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Surrogate Reaction in Inverse Kinematics at the ESR

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Neutron-induced reaction cross sections of short-lived nuclei are crucial for our understanding of nuclear astrophysics and for various applications in nuclear technology. However, direct measurements of these cross sections are extremely challenging or even impossible, due to the difficulty in producing and handling the required radioactive targets.

We are developing a novel approach that, for the first time, employs surrogate reactions in inverse kinematics at a heavy-ion storage ring [1][2]. This method enables us to measure all de-excitation probabilities as a function of the excitation energy of nuclei formed via surrogate reactions, with unprecedented precision, thereby allowing for the indirect determination of the desired neutron-induced cross sections.

In this talk, I will present our methodology and the results from our second successful surrogate-reaction experiment conducted at the ESR storage ring of the GSI/FAIR facility in Darmstadt, Germany. In this experiment, we investigated the (d,p) and (d,d') surrogate reactions on ^{238}U, achieving a major breakthrough: for the first time, we simultaneously measured fission, γ-ray, neutron, as well as two- and three-neutron emission probabilities.

Simultaneous measurement of all competing decay channels enables the precise determination of key nuclear properties such as fission barriers, particle transmission coefficients, γ-ray strength functions, and nuclear level densities, which in turn allow us to infer neutron-induced cross sections for (n,f), (n,γ), (n,n'), (n,2n), and (n,3n) reactions.

[1] M. Sguazzin {\it et al.}, Phys. Lett. **134**, 2025, 072501.

[2] M. Sguazzin {\it et al.}, Phys. Rev. C **111**, 2025, 024614.

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