Title of the thesis: “Flavour violation at the high-intensity frontier: searches for new physics”

Supervisor: Ana M. TEIXEIRA

Laboratory: Laboratoire de Physique de Clermont - LPC
University: UCA – Université de Clermont Auvergne
Email and Phone: ana.teixeira@clermont.in2p3.fr (+ 33 4 7340 7301)
Possible co-supervisor: Jean ORLOFF (orloff@in2p3.fr)

Laboratory: Laboratoire de Physique de Clermont - LPC
University: UCA – Université de Clermont Auvergne

Summary:
The Standard Model of Particle Physics (SM) provides an extraordinarily successful and yet simple description of elementary particles and their interactions. Nevertheless, it is now firmly established that the SM cannot account for a certain number of observations, in particular neutrino oscillations, the baryon asymmetry of the Universe, and dark matter; New Physics (NP) is thus required to explain these observational caveats and possibly to ease SM theoretical issues.

In view of the absence of direct evidence for new states (despite the massive effort carried at the LHC), searches for NP at the so-called "High Intensity frontier" emerge as powerful probes to unveil the underlying extension of the SM at work. Indirect searches focus on deviations from SM predictions — leading to apparent tensions with experimental observations—, or then on very rare processes, forbidden in the SM. In this sense, flavour observables, both in the quark and lepton sectors, are very promising NP probes. In recent years, several tensions between observation and SM predictions have hinted at the presence of NP: these include the anomalous magnetic moment of light charged leptons, and further (anomalous) deviations from lepton flavour universality in meson decays. Interestingly, all these tensions are rooted in the lepton sector, rendering the search for NP in lepton(-related) observables a very promising research field.

The experimental searches in the field of flavour physics are also entering a unique and unprecedented epoch, with several ongoing facilities (g-2@FNAL, Belle II@KEK, as well as LHCb and NA62 at CERN), and several others expected to start taking data in the near future (MEGII and Mu3e at PSI, as well as COMET at J-PARC and Mu2e at FNAL).

The Ph.D. project will be focused on the impact of well-motivated models of New Physics (for instance SM extensions via the addition of sterile fermions, or other exotic states such as leptoquarks) for the many high-intensity observables, including those at the origin of the existing discrepancies. The latter include neutrino properties, flavour violation and lepton flavour violation in charged lepton transitions and decays, as well as leptonic and semi-leptonic decays of B and K mesons. Of particular relevance will be the rare leptonic transitions studied at the coming COMET experiment, and exchanges with the members of the collaboration.
École Doctorale des Sciences Fondamentales

A synergetic approach, relying on the study of observables stemming from distinct sectors, will also be pursued; this will also call upon the complementarity between the results of the indirect searches and the potential of possible studies and discoveries at the high energy frontier (namely results of direct searches and searches for long lived states). In addition to a theoretical approach, the student will gain insight into the experimental methods. This aspect is crucial to interpret and address new data, as well as to identify and propose new observables (or new aspects of pre-existing ones).