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Experimental results of high-energy fission and quasi-fission dynamics with fusion-induced fission reactions at VAMOS++

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During the last ten years, the use of inverse kinematics in the experimental study of fission is bringing a wealth of new observables obtained in single measurements, which allows their analysis and, also importantly, of their correlations [1, 2]. An ongoing application of this technique the basis of a series of experiments performed with the variablemode, large-acceptance VAMOS++ spectrometer at GANIL (France) [3, 4]. In these experiments, fission reactions are induced by fusion and transfer reactions between a 238U beam and a set of different light targets. The kinematics of the transfer and fusion reactions allows us to identify the fissioning system and determine its initial excitation energy [5], while the data from the VAMOS spectrometer gives us the isotopic identification for the full fragments distribution, and their velocity vectors. These measurements result in an accurate determination of the fragments mass before and after post-scission neutron evaporation, their neutron multiplicity, the total kinetic and excitation energy, and their emission angle in the centre of mass [1, 6, 7]. In addition, these characteristics can be studied as a function of the initial excitation energy of the fissioning system [9]. The correlation between these magnitudes also permits to determine, for instance, the scission configuration and the sharing of excitation energy between the fragments [8, 9], and even to obtain information about the balance between intrinsic and collective excitation energy [10].

In a recent experiment, we have focused on the survival of nuclear structure effects in high excitation energy and the frontier between fission and quasi-fission. The main objective is to build and to study observables that would allow us to estimate the fission and quasi- fission components of the production and to identify relevant shells, such as newly highlighted octupolar-deformed closed shells [11], and their role on the fission dynamics at high energy.

The results of our analysis show that the ratio between neutrons and protons at scission as a function of the fragment split, together with the total kinetic and excitation energies, and the isotopic yields, reveal the presence of structure effects related at high energy, even if pre scission evaporation is taken into account.

Concerning the quasi-fission component, the classical mass-angular distribution is completed in our case with the fragment identification, the ratio between neutrons and protons, and more importantly, the ratio between the production of fragments with an even and odd number of protons, the so-called even-odd effect [12, 13]. The latter shows a clear different mechanism for fission and quasi- fission that can be used to address, not only the separation between fission and quasi-fission, but also to study the energy dissipated in each of these processes.

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