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Simultaneous measurement of fission, gamma, and multi-neutron emission in surrogate reactions at a heavy-ion storage ring

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Neutron-induced reaction cross sections of short-lived nuclei are crucial for our understanding of nuclear fission and nuclear structure, with important applications for nuclear astrophysics and a wide range of nuclear technology. However, direct measurements of these cross sections are extremely challenging, or even impossible, due to the difficulty of producing and handling the required radioactive targets. In addition, measuring cross sections for radiative capture (n,gamma) and multi-neutron-emission (n,xn) of fissionable nuclei is extremely complicated due to the intense background of gamma-rays and neutrons generated by the fission fragments.

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 the measurement of all de-excitation channel probabilities as a function of the excitation energy of nuclei formed in surrogate reactions, allowing the indirect determination of the neutron-induced cross sections.

In this contribution, I will present our methodology and the results from our last 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 U-238 and achieved a major milestone: for the first time, fission,
gamma-ray emission, single-neutron emission, as well as two- and three-neutron emission probabilities were measured simultaneously.

The simultaneous measurement of all competing decay channels places stringent constraints on key nuclear properties such as fission barriers, gamma-ray strength functions, and nuclear level densities. These quantities, in turn, allow us to infer neutron-induced cross sections for the (n,f), (n,gamma), (n,n'), (n,2n), and (n,3n) reactions.

[1] M. Sguazzin *et al.*, Phys. Lett. **134**, 2025, 072501.
[2] M. Sguazzin *et al.*, Phys. Rev. C **111**, 2025, 024614.

Type of contribution

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