Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Indirect searches for new physics via flavour violation observables

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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 (ν) masses and their mixings, the baryon asymmetry of the Universe, and dark matter; New Physics (NP) is thus required to explain the observational caveats (and possibly ease SM theoretical issues).
In the absence of direct evidence for new states (despite the massive effort carried at the LHC), indirect searches for NP emerge as a powerful probe 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 in very rare processes forbidden in the SM. Flavour observables, both in the quark and lepton sectors, in which higher-order (loop) contributions play a significant or even leading role, have become extremely relevant probes

of NP. Other than the clear evidence for NP manifest in ν masses and mixings, a number of tensions between SM predictions and experimental measurements have been identified; interestingly, many of the latter are related to processes involving both hadron and lepton flavours, in particular the recent observations suggesting anomalous deviations from lepton flavour universality. The experimental searches for such observables occur in many fronts: other than numerous ν-dedicated experiments, many high-intensity facilities such as MEG, Mu2e, Mu3e and COMET, are exploring several low-energy lepton observables (violation of lepton flavour, number and universality); the LHCb experiment, as well as the upcoming SuperKEKB facility and NA62 are pursuing hadron flavour physics.

The PhD project will be focused in the impact of well-motivated models of New Physics (in particular models of massive neutrinos) for the observables at the origin of the existing discrepancies. These include ν properties, purely leptonic observables, as well as leptonic and semileptonic decays of B and K mesons. 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-existent ones). The complementarity between the results of these indirect searches and the potential of possible discoveries at high-energy colliders will also be addressed, so that the complete strategies for unveiling NP models can be explored.

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