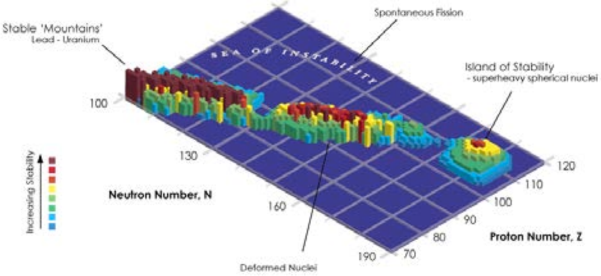
« TOWARDS THE "ISLANDS OF STABILITY" OF SUPERHEAVY ELEMENTS: DECAY SPECTROSCOPY OF ^{250}NO »

DESCRIPTION AND CONTEXT

Nuclei contain, as an excellent approximation, all the mass in our close surroundings, while they represent only a small fraction of the matter in the universe. 253 stable nuclei are known today (for 83 different chemical elements). But those are only the tip of the iceberg since most nuclei are indeed radioactive. The physicists have managed to synthesize around 3300 of them. But we are far from having reached the limit of the nuclear landscape, since we expect that more than 8000 nuclei could be bound.

Among these radioactive, exotic nuclei, the heaviest of them are of special interest, because they are also new chemical elements. These are the so-called "Super Heavy Elements" (SHE), with more than 104 protons that own their cohesion to quantum shell effects fighting the repulsion between their protons. How many isotopes of an element can exist? What are their lifetimes? Which properties determine their stability? How can they be synthesized? Were they ever synthesized in stars? Hunting for super heavy elements one of the most exciting and active topics during the last few years and has already produced new elements such as 113, 115, 117 and 118 in accelerator experiments. The major difficulty for the synthesis and study of these nuclei is their extremely low production cross-sections: only 20 atoms of the different Z= 114 element (Flerovium isotopes) have been produced in all the experiments around the world. We are nowadays far from understanding the properties of the nuclei in this region and from localizing the "island of stability" (nuclei with the longest lifetimes) that the theoretical models predict. Information on nuclear deformation, single particle properties, and resistance against fission under rotation must be extracted from data. The decay properties allow for tracing the single-particle or quasi-particle. The ordering of the single-particle orbitals will provide a possibility to test the model for a better understanding of the structure of the SHE close to the island of stability.

We propose to perform spectroscopic studies exploring the region around Z=102 and N=150 so called ''transfermium region''. Such kinds of experiments are nowadays carried out using high intense beams from linear accelerator or synchrotron and very selective spectrometer coupled with last generation Germanium and Silicon detectors.



GROUP/LABO/SUPERVISOR DESCRIPTION

The student will be part of Laboratoire d'Etudes du Noyau Atomique at IRFU/SphN. This laboratory includes 20 people involved in three different fields: Spectroscopy of deformed nuclei, structure and spectroscopy of exotic nuclei via direct reaction and spectroscopy of heavy and super heavy elements. The latter is composed of three permanent physicists and two students.

THESIS WORK

The work proposed will be, as first step, the analysis of experiment performed at Jyvaskyla (Finland) on the even-even ^{250}No nuclei. The objective of such an experiment is to study the decay properties of ^{250}No (almost unknown nuclei) and give an answer to the puzzling question concerning its fission half-life, which provides valuable insight into the degrees of freedom controlling the height of the fission barrier. It should also be possible to add further spectroscopic information on the isomeric states using the calorimetric method, via electron-gamma coincidences measurements, and to investigate the configuration of the isomeric state.

The results of such experiment will be compared with theoretical work using mean field calculation of Hatree-Fock-Bogoliubov type.

Such study belongs to a long-term scientific program aiming to understand the structure of heavy and super heavy elements. To pursuit such studies, a new spectrometer for heavy elements S^3 will be available at GANIL (France) in 2017, where the LENA group is particularly committed.

The student, indeed, will be deeply involved in the technical development for the new focal plane detector system for the S^3 Spectrometer, SIRIUS. She/He will be responsible for the tests with the new silicon detectors coupled with last generation digital electronics (in-house development). The student will take an active part in the final tests of the whole SIRIUS detector to be carried out at GANIL under in-beam condition.

FORMATION ET COMPÉTENCES REQUISES

The candidate should be creative, with a strong ability to work problem oriented. He/she should also enjoy interdisciplinary research and take keen interest in learning and working in teams.

ACQUIRED SKILLS

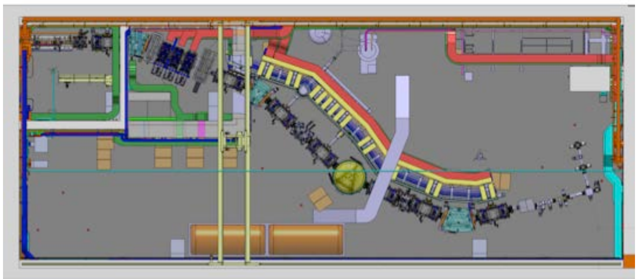
This thesis work melds several scientific and technical specialties. The student will acquire experience to perform data analysis using common scientific tools based on C++ and root. The student will learn basics concept in digital signal processing engineering and how to develop algorithm in object-oriented language. He/She will acquire knowledge about synthesis and properties of heavy and superheavy elements.

The international environment, where the experiments will take place e.g. at GANIL (France), at RITU gas-filled separator (Jyväskylä-Finland), will give to the PhD the opportunity to acquire insight into latest technologies in terms of electronics, state-of-arts detectors system (AGATA, EXOGAM, JUROGAM) and spectrometers.

This position will offer an excellent opportunity to interact with leading scientists from around the world and perform experiments at the research frontiers of the nuclear physics.

COLLABORATIONS/ PARTNERSHIPS

The thesis work will be carried out at large international facilities: GANIL (France) and Jyväskylä cyclotron laboratory in Finland.



Ganil, with the most intensive high beam from the Linear driver Accelerator (Linac) coupled with S3 (see figure above) spectrometer with its state of the art detection and data acquisition system, offers unique experimental facility for nuclear studies of the heaviest man-made elements.

The University of Jyvaskyla with the most advanced germanium detector array coupled with digital electronics and gas filled separator represent a unique opportunity to perform in-beam spectroscopy.

CONTACTS

Researcher: B. Sulignano; Ch.Theisen
barbara.sulignano@cea.fr; christophe.theisen@cea.fr

Website:
http://irfu.cea.fr/Sphn/Phocea/Vie_des_labos/Ast/