Bi-modal feature studies in angular distributions of ^{225}Pa light actinide nuclei

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The mechanism of mass division in fission of atomic nuclei has been an intriguing problem in nuclear physics for several years. Generally, it is observed that asymmetric mass division is predominant in spontaneous fission [1] or low energy induced fission of actinide nuclei whereas nuclei around ^{208}Pb fission mainly to symmetric mass division[2]. Some nuclei in the region of ^{228}Ra shows three-humped structure of the mass distribution reflecting contributions from both symmetric and asymmetric mass components[3, 4]. With growing excitation energy of the fissioning nucleus, the asymmetric mass distribution changes to symmetric Gaussian distribution. These characteristics are explained according to the concept of independent fission channels (modes) which corresponds to specific valleys in the potential-energy surface (PES) of the fissioning nucleus [1, 5, 6]. Recently, This two-mode nature of fission phenomenon has been observed in heavy ion induced fission of light actinides nuclei [7].

Apart from mass distribution, angular distributions of fission fragments exhibit the different saddle-point nuclear shape dependence. For e.g., If the modes of mass-division correspond to different saddle-point configurations, there can be correlation expected between angular anisotropy and mass distribution of fission products. A clear dependence of the angular anisotropy on the fragment mass number have been observed in proton, alpha on actnide target induced reaction mass A≈ 226 such as the anisotropies of the symmetrically divided products were found considerably smaller than those of the asymmetrically divided ones. However heavy ion induced reaction populating light actinide nuclei mass A≈ 226, there is not clear correlation observed the influence of mass division of angular anisotropies. In present work, we try to understand the dependence of the angular anisotropy (AA) on the fragment mass number for $^{19}F + ^{206}Pb \longrightarrow ^{225}Pa^*$ and compared with existing data of AA of ^{16}O + ^{209}Bi reaction [8].

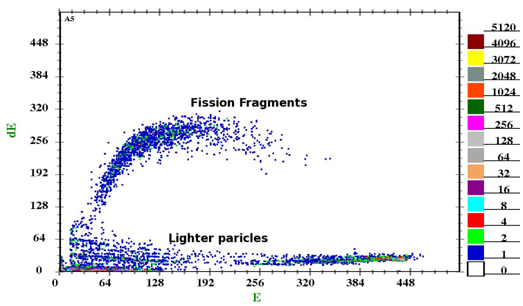

FIG. 1: Online dE-vs-E energy spectra obtained at angle of 150°with respect to beam direction for beam energy Elab=94 MeV

The angular distribution measurements have been performed employing HYTAR (Hybrid Telescope Array) facility, using beam ^{19}F from 15UD pelletron at IUAC, New Delhi. We have used beam of ^{19}F at laboratory energies ranges from 80 to 112 MeV. The hybrid detector is a combination of gas ionization chamber (as dE detector) and silicon detector (as E detector). The active length of dE detector is 18 mm and operated at 90 mbar of isobutane gas. The thickness of E detector is 300

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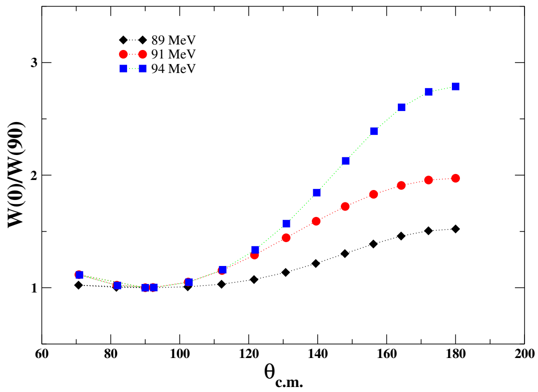

FIG. 2: the fission fragment angular distributions for the $^{19}F + ^{206}Pb \longrightarrow ^{225}Pa^{*}$ around capture barrier (V$_B$ = 93 MeV) energies.

m which is sufficient to completely stop the particles with residual energies. The defining apertures of all the telescopes are 7 mm with angular opening of 1.5°. The experimentally measured fission fragment angular distributions were transformed from laboratory to center-of mass frame using Viola systematic for symmetric fission. The normalized fission yields are calculated as a function of angle at each energy. Rutherford scattering events in the monitor detectors were used for the normalization to obtain the absolute fission angular distribution.

The fission fragment angular distributions around capture barrier energies has been shown in fig.2. There is no large anisotropy enhancement observed below capture barrier. The capture barrier energies corresponds to around 30 MeV excitation energies. Lower than this excitation, a strong evidence for survival of microscopic shell effects in fission of light actinide nuclei ^{224,226}Th ^{225,227}Pa, and ^{228}U have been confirmed through their mass distribution measurements [7]. As symmetry and asymmetry two-mode feature of fission arises due to the shell effects changing the landscape of the potential-energy surfaces. In present angular distribution measurement, this effect is not very clearly visible. The reaction ^{16}O + ^{209}Bi and ^{19}F + ^{206}Pb exhibit the similar kind of behavior. However analysis of angular distribution measurements for this nuclei is in its preliminary stage. In summary, we attempted to study the the multi mode fission in light actinide $^{19}F + ^{206}Pb \longrightarrow ^{225}Pa^{*}$ nuclei via dependence of mass division on angular anisotropy at lower excitation energy of the fissioning nucleus.

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