PhD position in experimental nuclear physics

Matter's Origin from RadioActivity: first experiments analysis

The MORA project gathers experts of ion manipulation in traps and laser orientation methods for searches of New Physics (NP) in nuclear beta decay, looking for possible hints to explain the matter-antimatter asymmetry observed in the Universe. The precise measurement of the so-called triple *D* correlation is sensitive to Time reversal violation, and via the CPT theorem, to CP violation. As such, the measurement of *D* in nuclear beta decay is a complementary probe to the electric dipole moment of the neutron. It is particularly sensitive to the existence of Leptoquarks, which are hypothetical gauge bosons appearing in the first theories of baryogenesis, and numerous theories beyond the Standard Model.
The symmetries of the MORA detection system and the well-controlled parameters of the trapped and polarized ion cloud permit to aim at a final sensitivity of a few 10^{-5} on *D*. Such a sensitivity is about one order of magnitude better than present limits on *D*, from measurements in neutron and ^{19}Ne decay. It should permit, in addition, to look for signs of CP violation, to probe for the first time the so-called Final State Interaction (FSI) effects. The FSI effects, caused by the electromagnetic interaction of the recoiling nucleus with the particle, are expected to mimic a tiny non-zero *D* at a level that varies from 10^{-5} to 10^{-4}, depending on the decaying nucleus. Their estimates rely on rather old calculations (1970's), which are presently being revised by theoreticians within the MORA project.
The first experiment for the polarization degree (proof of principle) and *D* correlation will be performed by February 2022 at JYFL, Finland. The measurement will be focused on the decay of $^{23}Mg^{+}$ ions with a half-life of 11.3s, a simple polarization scheme, and will eventually be available in copious intensities at the future DESIR facility at GANIL [2] for measurements with the highest sensitivity to new physics.
The final sensitivity on *D* depends on the level of systematics effects kept under control. The individual simulations of detectors of MORA are already performed with GEANT4 and PENELOPE Monte Carlo code. Dedicated studies for the systematic effects and the analysis tools are under development. The goal of this doctoral thesis will be to analyze the data taken from the experiment, continue the studies to reduce the systematic effects as much as possible, and disseminate the experimental data at national and international conferences.

[1] *The MORA project*, P. Delahaye, E. Liénard, I. Moore et al., Hyp. Int. (2019) 240:63; arXiv:1812.02970
[2] https://anr.fr/ProjetIA-11-EQPX-0012

Expected skills:

- Skills in numerical methods and data analysis, statistics
- Experimental physics
- Good communication skills
- Programming C++/python

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