Shell effects in the fission of nuclei around Mercury

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Nuclear fission is a complex dynamic phenomenon that involves a subtle interplay of collective and single particle effects. Though discovered 80 years back, fission continues to be one of the most interesting topics of nuclear physics research even today. It serves as the unique tool to understand the nuclear potential energy landscape and its evolution. The asymmetric mass split observed in low energy fission of actinides, unlike the predictions of liquid drop model, clearly illustrates the role of microscopic degrees of freedom in fission. Since microscopic effects depend the nucleons present in the system significantly, their effects in the potential energy surface are also expected to be substantially different in different nuclei. On the other hand, these effects wash out with increasing excitation energy which leaves extreme challenges in understanding their roles in fission.

Mass-asymmetric fission observed in the spontaneous and low energy fission of actinide nuclei were often attributed to the fragment shell properties [1]. However, the asymmetric mass-split observed in the β-delayed fission of ^{180}Hg [2, 3] suggested that shell structure other than those of the fragments play a crucial role in the fission of neutron deficient pre-actinide nuclei. Different theoretical formalisms were put forward to explain the unexpected onset of asymmetric fission in the Hg region at very low excitation energies [4, 5]. While such low energy fission can also be achieved in spontaneous and thermal neutron induced fission, it is very difficult to achieve such fissioning system with similar conditions in charged particle/heavy ion induced reactions. The exponential fall of the fission cross section at near barrier energies further complicates the scenario.

We reported fission fragment mass-angle and mass ratio distribution measurements for the ^{40}Ca+^{142}Nd and ^{13}C+^{182}W reactions [6] forming the compound systems ^{182}Hg and ^{195}Hg, respectively. In this work we observed mass-asymmetric fission in neutron deficient Hg nuclei populated via heavy ion fusion reaction, for the first time. A symmetric fragment mass distribution was observed in the heavier isotope of Hg. Signatures of mass asymmetric fission were also reported in the fission of ^{180,190}Hg nuclei populated through ^{36}Ar+^{144,154}Sm reactions, respectively, in Ref. [7].

In this context, we performed a series of measurements populating different nuclei around Hg at low excitation energies. The experiments were performed at the Heavy Ion Accelerator Facility of Australian National University. Pulsed beams of ^{40,48}Ca, ^{32}S and ^{12}C with a pulse separation of 107 ns and FWHM of 0.7-1.5 ns from the 14UD Pelletron accelerator were used to produce the isotopes of Hg, Pt, Os and Pb in these experiments. The mass-angle and mass ratio distributions of the binary fragments were obtained using the kinematic coincidence method. Signatures of mass-asymmetric component is noticed in the fission of Os, Pt and Hg isotopes. A clear transition to symmetric split is observed in Pb isotopes. A comparison of the width of the mass distribution of different isotopes of the same compound nucleus also indicates the onset of mass-asymmetric fission in such nuclei.

Latest experimental results will be dis-

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