Doctoral INPhINIT - INCOMING Fellowship Programme 2020 Call for applications

Position: Fission and quasi-fission: from the barrier to the scission

Leader: Manuel Caamaño (manuel.fresco@usc.es)

Centre description

The Galician Institute for High Energy Physics (Instituto Galego de Física de Altas Enerxías, IGFAE) is a joint research institute of the University of Santiago de Compostela and Xunta de Galicia (the Galician Autonomous Government). It was officially created on July 2, 1999. The main goal of the Institute is to coordinate and foster the scientific and technical research in the field of High Energy Physics, Particle and Nuclear Physics and related areas as Astrophysics, Medical Physics and Instrumentation. Of primary importance is the planning and promotion of the relation with large experimental facilities, especially with CERN, GSI/FAIR and the Pierre Auger Observatory at present.

The experimental groups at IGFAE coordinate the Spanish participation in the LHCb Collaboration at CERN, the Spanish participation in the Pierre Auger Observatory, as well as the Spanish participation in the GSI/FAIR nuclear facility. Members of the Institute have a relevant participation in the LHCb upgrade planning, in the LHeC project development and planning, etc. In the last couple of years, a new line has also been open with the building of a new facility (LaserPET) at the University of Santiago de Compostela aiming to produce radioisotopes for medical use by a laser-induced plasma accelerator. Moreover, the theory section of the Institute holds an excellent international reputation, with participation in different international committees, invitations to plenary talks and large-impact publications.

Research project and research line description

Since its discovery, fission appeared as a complex process where different nuclear properties interplay to shape the characteristics of the emerging fission fragment distributions. However, so far, a complete description and understanding of the process is yet a challenge for theory

and experimental efforts. The general goal of this work is to assess the dynamics and the role of nuclear structure in fission and quasi-fission reactions.

From an experimental perspective, nuclear structure leaves traces of its effects in several observables. The fragment yield distribution, their kinetic energy, and the release of excess energy in the form of neutron evaporation are governed by nuclear structure. This work will study these properties in systematics to identify repeating patterns and associate them to nuclear shells. In addition, the use of fusion-fission reactions will allow to study the influence of quasi-fission channels. These are reactions where the beam and the target nuclei do not reach complete fusion, but they exchange of nucleons for a reduced time. The effects of shells are supposed to be completely different from those in fission and, so far, never measured.

The methodology is based on the study of experimental data taken in an ongoing experimental campaign in the accelerator of heavy ions GANIL (France). In this campaign, a uranium beam is accelerated to impinge on a series of light-nuclei targets. These collisions produce a number of reaction channels; among them, transfer- and fusion-induced channels. In this work, we will focus on three lines: the study of fusion-fission reactions in the search for features or signatures of structure effects in these high-energy fission reactions; the study of quasi-fission reactions concerning the proton and neutron exchange between the pre-fragments and the role of spherical shells; and the systematic study of fission dynamics through the measurement of transfer-induced fission channels.

Job description

The successful candidate will be in charge of the data analysis for the E753 experiment. He/she will be enrolled in the University of Santiago de Compostela and will be part of the FiCA research group of the IGFAE. Besides fission studies, the group activities also include nuclear structure at low energy, and the development of new detectors in which the candidate is welcome to contribute. The group collaborates with other teams in different international institutions, such as GANIL (France), U. of Surrey (UK), LNL/IFN (Italy), ISOLDE/CERN (Switzerland), RNCP (Japan), and U. of Lisboa (Portugal) among others.

The candidate will work in collaboration with personnel from the experimental team at GANL (France). For that, it is foreseen to do frequent stays in the facilities where the experiment was performed, and also, he/she will be involved in the setup and realization of new experiments of the current fission campaign. Also, as soon as preliminary results are produced, the resulting shells and fission features will be evaluated both in their relative contributions and their associated neutron and proton numbers and compared with state-of-the-art models. The candidate will communicate and discuss his/her work at international conferences and workshops and prepare the associated papers for publication in high-impact journals.

The candidate is expected to possess a sufficient knowledge on nuclear theory and experimental skills. In particular, laboratory and accelerator training, as well as familiarity with magnetic spectrometers and ion optics is welcome. A deep knowledge on fission and quasi-fission reactions is not mandatory but highly recommended. The candidate will use complex analysis tools, and he/she is expected to be able to develop the required software programs and routines to treat the data.