UNIVERSITÉ Clermont Auvergne

Chimie – Mathématiques – Physique – Sciences de l'Univers

Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Search for the coherent neutrinoless transition of a muon to an electron in a muonic atom with the COMET experiment at J-Parc

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Summary:
The discovery of flavour violation by the neutrino oscillations opened a particularly promising way of searching for Physics Beyond the Standard Model. Indeed, the charged lepton flavour violation (cLFV) seems also likely to occur. Being forbidden in the Standard Model (SM), and strongly suppressed in minimal SM extensions that can account for neutrino oscillation data, cLFV would not only prove the existence of New Physics, but also identify its nature.
The existence of very high intensity muon-beams renders the neutrinoless muon-electron conversion of a muonic atom a powerful observable that was already used to put stringent bounds on cLFV. These bounds are expected to be dramatically improved by the upcoming experiments, Mu2e at FNAL (USA) and COMET (COherent Muon to Electron Transition) at the Japan Proton Accelerator Research Complex (J-PARC).

The four French labs involved in clFV searches have chosen to participate to COMET. The experiment has the advantage of the highest intensity muon beam in the world, and it was designed to minimise at the same time the background noise induced by this beam. The very intense, pulsed muon beam is used to form muonium atoms by capturing the muons in an Aluminum target. The capture likelihood is optimised by increasing the fraction of low energy muons in the beam using a pion capture solenoid and by further selecting their charge and momentum with a transport solenoid. The ones that are stopped by the target end up forming a 1s bound state and then either decay in orbit (identified by the occurrenceμ^-→ e^-ν of $\mu\nu^-$the neutrinoless muone), or are captured by the nucleus, -to-electron conversion, μ^-+(A, Z) →μ ν^- +μ (A, Z+(A, Z) −→1) e. $^-$New physics would be + (A, Z).

The event signature of coherent μ−e conversion in a muonic atom is the emission of a mono-energetic single electron with a well-defined energy (104.497 MeV for Aluminum), originating from the Aluminum target. This electron will be measured very precisely by COMET using a cylindrical drift chamber (CyDet), that surrounds the target and is placed in a 1 T magnetic field. The pulsed muon beam and several other subdetectors, among which a Cosmic Ray Veto (CRV) will ensure that different particles or electrons not originating from the target will not mimic the signal searched for at levels that would compromise the sensitivity of the experiment.

The PhD is expected to improve the sensitivity of the experiment to the neutrinoless muon-electron conversion by implementing advanced algorithms that take into account (1) the real performance of the subdetectors, as measured by ongoing tests and COMET α-Phase that will start in 2022 (2) robust background estimates, in particular for the dominant background induced by the by the atmospheric muon flux that was recently estimated within the LPC team. Since the COMET group at LPC is in charge of an extension of the Cosmic Ray Veto based on Glass Resistive Plate Chambers, the PhD candidate will have the opportunity to participate to the commissioning of the detectors at LPC and at JParc.

COMET is an international collaboration with a large number of participating countries. The PhD is expected to work in tight collaboration with KEK and Osaka University teams in Japan, Melbourne University (Australia) and Imperial College London (UK) teams. Extended stays in Japan for installing and commissioning detectors and for data taking are foreseen.

High level expertise in particle physics and data analysis, familiarity with C/C++ programming are required. Experience in instrumentation is an advantage.