

INTERNSHIP PROPOSAL

Title of internship: Optimization of the in-gas-jet laser spectroscopy of lanthanides for first experiments at SPIRAL2-S³

Level (L3, M1, M2)	M2
For M2, can be followed with PhD? (indicate the title of the PhD)	YES Laser spectroscopy of neutron-deficient lanthanides for a study of the N = 82 nuclear shell closure
Period / length of the internship (indicate the year)	Spring-summer 2027, typically 3 months (to be decided with student)
Supervisor	Vladimir Manea
Team/Service	Spectroscopy, Decay and Fission
Pole	Nuclear
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Description of the internship

The SPIRAL2 facility in GANIL, together with the Super Separator Spectrometer (S³), aims to produce exotic nuclei towards the proton-rich edge of the nuclear chart. To study the properties of these unstable nuclei, an experimental setup called the S³ Low Energy Branch (S³-LEB) is currently installed at the focal plane of the spectrometer. Its role is to stop the nuclei in a gas cell, extract them in a jet and interact with them using tunable lasers, in order to very precisely

determine, by laser spectroscopy, the energies of their atomic resonances. Due to the hyperfine interaction, these energies are sensitive to the electromagnetic properties of the nucleus and allow determining its charge radius, or its magnetic/quadrupole moments. These properties give information on the orbits occupied by the nucleons, or the shape of the nucleus, and can thus challenge the predictions of nuclear models.

In parallel to the preparation work of the S^3 -LEB experiment at GANIL, a test experimental setup is being used to improve the performance of the gas cell, namely reduce the time it requires to extract the nuclei stopped in the gas (to avoid losing the nuclei by radioactive decay) and increase the fraction of the nuclei which are completely neutralized (to allow probing them with lasers). This Fast Radioactive Ion Extraction and Neutralization Device (FRIEND) for S^3 is currently installed at GANIL and has performed first proof-of-principle laser-ionization experiments, with tests of ion recombination methods planned to start. Experiments with S^3 -LEB and FRIENDS³ focus on optimizing the laser spectroscopy of lanthanides, which will be the first radioactive isotopes studied at S^3 .

The internship will take place at IJCLab, in Orsay, with a travel of maximum 3 weeks foreseen to GANIL. During the work at IJCLab, the student will perform simulations using COMSOL/SIMION and/or GEANT4 in order to obtain an as accurate as possible representation of the phenomena taking place in the gas cell, with a focus on the creation of electrons and recombination with ions, prior to the laser excitation, as well as the population and thermalization of daughter states in the gas. Some experimental activities with simplified gas cells will also take place at IJCLab. During the travel to GANIL, the student will participate in actual laser-spectroscopy experiments with the S^3 -LEB or FRIENDS³ setups, in which he/she will apply the concepts developed in Orsay.

Description of the team/service

The Spectroscopy, Decay and Fission team of the Nuclear Pole of IJCLab is a research group using different experimental methods in order to probe the structure and decay modes of the atomic nuclei. Ranging from direct methods involving gamma-ray/particle/fission-fragment spectroscopy to indirect methods exploiting the hyperfine interaction or the mass defect, the team is focused on improving the fundamental understanding of nuclei which are either very heavy, or which present a very large imbalance between protons and neutrons. The team performs experiments at different national and international facilities and is deeply involved in the GANIL scientific program.

While in GANIL, the student will work with members of the Spectroscopy, Decay and Fission team present on site (at least the supervisor who will travel at the same time) and will collaborate with the S^3 -LEB team, counting several permanent researchers, postdocs and PhD students. They are all involved in different aspects of the S^3 -LEB preparation, or R&D projects.

