Role of quasi-fission on fragment mass distribution in $^{28}Si + ^{197}Au$ reaction.

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Introduction

In nuclear experiments with heavy ion beams, several reaction processes take place at energies around the coulomb barrier. For reactions with heavy targets, fusion-fission, quasi-fission, and transfer induced fission are the competing processes. Quasi-fission process, in which the system reseparates before reaching a compact compound nucleus, is major hurdle in the formation of heavy and super-heavy evaporation residues (ER)[1].

In quasi-fission process, the unconditional saddle point shape is more compact than the entrance-channel contact configuration of the interacting di-nuclear composite system. For quasi-fission process, the fission barrier is not completely vanished it will have a finite height. To distinguish between the fully equilibrated compound nucleus fission and quasi-fission, fission fragment mass distribution is one of the important probes. The width of the mass distribution depends strongly on the entrance channel properties, such as mass asymmetry, deformation of interacting nuclei, collision energy, and the Coulomb factor Z_1Z_2. Onset of mass asymmetry or a sudden increase in mass width would be a strong signal of quasi-fission [2,3]. Anomalous peak like structure in mass width distribution was observed in ^{16}O, ^{19}F + ^{232}Th reactions at energies around the coulomb barrier and this result was explained due to the presence of quasi-fission at around barrier energies[4,5]

In the present work, we have investigated the mass distribution of fission fragments formed in ^{28}Si ion induced fission on ^{197}Au target around coulomb barrier. The mass distribution was measured around coulomb barrier at energies ranging from 135.4 MeV to 180MeV.

Experimental details and data analysis

The experiment was performed at BARC-TIFR-Pelletron-Linac Facility, Mumbai. Pulsed beam of ^{28}Si of ~1.5 ns width and a period of 107.3 ns was used. The ^{197}Au (250 μg/cm^2) target was mounted on a target ladder in the center of the general purpose scattering chamber. Fission fragments were detected in coincidence by using two position-sensitive Multi-Wire proportional counter (MWPC) detectors mounted inside the scattering chamber and placed at the folding angle. Both the MWPCs used were having window dimensions of 17.5cms X 7cms. One of the detector was placed at a distance of 54.9 cm from the target ladder while the other at a distance of 27.5cm. Angular coverage of the detectors were around 18° and 35° respectively. Two Silicon detectors as monitor of elastically scattered particles were used with one placed at an angle of 20° while other at an angle of -20°. The ionizing medium inside MWPC used was isobutane gas at 3.0 mbar. The X-Y positions, the energy loss in each of the detectors, the time difference between the arrivals of coincident fragments at the detectors as well as individual time of flight of fragments with respect to RF beam bunching signal were recorded event by event. The position calibration of the detectors was carried out using the known positions of the edges of the illuminated areas of the detectors, when the events were collected in singles mode using ^{252}Cf source. The calibrated X and Y positions from the two detectors were then converted to θ and φ respectively.

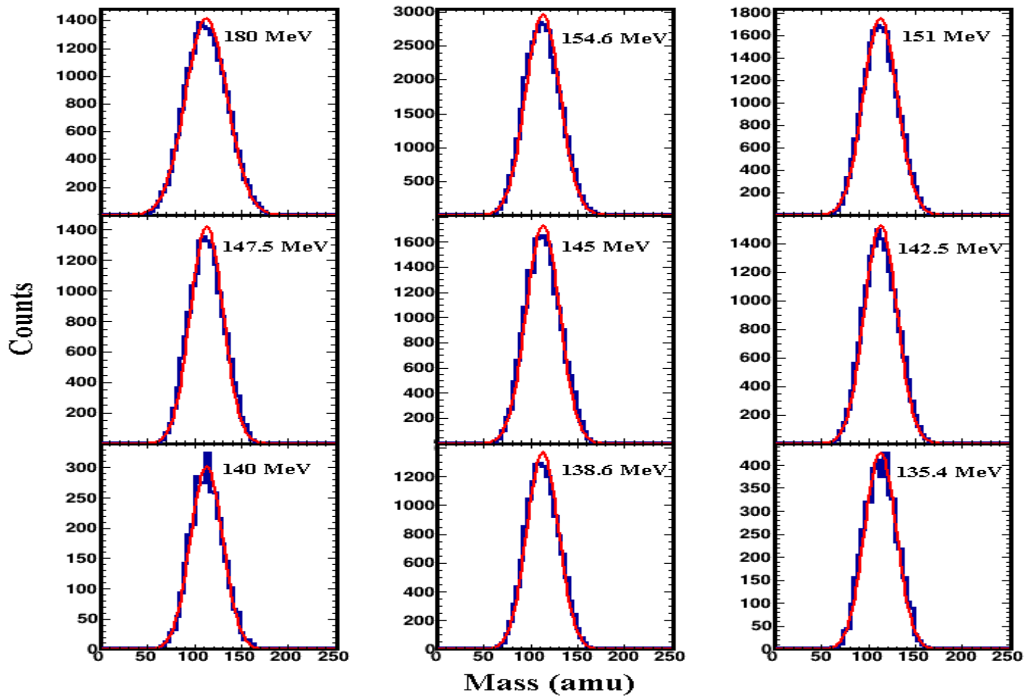

Fig. 1 Mass distribution obtained for various energies for $^{28}Si + ^{197}Au$ reaction.

The velocities were reconstructed from the timing and positions information. The velocities were transformed to center of mass frame. The conservation of momentum was used to obtain mass distribution. Figure 1 shows mass distribution obtained for various energies. Figure 2 shows the mass width versus projectile energy in laboratory frame.

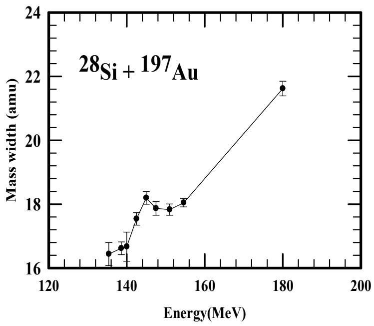

Figure.2 Mass width versus projectile energy.

Results and conclusion

The obtained mass width decreases with decrease in projectile energy and a peak like structure has been observed at energies around the coulomb barrier, similar to that reported earlier by Ghosh et al. for ^{16}O, $^{19}F + ^{232}Th$ systems [4,5]. This may be explained due to the dominance of quasi-fission processes at these energies, as the cross section of the fusion-fission process decreases exponentially at sub-barrier energies.

References:

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