GRIFON group, LPCTrap team
Professor Etienne Liénard, UNICAEN
Doctor Xavier Fléchard, CNRS
Doctor Gilles Quéméner, CNRS

Post-doctoral position at LPC Caen

THESMOG Project

(Test of tHE Standard MOdel at Ganil)

The LPCTrap team from the GRIFON group (Groupe Interactions Fodamentales et nature du Neutrino) at LPC Caen is seeking a Postdoctoral Research Associate (PRA) to support an experimental program aiming at testing the Standard Model of Particle Physics at the precision frontier.

The LPCTrap device, developed by LPC Caen, is the only instrument installed on LIRAT, the low energy beamline of the SPIRAL installation in GANIL. The main element of the device is a transparent Paul trap which allows confining in line the radioactive ions produced by the SPIRAL source to carefully study the decay products. The goal is to test the Standard Model (SM) of particles from radioactive ion nuclear β decay. Two detectors placed on either side of the trap allow detecting in coincidence the β particles and the recoiling ions, to study the angular correlations between the decay products. The correlation parameter, “a”, is deduced from the time-of-flight distribution of the recoiling ions. It is sensitive to the different components of the weak interaction, both to components admitted in the SM and to others, called exotic, banned by the SM but allowed in a more general theory.

From 1998 to 2004, the whole setup was developed and tested, thanks to a major investment from the Basse-Normandie Region and the CNRS. In 2005, the device was installed at LIRAT for commissioning and, from 2006 to 2013, data were taken with the $^{6}He^{1+}$, $^{35}Ar^{1+}$ and $^{19}Ne^{1+}$ ions produced by SPIRAL.

Regarding the “a” correlation parameter, the systematic effects' analysis of the first experiment [1] showed that it was necessary to simulate the experiment in the most realistically way, by reproducing, in particular, the dynamics of the trapped radioactive ion cloud, by propagating the recoil ions in realistic electric fields, and by taking into account the diffusion of the β particles in the whole accessible volume. This requires reproducing as much as possible the geometry of the mechanical assembly present in the measuring chamber. Since these findings, upgraded simulation codes are being developed. The cloud dynamics is reproduced by a homemade code running on GPU (Graphical Processor Unit), which allows taking into account all the processes involved during the trapping, namely the ions motion in the realistic trap RF field, their interaction with the cooling gas and the Coulomb repulsion they undergo, linked to the presence of other ions (space charge). Both the recoiling ions and β particles tracking is done by the code GEANT4, via a homemade interfacing program (BAYEUX) which makes it possible to adjust the decay parameters, to code the geometry and to load maps of the realistic electric fields prevailing in the device. These field maps were also generated by a code developed at LPC Caen. The set of codes must provide simulated data as close as possible to reality in a frame defined by the decay parameters.

In parallel, an experimental data processing and analysis program is also under development to extract the desired correlation parameter, using the simulated data. Today, given the complexity of the codes, verification tests are still necessary before their use on the recorded experimental data.

The main task of the proposed work is to finalize the analysis of the experiments carried out with ^{19}Ne and ^{35}Ar. This analysis, inseparable from the simulations, includes a thorough study of systematic effects. It is typically to continue the development and optimization of existing programs with in particular the implementation of a number of functions to facilitate the comprehensive study of systematic effects. The statistics obtained from our latest experimentswith ^{35}Ar is particularly high and should lead to an unparalleled accuracy. The stakes are crucial and there is potentially key publications in the international community. This task is therefore at the heart of the THESMOG project and will serve as a basis for the other tasks listed below.

The second task deals with the rejuvenation of the trapping device by implementing and using tools for ion trapping simulations for which LPC Caen has the expertise. The beam manipulation optics from the source to the trap shall also be simulated and developed in close collaboration with the GANIL team, which has expertise in beam transport. Priority will be given to simulations for the design of an isobar separator to purify the beams from the new SPIRAL source.

Once these two tasks will be fullfilled, torough simulations from the source to the trap (including detectors), will be used to optimize transmission of the beamline and to maximize the number of trapped ions for each of the nuclei of interest delivered by the new source. These simulations will also make it possible to define the statistics required to obtain the desired precision. Thus, from this whole work, an ambitious new project could be set up to measure the "a" parameter in the mirror decay of ^{21}Na^{1+}, ^{23}Mg^{1+}, ^{33}Cl^{1+} and ^{37}K^{1+} ions.

The sought PRA is expected to conduct a large part of the work described above, also including seminar and conference presentations, technical paper writing and supervision of Master degree students. Applicants with PhD will be considered from all areas of experimental particle or nuclear physics. Knowledge of Monte Carlo simulations (GEANT4) and C++ programming is required. Knowledge of GPU and High Power Computing (CUDA) will be an asset but is not mandatory.

The position is a 30 months contract starting on December 2018. It is based at the Laboratoire de Physique Corpusculaire (LPC) in Caen, Normandy and will be driven in close collaboration with the co-responsible of the project, Dr Jean-Charles Thomas from GANIL. THESMOG is a European collaboration between researchers from France (GANIL, LPC Caen) and Belgium (IKS Leuven). It is supported by a grant « Réseau d'Intérêts Normand (RIN) » from the Région Normandie.
Interested candidates should send a motivation letter with a CV including a list of publications and 2 contact references to Gilles Quéméner (quemener@lpccaen.in2p3.fr).

References :

[1] X. Fléchard *et al.* Journal of Physics G: Nuclear and Particle Physics 38 (2011) 055101.

Group contacts :

Etienne Liénard, lienard@lpccaen.in2p3.fr, (33) 2 31 45 24 20

Xavier Fléchard, flechard@lpccaen.in2p3.fr, (33) 2 31 45 25 42

Gilles Quéméner, quemener@lpccaen.in2p3.fr, (33) 2 31 45 25 40