M2 internship proposal:
"Introduction to low-scale models of neutrino mass generation and their associated phenomenology"

Abstract: Neutrino oscillations remain the only laboratory evidence of New Physics. In order to accommodate massive neutrinos and leptonic mixings, the Standard Model of particle physics must necessarily be extended, and numerous possibilities allow accounting for neutrino oscillation data. Among the many realisations of the seesaw mechanism, certain allow explaining the smallness of active neutrino masses in a natural way relying on new states which are not excessively heavy. These models can have a very rich and diversified phenomenology, and one can expect contributions to a vast array of observables. The Theory Group at LPCA has done extensive work on the phenomenological implications of low-scale seesaw models, as well as the associated prospects for observables that will be explored in the next generation of low-energy dedicated facilities, and are also part of the programme of future high-energy colliders.

This Master-2 internship will offer the student the opportunity to become familiarised with New Physics models of neutrino mass generation, in particular the different seesaw realisations and their variants. Emphasis will be given to understanding how such SM extensions can account for oscillation data, and how available data (particle physics and cosmology) can directly and indirectly constrain the new states and interactions. Focusing on the case of Standard Model extensions via sterile fermions, the student will then be introduced to numerous observables that are sensitive to presence of the new states, and which are currently the object of an intensive dedicated experimental programme. In particular, this will call upon the computation of one-loop processes leading to the violation of charged lepton flavours (such as $\mu \to e\gamma$, or $\mu \to 3e$), also learning how to use semi-analytical dedicated tools. From the derived results, or relying on available constraints, the goal is then to infer constraints on specific regimes for these low-scale seesaw realisations.

Requirements: Advanced QFT courses and good knowledge of the Standard Model; computation of tree-level processes and simple one-loop transitions. Fundamental aspects of neutrino physics (oscillations, Dirac vs. Majorana description). Knowledge of Mathematica and Python can be advantageous (but are not required).

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