Fission fragment Mass-TKE distribution of Thorium nuclei

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Introduction

The heavy ion induced fusion-fission reaction mechanism is a complex process and can be studied by measuring various observables of fission fragments. The fragment mass distributions, total kinetic energy (TKE) distributions and their widths are expected to provide information on the compound nucleus decay and formation of the nascent fission fragments at the scission point. An asymmetric structure of mass distribution is known to exist in the spontaneous and low-energy induced fission in actinides [1], due to shell stabilization in the heavier fission fragments at Z=50 and/or N=82 spherical shell configuration and at N=86-88 deformed shell closure.

However, in Ra-Th region, it has been observed that the mass and/or charge distributions contain two components corresponding to symmetric and asymmetric mass division [2]. The fission dynamics can be understood by examining the individual fission modes which are suggested by Brosa et al [3]. These fission modes can be clearly identified with the help of Mass-TKE distributions. It is also observed that the increase in nucleon number of the fissioning of heavy nucleus has shown a transition from symmetric to asymmetric fission modes in Ra-Th region [4] which may be ascribed to the neutron numbers. In the present program, experiments are performed to study the fission fragment Mass-TKE distributions in ^{A}Th* nuclei (A=222-226) produced in O + Pb reactions at excitation energies upto about 100MeV.

Experimental Details:

Experimental measurements are performed using NAND facility [5] at IUAC, New Delhi. A pulsed beam of ^{18}O with a pulse width of 1nano-seconds and repetition rate of 250nano-seconds was provided by Pelletron [6] followed by Super Conducting LINAC [7] accelerator combined facility. In this experiment thin target ^{208,206,207,204}Pb were used. Targets are prepared with a thickness of approximately 200μg/cm^2 deposited on 30μg/cm^2 carbon layer backing. The measurements are performed at a range of beam energies from 76MeV to 155MeV. The fission fragments Time-of-Flight (TOF) was measured relative to the RF signal of the LINAC. Fission fragments were detected by two multi wire proportional counters (MWPCs) in coincidence. These two detectors are placed at folding angle of 160^o for the beam energies of 105 MeV to 155 MeV and 165^o for the beam energies of 76MeV to 95MeV. Neutron multiplicity data was also collected at selected lower energies.

Data Analysis and Results:

Primary fission fragment masses were estimated using double velocity (2V) method. The fragment masses were extracted by determining the mass ratio (MR) with the center of mass velocities, as follows

$$MR = \frac{v_{1cm}}{(v_{1cm} + v_{2cm})}$$

where v_{1cm} and v_{2cm} are the center of mass velocities of the fragments 1 and 2.

Velocity vectors are determined by using the time of flights (TOF) obtained in Absolute Time method (ATM) and the position information (x,y) from the MWPCs. This position information later converted into *(θ, Φ)*.

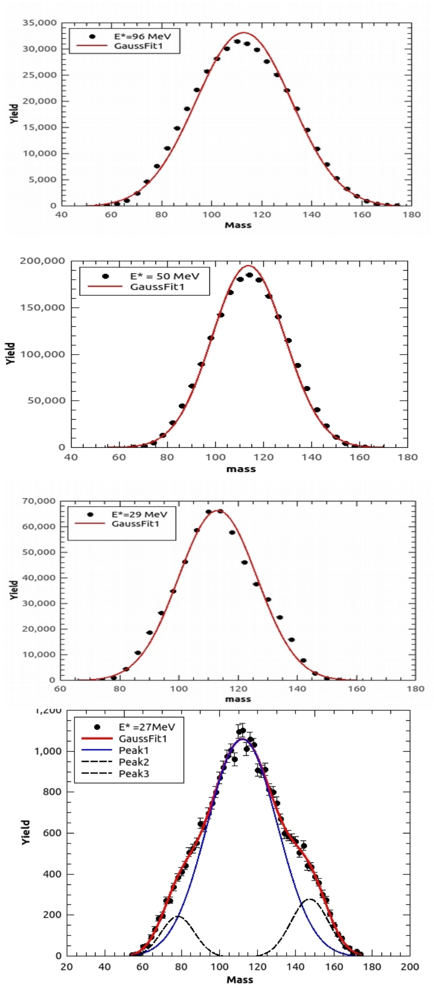

Figure: Fission fragment mass distributions of ^{226}Th* nucleus at excitation energies between E*=27 MeV- 96 MeV.

The recoil velocity component of the compound nucleus was constructed using the measured folding angles and the fragment velocities in lab frame. Center of mass velocities were constructed from this velocity components and lab velocities. The above shown Figure is illustrating the primary fission fragment mass distributions of ^{18}O+^{208}Pb=^{226}Th* in the excitation energies ranging from 27 MeV – 96 MeV. At highest excitation energies mass distribution was fitted with a single Gaussian peak. However at lower energies quality of the single peak fit seems to have gone bad and at lowest excitation energy E*=27 MeV, presence of asymmetric component can be clearly seen. This provides evidence for the coexistence of two fission modes in the fission of ^{226}Th. The dynamics of the nascent fragments can be understood by analyzing the Mass-TKE distributions.

The total kinetic energies were also calculated with the estimated masses and velocities. But, it has been showing that, the energies of the fragments has to be corrected for pre-scission neutron emission and the estimation of the energy loss of the fragments inside the target is also in progress. The total kinetic energies and the final fragment mass distributions will be presented.

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