



PhD position in experimental nuclear physics

Development of an X-ray detection system for particle ID of superheavy nuclei

Description:

The synthesis and study of the heaviest nuclei in the region of superheavy elements (SHE) is still one of the major challenges of modern nuclear physics. Despite world-wide efforts and achievements throughout more than half a century, resulting in atomic number $Z=118$ and isotopes of element oganesson as heaviest nuclear species synthesized so far, the envisaged "island of stability" of superheavy nuclei (SHN) has not yet been reached. The major ingredients for the stability and existence of those heavy systems are nuclear structure features, the so-called shell effects. Predictions of the various models on the market for closed proton and neutron shells point to numbers like 174 and 182 for the closed neutron shell and 114, 120 and 126 for the respective number of protons.

Experimental studies of the nuclear structure of the already known nuclei as well as the synthesis of new isotopes are essential for the progress of the field. Complex instrumentation at heavy ion accelerator facilities like the new linear accelerator installation SPIRAL2 at GANIL are the key ingredients to allow these investigations. Up to now those SHN are produced in heavy ion fusion reactions, where the reaction products are separated from the primary beam by an effective ion-optical separator and then studied by a comprehensive detection system for particles and photons, including alpha-, gamma-, fission fragment and conversion electron spectroscopy.

The identification of the studied nuclei in atomic charge Z and nuclear mass A , typically based on decay features of known nuclei, e.g. by alpha spectroscopy of subsequent decay chain members, face severe limitations for hitherto unknown nuclei. The separator-spectrometer set-up S^3 at GANIL-Spiral2 is equipped with mass spectroscopic capabilities sufficient to resolve the mass A of SHN. At its focal plane the comprehensive detection system SIRIUS consists of an efficient silicon detection array for particle (reaction products, alphas, fission fragments, e^- and light charged particles). It will be accompanied by an array of large volume (typical dimensions: $(10 \times 10 \times 9) \text{ cm}^3$) germanium detectors for gamma spectroscopy. To establish the atomic charge of the species of interest, characteristic X-rays can be used, whose energies are, however, at and below the energy detection threshold of those large volume germanium detectors. To provide the means for an efficient X-ray spectroscopy, the development and implementation of a photon detection system with lower energy threshold and enhanced efficiency for X-ray energies in the range from $\approx 15 \text{ keV}$ to $\approx 100 \text{ keV}$ is the major task of the Ph.D. thesis work.

On the instrumental side, our group is currently investigating the use of thick silicon detectors for X-rays, in collaboration with IJCLab and IPHC, needed at the S^3 focal plane. The development of such a system, its integration in the SIRIUS set-up as well as its in-beam test and use for SHN decay spectroscopy will be the main tasks of the Ph.D. thesis.



On the physics side our group pursues and is involved in the spectroscopic studies of very heavy and superheavy nuclei on site at GANIL-SPIRAL2 as well as in activities at international accelerator laboratories like Argonne National Laboratory (ANL), Argonne, U.S.A Helmholtzzentrum for Heavy Ion Research GSI, Darmstadt, Germany, Japanese Atomic Energy Agency (JAEA), Tokai, Japan and others. The subjects of our research comprise spectroscopic studies of heavy and superheavy nuclei produced in fusion reactions as well as the investigation of alternative reaction schemes to produce exotic heavy nuclear systems like the exchange of nucleons between projectile and target in heavy-ion collisions, so-called multi-nucleon transfer (MNT) reactions. These activities in which the Ph.D. student will be involved, are efficient preparatory studies for the experiment campaigns planned at S³ which is scheduled to come online in 2026.

Expected skills:

Team work capabilities

English

Computer coding (C++, ROOT, LINUX, ...)

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