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Fission studies at HIE-ISOLDE with the TSR

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Studies of nuclear fission in direct kinematics are limited by the availability of targets and the reduced velocity of the fission fragments, which makes their identification in charge rather complicated, in particular for the heavy fragment. Experiments in inverse kinematics carried out at GSI [1, 2] and GANIL [3] have strongly contributed to a revival of fission studies. The
GSI experiments have shown the interest of measuring fission-fragment yields and kinetic energies over long isotopic chains for the understanding of the fission process. These studies have considerably helped in revealing hidden regularities on the influence of shell effects on the fission process. Still, there remain unexplored regions. Moreover, there is a great interest
in studying the evolution of fission observables with the excitation energy of the fissioning nucleus, which was not possible in the experiments done at GSI. For instance, fission probabilities as a function of excitation energy are extremely sensitive to the properties of the fission barriers and nuclear level densities. In addition, many experiments have shown that fission probabilities can be used to obtain neutron-induced fission cross sections of short-lived
nuclei of interest for astrophysics and reactor physics, but for which direct measurements with neutron beams are not possible [4]. Another example of the need for measurements as a function of excitation energy is the odd-even staggering in the fission-fragment elemental yields, which is one of the most prominent manifestations of the influence of pairing correlations in nuclei. Recent studies have shown that the odd-even effect can be explained as
a consequence of the complete transfer of excitation energy from the light to the heavy fission fragment [5]. To further investigate this peculiar process of energy transfer, systematic measurements of the odd-even staggering in elemental yields as a function of excitation energy and for a broad range of fissioning nuclei are needed.

In this contribution we will show that the coupling of HIE-ISOLDE to the TSR opens up highly interesting possibilities for fission studies. We propose to study fission by means of transfer reactions with radioactive beams in inverse kinematics. HIE-ISOLDE will produce numerous beams of pre-actinides and actinides over unprecedented long isotopic chains, spanning new regions of the chart of nuclei for which fission has never been studied. The quality of these beams will be highly improved by cooling and storing them in the Test Storage Ring (TSR). The cooled beams can then interact with a gas-jet target to induce fission. We will discuss possible setups based on the detection of the target-like and the fission fragments in coincidence, which aim to determine the fission probability, as well as the kinetic energy and the elemental yields of the fission fragments as a function of excitation energy. The good beam quality and the limited straggling in the gas-jet target are particularly relevant for obtaining a good excitation energy resolution, which is needed to measure the fission probabilities at the fission threshold. In addition, one of the major problems in the measurement of fission probabilities is the presence of spurious events originating from reactions on the target backing (or windows) and on target contaminants (e.g. oxygen).
Therefore, the use of windowless, pure gas-jet targets represents an enormous advantage. Finally, the increased beam energy provided by HIE-ISOLDE and the good beam quality provided by the TSR shall considerably help in the identification in charge of the fissionfragments.

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