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Fission isomer studies at FRS/GSI and IGISOL/JYFL-ACCLAB

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The structure of fission barriers in actinide nuclei is characterized by pronounced multi-humped shapes, which give rise to long-lived isomeric states trapped in secondary minima of the potential-energy surface. These complex barrier profiles emerge from the interplay between macroscopic liquid-drop behavior and microscopic shell effects. In the region around the deformed magic neutron number N = 146 (Z=92–97, N=141–151), this mechanism leads to the formation of a distinct "island" of fission isomers. To date, 35 such isomers have been experimentally identified, with half-lives spanning from a few picoseconds to several milliseconds. As strongly deformed low-spin configurations stabilized by shell corrections, fission isomers provide a sensitive probe of nuclear structure at extreme deformation and offer an important benchmark for the shell effects expected to govern the stability of superheavy nuclei.

Until recently, studies of fission isomers relied almost exclusively on light-particle–induced reactions. In a first experiment at the Fragment Separator (FRS) at GSI, we demonstrated for the first time the use of projectile fragmentation of 1 GeV/u 238U beams to populate and investigate fission isomers. This approach provides access to isotopes that are difficult or impossible to reach with conventional reactions and, combined with in-flight separation, enables the study of short-lived isomers with high beam purity and event-by-event identification. Two complementary detection techniques were employed to cover half-lives from about 50 ns to 50 ms: (i) implantation in a fast plastic scintillator and (ii) thermalization in the cryogenic stopping cell of the FRS Ion Catcher with subsequent decay detection.

Since this initial measurement, the analysis of the first GSI experiment has been essentially completed, a second improved experiment at the FRS has been successfully performed, and a first experiment at IGISOL in Jyväskylä has been carried out, providing first results. At IGISOL, light-ion induced reactions are used, but contrary to past experiments, the production and detection of fission isomers is spatially separated, allowing a quasi-background-free detection of the fission isomers.

Type of contribution

Invited Speaker

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