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Fission studies using complete measurements in inverse kinematics

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Fission reactions induced by relativistic heavy nuclei in combination with a large acceptance dipole magnet and advance tracking and time-of-flight detectors (SOFIA detection setup at GSI) allowed for the first time the complete identification of both fission fragments in atomic and mass number [1]. By using different target materials, it was also possible to favour fission reactions at low and high excitation energies, namely lead inducing coulex and protons inducing spallation. In addition, these kinematic conditions also allow the study of a wide variety of unstable fissile nuclei. The first experiments made it possible to study the role of shell effects in fission [2] and the dynamics of fission at high excitation energies [3].
More recently, these experiments have been enhanced by merging the SOFIA and R3B/FAIR setups. The R3B target area detectors (silicon tracker and Califa calorimeter) allow the determination of the missing energy in quasi-free scattering (p,2p) reactions using a liquid hydrogen target. In the case of (p,2p)-induced fission reactions, the missing energy corresponds to the excitation energy of the fissioning nuclei, which was not accessible in previous measurements. In addition, the new setup is able to measure the gamma rays and neutrons emitted during the fission process. These will be the first complete kinematic measurements of fission reactions.
In this talk I will present the first results of the study of the fission process with the R3B setup at GSI/FAIR. In particular, I will show how the complete identification of both fission fragments and the measurement of the excitation energy of the fissioning nucleus allowed us to systematically study the shell effects from the simultaneous measurement of the mass and charge fission yields, but also the evolution of the shell effects on the fission yields with temperature and the sharing of the excitation energy between the two fission fragments.

[1] E. Pellereau et al., Phys. Rev. C 95, 054603 (2017).
[2] A. Chatillon e t a l . , Phys. Rev. Lett. 124, 202502 (2020).
[3] J.L. Rodríguez-Sánchez e t a l ., Phys. Rev. C 94, 061601(R) (2016).

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