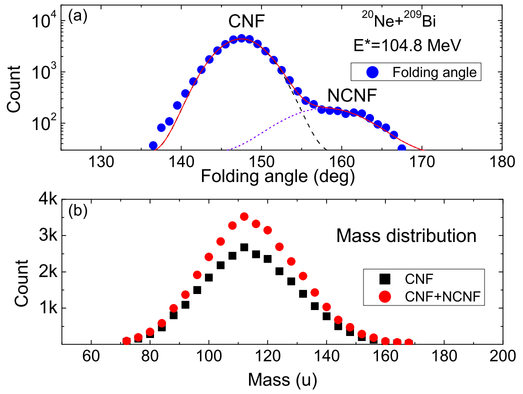

FIG. 1: The representative (a) folding angle and (b) mass distribution for the system ^{20}Ne+^{209}Bi at the incident energy of 180 MeV.

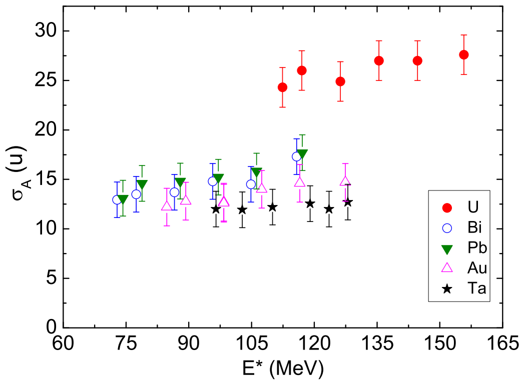

FIG. 2: The variance of mass distributions for all the measured systems for the projectile ^{20}Ne as a function of excitation energy for CNF process.

angle is related to the non-compound nuclear fission (NCNF). It is interesting to note from Fig. 1 (a) is that the position of the second peak matches with the calculated folding angle corresponding to the Incomplete fusion of heavy fragment through elastic break up.

The Fig. 1 (b) indicate that the extracted fission fragment mass distributions for CNF process and for all the reactions (CNF+NCNF) leading to fission are symmetric in nature. The variance of the mass distribution is slightly higher for fission from all channels compared to the same for fusion-fission channel. This indicates that CNF is the most dominant reaction mechanism even at reactions involving high energy (E/A = 7.2-9.6 MeV/A) and angular momentum.

In Fig. 2 the variation of the variance of the mass distributions is shown as a function of excitation energy for all the systems for CNF events that were selected using folding angle technique. The monotonic increase of the variance of the mass distribution signifies that the fragments are originated from the fusion fission process. The figure also shows that the variance of the mass distribution increases with the increase of target mass, but the increment is substantially higher for actinides target ^{238}U compared to pre-actinides.

We have also studied the variance of the fragment mass distribution with fissility and tested the predictive power of the GEneral description of Fission observables (GEF) code [5] that was recently developed to study fission-related nuclear data. The details of the studies will be presented in the symposium.

Our systematic study of mass and folding angular distribution for large group of a target nuclei from ^{181}Ta to ^{238}U; and wide region of excitation energies well above the Coulomb barrier provides further development of our understanding of the dynamics of nuclear fission process.

Acknowledgments

The authors are thankful to VECC Cyclotron staffs for providing high quality beams. We thank Mrs. R. M. Saha, Mr. J Meena, Mr. J Sahoo, Mr. A Saha, and Mr. S. Dalal for their help during the experiment.

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