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Indirect measurements of neutron-induced reaction cross sections at storage rings

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Obtaining reliable cross sections for neutron-induced reactions on unstable nuclei is a highly important task and a major challenge. These data are essential for understanding the synthesis of heavy elements in stars and for applications in nuclear technology. However, their measurement is very complicated as both projectile and target are radioactive. The best alternative to infer these cross sections is to use the surrogate-reaction method in inverse kinematics, where the nucleus formed in the neutron-induced reaction of interest is produced by a reaction involving a radioactive heavy-ion beam and a stable, light target nucleus. The decay probabilities (for fission, neutron and gamma-ray emission) of the nucleus produced by the surrogate reaction provide precious information to constrain models and enable much more accurate predictions of the desired neutron-induced reaction cross sections.

Our aim is to investigate surrogate reactions in inverse kinematics at the CRYRING@ESR, which is the ideal instrument for this purpose as it will allow us to measure the decay probabilities of many short-lived nuclei with unrivaled accuracy.

Several steps are necessary before conducting the first surrogate-reaction experiment at CRYRING. In June 2022, we will perform a first proof-of-principle experiment at the ESR to demonstrate the validity of our new methodology for measuring gamma-ray- and neutron-emission probabilities. In the present proposal, we propose a second proof-of-principle experiment to measure, in addition, the fission probability. For this purpose, the set-up developed in the first proof-of-principle experiment will be complemented with several fission detectors made of solar cells. The full set-up and methodology will be validated by measuring for the first time simultaneously the fission, neutron and gamma-ray emission probabilities of several uranium isotopes formed in the interaction of a 238U92+ beam with a deuterium gas-jet target.

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