PhD position in experimental nuclear physics

Study of the neutron-induced uranium-235 fission between 0.5 à 40 MeV at NFS-SPIRAL2 with the FALSTAFF spectrometer and FIFRELIN model

Description:

Basic research in nuclear physics remains necessary within the framework of the French program of renewal of nuclear energy. The development of nuclear deexcitation & fission models, phenomenological as well as microscopic has had a renewal of interest in the past decades. However, the capacity of these models to explain or predict fission observables such as mass yields, charge or kinetic-energy spectra of the fission fragments (FF), neutron or gamma multiplicities remains somewhat limited. The phenomenological models used for data evaluation or for the production of nuclear data bases necessary for nuclear reactor simulations use even more microscopic modelling in order, on the one hand, mass and charge yields of FF at scission or the sharing of the excitation energy between both FF or, on the other hand, level densities of FF de excitation through particle emission (neutrons, gammas).

Parameters used in these modelling are not sufficiently known and need to be determined from measurements of experimental observables. Hence, more complete data are necessary combining fission-yield measurements with FF kinematics reconstruction on a large range of excitation energy.

Within this context, we have developed the FALSTAFF spectrometer, to study the fission of actinides, induced by neutrons in an energy ranging from ~0.5 to 40 MeV, available at the NFS facility (Neutron For Science), one of the experimental area of the GANIL/SPIRAL2 accelerator. FALSTAFF is based on the time-of-flight and residual-kinetic energy measurement technique. FALSTAFF is made of two identical detection arms (for coincidence measurement of FF on an event-by-event basis), which allows the determination of the velocity vectors and kinetic energies of both FF. We used the first arm in two experiments at SPIRAL2-NFS in 2022 & 2024. The results were promising and hence the basis of the motivation to build the second detection arm, which will be finished by end of 2025. We achieve a high time resolution with two secondary-electron detectors (SED) for the time-of-flight. An axial ionisation chamber permits the measurement of the FF residual kinetic energies. The combination of both observables gives access to the FF masses after neutron evaporation, through the EV method (energy-velocity). The FF coincidence detection provide information on the FF masses prior to their de excitation, through the 2V method. We will therefore be able to determine the neutron multiplicity on an event-by-event basis and correlate it to the FF masses. This is an experimental observable of great importance in order to study the sharing of the excitation energy between both FF.

The proposed thesis subject is made of two parts. The first deals with the realization and data analysis of an experiment aiming at studying at SPIRAL2-NFS the neutron-induced fission of ^{235}U. The second part aims at using the FIFRELIN model, developed at CEA-Cadarache, for the interpretation of the experiment's data. FIFRELIN is modelling the generation & de excitation of FF. It takes into account models to compute the fissioning-system excitation energy sharing between both FF as well as the angular momentum generation. FIFRELIN is able to compute neutron & gamma energy-spectra. It is often compared with data or other codes, at thermal neutron energies and currently used in data evaluation process, e.g. for European databases such as JEFF. It was recently adapted to describe fission for excitation energies up to 20 MeV, where its predictions need comparison with experimental observables. Necessary adaptations of FIFRELIN's inputs for the description of FALSTAFF data will be part of the thesis.

Expected skills:
Nuclear physics, particle detection, object-oriented programing

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