^{238}U+^{12}C transfer reactions in inverse kinematics: An experimental approach for fission studies

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Transfer-induced fission has been widely used in the past to study fission barriers [1] and is exploited, in the frame of the surrogate technique [2], for the investigation of fissioning systems that are not suitable for neutron-irradiation measurements. The method consists in measuring the fission probability of the same compound nucleus that would be produced by neutron capture, but using light-transfer reactions as stripping or pickup between hydrogen- or helium-isotope beams and actinide targets close to the nuclei of interest. The validity of this technique relies on strong assumptions concerning the spin distribution populated in the compound nucleus and its decay, being nowadays a subject of intense debates.

Our experimental approach makes use of inelastic and multi-nucleon transfer reactions between a ^{238}U beam and ^{12}C target for the production of the fissioning systems of interest, pushing transfer-induced fission measurements towards heavier transfer reactions. In this way, a single experiment gives access to a broader collection on fissioning systems and allows the investigation of different excitation-energy regimes, depending on the transferred nucleons. A ^{238}U beam accelerated up to an energy slightly above the Coulomb barrier was shoot on a 100 μg/cm^2-thick ^{12}C target and heavy actinides from U to Am, with excitation energies below 30 MeV, were produced through inelastic scattering and multinucleon transfer. The energy and angle of the target-like partners in the exit channels were measured in a double annular Si telescope, providing a complete characterisation of the produced fissioning systems in atomic and mass numbers, as well as a measurement of the total excitation energy gained in the reaction. In addition, the use of a magnetic spectrometer combined with the inverse kinematics (heavy projectile and light target) gives access to the complete identification in mass and atomic numbers, ionic charge-state and kinetic energy of the whole fission fragments in the ranges Z$\approx$30–60 and A$\approx$80–160. The set-up also included several clusters of Ge detectors in the target region for coincident γ-ray measurements. They allow the investigation of possible excitation of the target-like partners in the exit channels, which is usually ignored, under the assumption of an excitation energy partition proportional to the mass of the nuclei. These data, which are now available for the first time, are crucial for the interpretation of the fission probabilities, as they define the sharing of excitation energy between the two reaction partners in the exit channel and thus the actual excitation energy carried by the fissioning system.

The information gathered in this work brings the possibility of unprecedented studies about the properties of the fission-fragment isotopic distributions for different fissioning systems and excitation energies [2]. At the same time, our experimental data provide a characterisation of ^{238}U+^{12}C inelastic and transfer reactions. The measurement of target-like partner excitation and fission probabilities offer us the opportunity of investigating the validity of the surrogate technique.

[1] A. Gavron et al., Phys. Rev. C 13, 2374 (1976).
[2] J. Escher et al., Phys. Rev. C 74, 054601 (2006).
[3] F. Farget et al., arXiv:1209.0816.