BSM flavour physics:
from LHCb anomalies to neutrino masses

What: Master 2 internship

Where: Laboratoire de Physique de Clermont, http://clrwww.in2p3.fr

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Next: continuation in PhD possible, pending on funding

Description

The completeness of the Standard Model (SM) as a description of fundamental interactions has entered a new era since the discovery of the Brout-Englert-Higgs boson in 2013. Aside quantum gravity, the phenomena for which the SM most clearly fails to provide an understanding are now: neutrino masses, baryon asymmetry of the universe and the dark matter problem. While there are more or less ad-hoc extensions beyond the SM (BSM) explaining each of these phenomena, none have received further experimental support beyond their original motivation, which could help discriminating among various possibilities.

Independently, anomalies in $b-$quark decays, violating the SM lepton flavour universality (LFUV), started appearing with low ($\sim 3\sigma$) but persistent or rising significance. These appeared in measurements, mostly by LHCb, of $b \to s\mu\bar{\mu}$ exclusive observables like the ratio $R_{K^{(*)}} = \mathrm{Br}(B \to K^{(*)}\mu\bar{\mu})/\mathrm{Br}(B \to K^{(*)}l\bar{l}$ or angular distributions, and of $b \to cl\bar{\nu}$ observables like $R_{D^{(*)}} = \mathrm{Br}(B \to D^{(*)}\tau\bar{\nu})/\mathrm{Br}(B \to K^{(*)}l\bar{\nu}$.

After reviewing these observables, and the significance of their deviations to the SM, the project will start by studying and comparing the extensions BSM that could accommodate such deviations, should they be confirmed, with a particular focus on the minimal renormalisable model adding a single spin 0 leptoquark. Starting from this model, the possibility of addressing the dark matter, the neutrino mass, and possibly the baryon asymmetry problems by minimal further extensions will be explored. More specifically, the requirements on leptoquarks Yukawa couplings imposed by flavour anomalies (either $b \to s$, or $b \to c$, or possibly both) will be compared to those arising from the requirements of thermal dark matter relic density, and of realistic neutrino masses and couplings.

This internship in particle phenomenology will require and develop knowledge in experimental data, analytic and numerical computation of observables in non standard models, and abilities to grasp and synthesize widely different aspects ranging from dark matter to neutrino and flavour physics.