Fission fragment mass distribution studies in ^{9}Be + ^{232}Th fission reaction

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Introduction

Heavy-ion fission, induced by weakly bound projectiles facilitates us to populate fissioning nucleus with varying excitation energy and nucleon degree of freedom. In case of weakly bound projectiles, along with complete fusion, peripheral reaction channels such transfer, breakup, and incomplete fusion also contribute. Role of these reaction channels on fission process which itself is quite complex is not firmly understood.

Fission fragment mass distribution is a very sensitive probe which can reveal not only the dynamics of fission process, but also the influence of peripheral reaction channels. In the recent past, effect of transfer induced fission channels on fragment mass distributions in ^{6,7}Li+^{238}U fission reactions has been observed quite unambiguously [1,2]. It is of very much importance to carry out further such investigations involving different loosely bound nuclei. With these motivations, we have measured fission fragment mass distribution in ^{9}Be+^{232}Th fission reaction at different energies around the Coulomb barrier.

Experimental details and data analysis

The experiment was performed at BARC-TIFR-Pelletron-Linac Facility, Mumbai. Pulsed beam of ^{9}Be of ~1.5 ns width and a period of 107.3 nsec was used. A self supporting ^{232}Th target (850 μg/cm^2) was mounted on a target-ladder that was oriented at 45° with respect to the beam direction. The fission fragments were detected in coincidence using two position-sensitive Multi-wire proportional counters (MWPCs) mounted inside a general purpose scattering chamber and kept at folding angle. Both the MWPCs used had a window dimension of 17.5 X 7 cm^2. One of the detector was kept at a distance of 54.2 cm from the target while another one at 27.5 cm with angular coverage of around 18° and 35° respectively. Two Silicon detectors were used at angles of ±20° for beam monitoring purpose. Isobutane gas was used at 3.0 mbar in both MWPCs. The X-Y positions, the energy loss in each of the detectors, the time difference between the arrivals of coincident fragments at the detector as well as individual time of flight of fragments with repect 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 using ^{252}Cf source. The calibrated X and Y positions from the two detectors were converted to polar (θ) and azimuthal (φ) angles. The velocities were reconstructed from the position and timing information. The Kinematic coincidence method [3] was used to determine the parallel and perpendicular components of fissioning nucleus velocity. A typical correlation between parallel and perpendicular velocities of the fissioning nucleus is shown in Fig.1 at beam energy of 45 MeV. Almost all the events at 45-MeV appear to be full momentum transfer events.

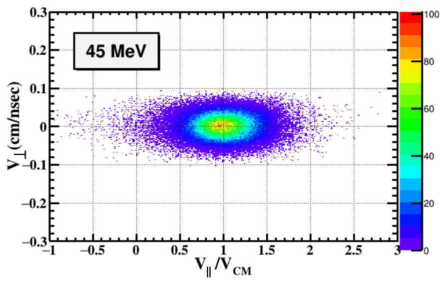

Fig.1 Correlation between parallel and perpendicular velocities of the fissioning nucleus.

Theoretical calculation done by Gudveen Sawhney, et al [4]. for the same system finds that the contribution of non compound fission processes is not significant. The fragment velocities were transformed to center of mass frame. The conservation of momentum was used to obtain mass distribution. Ratio of parallel component of the fissioning nucleus to the recoil velocity of compound nucleus is plotted as a function of fragment mass ratio as shown in Figure 2.

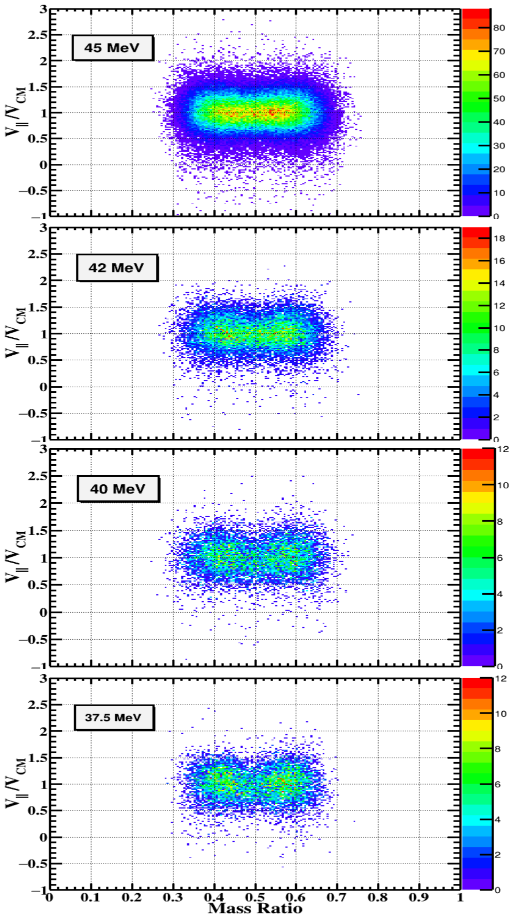

Fig.2 Correlation between parallel component of velocity of fissioning nucleus and mass ratio of the fission fragments.

Results and discussion

Figure 3 shows the mass distribution obtained at various energies. It is clearly seen from Figs. 2 and 3 that fraction of asymmetric mass division increases with deceasing beam energy down to sub-barrier energy region. The lighter fragment mass peaks around 104 amu and the heavier fragment peaks around 137 amu. The peak-to-valley (P:V) ratio is increasing with decreasing energies as shown in figure 4. Trend of P:V ratio is consistent with shell-model expectations. Detailed data analysis is in progress.

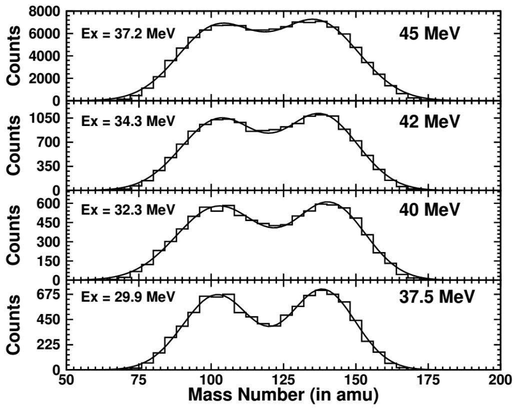

Fig.3 Mass distribution obtained at various energies.

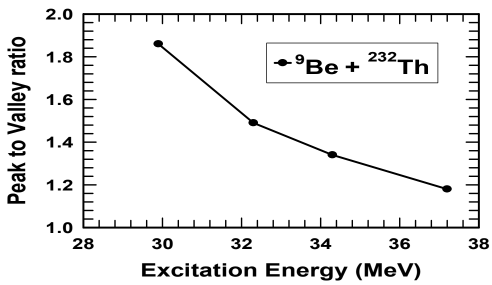

Fig.4 Peak to valley ratio vs Excitation energy for the given system.

References

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