Binary Fragmentation Dynamics of ^{48}Ti + ^{232}Th Reaction at 280 MeV Bombarding Energy

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Introduction

The study of reaction dynamics of heavy and super-heavy nuclei gives crucial information about the formation probability of compound nucleus (CN), the fission barriers and cross-section of these nuclei. QF happens to be the prominent mechanism which hinders the formation of SHE in the fusion of massive nuclei. Since CN fission and quasi-fission (QF) are both binary decay channels characterized by large nucleon exchange and energy dissipation, it is cumbersome to perform the experimental separation between QF and FF. Both these processes are distinguished from each other based on the analysis of different experimental observables of fission-like fragments, namely, mass distribution (MD), mass and energy distributions (MED), mass and angular distribution (MAD). Intense efforts have been made in the recent years to study the reaction dynamics of the composite system formed by the fusion of actinide nuclei with heavier projectiles such as Ti, Cr, Fe or Ni leading to the formation of CN with Z= 104-126. Very recently the probes of MD, MED and MAD were utilized to understand the fragmentation dynamics of the systems of ^{50}Ti + ^{208}Pb [1] and ^{48}Ti + ^{208}Pb [2] by Appannababu et al. and Thakur et al. using a spherical target ^{208}Pb. With this motivation as a representative case, we have performed measurements of MD and Mass-Total Kinetic Energy (TKE) correlation for the reaction of ^{48}Ti + ^{232}Th populating super-heavy nucleus ^{280}Cn at E*=63.5 MeV. The present study involves the investigation of fission dynamics of a super-heavy system ^{280}Cn (Z=112) using a deformed ^{232}Th thin target. This work involves the study of competition between compound nucleus fission and quasi-fission in heavy-ion induced reaction at energy well above the Coulomb barrier.

Experimental details and data analysis

The details of the experimental setup are same as given in [3]. The experimental data analysis was carried out using ROOT software package. The data was analysed event-by-event and mass distribution was achieved using the method of kinematic coincidences comprising of accurate determination of TOF, velocity, scattering angles (θ_{lab}, ϕ_{lab}) of the fragments. Elastically scattered events were taken into consideration for the calibration of the TOF spectrum of fission fragments. The calibrated (x,y) positions were then converted to scattering (polar) angle θ_{lab} and azimuthal angle ϕ_{lab}, event by event. Further the velocities of the fission fragments were then extracted from the obtained TOF and angles using absolute time method (ATM) approach. From these measured velocities, the primary masses and energies of the fission fragments were calculated by assuming binary

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kinematics, conservation of linear momentum and mass-conservation relations. The provisional masses so obtained were corrected for energy loss in the target and MWPC detector foil by adopting iteration procedure [2]. This process was repeated to ensure convergence to final masses of fragments and kinetic energies.

Results and discussion

The center-of-mass total kinetic energy of the fission fragments has been extracted from the final masses and velocities of the fragments. Mass-TKE distribution of the final fragments obtained in the reaction of ^{48}Ti +^{232}Th at bombarding energy of 280 MeV is shown in fig 1. The scatter plot of Mass-TKE

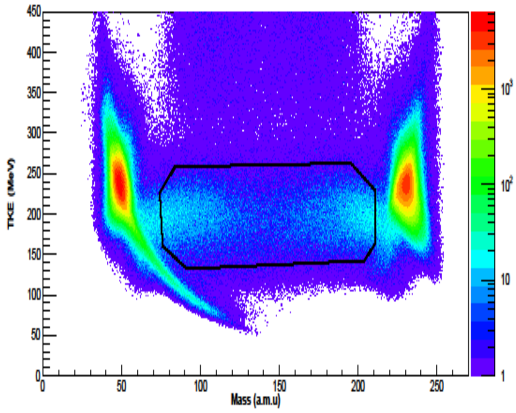

FIG. 1: Mass-TKE correlation for the reaction of ^{48}Ti +^{232}Th at E*=63.5 MeV.

distribution shows the dominating events close to target and projectile masses which correspond to elastic, quasi-elastic and DIC kind of events. The products of energy straggling and small-angle scattering inside the target material and detector foils can be seen as tail coming from the elastic scattering peak to the mass symmetry with a prominent decrease in the TKE. However, in the intermediate region, a significant number of events corresponding to QF and FF are present between A ∼ 70-210. Fusion-fission is expected to take place in the symmetric mass split region of A = 140±20. The corresponding mass distribution for the intermediate region which is marked as black polygon gate is shown in fig 2. The mass distribution of the studied reaction has typical wide double humped shape which is caused by QF. It can also be seen that the major part of fission-like fragments are lying near the masses of target and projectile nuclei. From the analysis of MD and M-TKE distribution a pronounced asymmmetric QF component is observed in this reaction of ^{48}Ti + ^{232}Th.

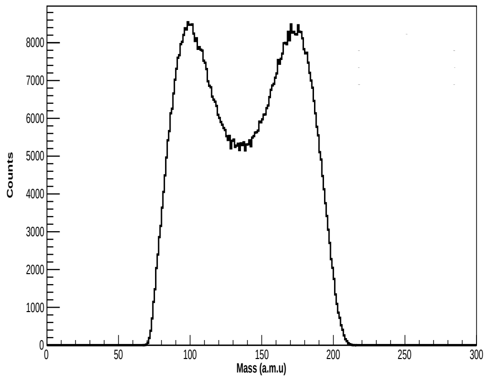

FIG. 2: Mass distribution for the gated region obtained for the reaction of ^{48}Ti +^{232}Th at 280 MeV bombarding energy.

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