M1 internship in experimental nuclear physics

Calculation of neutron multiplicities from isotopic fission yields

Introduction

The fission of nuclei is a long and complex process involving extreme deformations, nuclear structure, and heat flows that decide the characteristics of the emerging fragments. Nevertheless, despite almost 80 years of intense research, fission is still far from being fully understood, and the theoretical and experimental knowledge remains incomplete.

Innovative experiments are conducted to widen our knowledge of fission, aiming notably at a complete identification and characterization of the fragments and the study of unstable fissioning systems. In particular, the access to post-neutron evaporation isotopic fission yields are good candidates to investigate the deexcitation of fission fragments.

The objective of this internship is to develop a numerical method to extract the neutron multiplicity from simulated isotopic fission yields.

Description of the work

In the fission process, neutrons are emitted by the fissioning system during the path from the saddle to the scission point and by the excited fission fragments after scission. Therefore, the neutron multiplicity reflects the energy that the fission process stored in the system and hence, it is a crucial observable to understand how fission evolves, for instance, in deformation. However, the direct measurement of neutron multiplicities suffers from technical difficulties, in particular, in correlation with other fission observables.

New experiments have been developed recently where post-neutron evaporation isotopic fission-fragment distributions are accessible. These observables have implicit information about the neutron multiplicities: the difference between the mass of the fissioning system and the sum of the masses of two complementary fragments corresponds, indeed, to the neutron multiplicity.

In a regime of excitation energy not too high, the proton number is a preserved quantity and the neutron multiplicity can be investigated as a function of it. Conceptually, the neutron multiplicity as a function of the fragment-proton number is the difference between the mass before and after the neutron evaporation, however the access to both masses is rarely achieved. When only the post-neutron evaporation distributions are accessible, an innovative method can be developed, based on the symmetry of the fragment distributions before the neutron evaporation, in order to reconstruct these pre-neutron evaporation distributions and obtain, hence, the neutron multiplicity.

The candidate will be in charge of the development of a general mathematical method to determine the neutron multiplicity as a function of the proton number of the fragments using simulated post-neutron evaporation fragment distributions. These simulated distributions will be produced by the GEF code, as well as simulated neutron multiplicities in order to compare with the results obtained from the calculation. The method will be based on an iterative process that will create a set of pre-neutron distributions for each set of neutron multiplicities and will converge when the pre-neutron distributions become symmetric, providing the correct neutron multiplicities. The candidate will also investigate the accuracy and the reliability of the method in terms of excitation energy by applying the method to real data.

The intern will become familiar with the most recent tools and techniques used in the nuclear field.

Expected skills:
Programing skills and prior knowledge of C++ will be very appreciated. The work will be conducted in an international environment and a good level of English is necessary.

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