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Determining neutron-induced reaction cross sections through surrogate reactions at storage rings

Investigating the interactions of neutrons with unstable nuclei is crucial to our understanding of nuclear astrophysics as it sheds light on the stellar nucleosynthesis of heavy elements. Obtaining accurate cross section data for neutron-induced reactions on these nuclei presents major experimental challenges since both beam and target are radioactive. The NECTAR (NuclEar reaCTions At storage Rings) project aims to solve this problem by using the surrogate-reaction method, where one may indirectly infer the neutron-induced cross sections of short-lived nuclei, in inverse kinematics. A heavy, radioactive nucleus in the beam is to interact with a light, stable nucleus in the target to produce the compound nucleus formed in the neutron-induced reaction of interest via an alternative or surrogate reaction such as transfer or inelastic scattering. This compound nucleus may decay by fission, neutron or gamma-ray emission, and the probabilities for these modes of decay are to be measured as a function of the excitation energy of the compound nucleus. This information is used to constrain model parameters and to inform more accurate predictions of neutron-induced reaction cross sections [1].

The heavy-ion storage rings at GSI/FAIR in Germany present an ideal laboratory for the development of the surrogate reaction method, which still suffers from various target-related issues. The sustained high beam quality, along with the use of an ultra-thin gas-jet target, makes it possible to measure excitation energies and decay probabilities with an unrivalled accuracy.
A first Proof-of-Principle experiment is to be performed during the first half of 2022 at the ESR storage ring facility. The 208Pb(p,p') reaction will be investigated in inverse kinematics with an incident beam of 208Pb at 30 AMeV. Target residues will be measured with a detector telescope inside the reaction chamber, in coincidence with beam residues using DSSSD detectors downstream after a dipole magnet, thus providing decay probabilities for both neutron and gamma-ray emission.
After this first pilot experiment, NECTAR will eventually move to the CRYRING facility at GSI/FAIR, where the detection setup will be supplemented with fission fragment detectors, thus enabling for fission, neutron and gamma-ray emission probabilities to be measured simultaneously for the first time at this facility.

This presentation will focus on the concept and technical development of NECTAR, as well as the preparation for these experiments at the storage rings of GSI/FAIR.

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[1] R. Pérez Sánchez, B. Jurado et al., Phys. Rev. Lett. 125 (2020) 122502.

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