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Determining neutron-induced reaction cross sections with surrogate reactions in inverse kinematics at heavy-ion storage rings

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Neutron-induced reaction cross sections of short-lived nuclei are essential in astrophysics. In particular, neutron-induced fission cross sections are essential as fission sets the end of the r-process path and influences the abundance patterns and light curves. However, these cross sections are very difficult or impossible to measure due to the difficulty to produce and handle the necessary radioactive targets. The NECTAR (Nuclear rEaCTions At storage Rings) project uses for the first time surrogate reactions in inverse kinematics at a heavy-ion storage ring. This allows one to measure the de-excitation probabilities as a function of the excitation energy of the nuclei formed through the surrogate reaction with unrivaled precision and indirectly determine the aforementioned cross sections.

In this contribution I will present the first results of the NECTAR surrogate-reaction experiment that took place in June 2024 at the ESR storage ring of the GSI/FAIR facility in Darmstadt. In this experiment, the ^{238}U(d,d') and ^{238}U(d,p) surrogate reactions were used to form the ^{238}U and ^{239}U compound nuclei, respectively, and measure for the first time the fission, γ-ray, neutron and even two- and three-neutron emission probabilities simultaneously. The measurement of all the decay channels competing with fission will allow us to precisely determine fundamental quantities such as fission barriers, particle transmission coefficients, γ-ray strength functions and nuclear level densities and to infer the ^{237,238}U(n,f), ^{237,238}U(n,g), ^{237,238}U(n,n'), ^{238}U(n,2n) and ^{238}U(n,3n) cross sections.

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