Non-Reciprocal Quantum Matter

In classical or quantum systems in thermal equilibrium the interactions between degrees of freedom are fundamentally symmetric or reciprocal, a statement dictated by Newton's third law and that in the quantum domain comes hand in hand with unitarity. Far from equilibrium however non-reciprocal interactions happen to be more the rule than the exception. Examples include optics, active matter, ecology and recently quantum systems. Non-reciprocity emerges naturally within non-Hermitian quantum mechanics, such as in the celebrated Hatano-Nelson model of particles hopping across a lattice with hopping different rates along opposite directions, and lead to a plethora of exotic topological and non equilibrium phenomena. However a fully consistent quantum description of non-reciprocal interactions requires the framework of open quantum systems and reservoir engineering.

The goal of this project is to explore the consequences of non-reciprocity on the dynamics of quantum many-body systems. Examples include the study of transport entanglement and phase transitions in presence of non-reciprocal couplings, in paradigmatic models of quantum many-body systems such as quantum spin chains or strongly correlated quantum impurity models.

During this theoretical internship, the Master's student will acquire, develop, and apply state- of-the-art techniques for open quantum many-body physics [1.2] to solve paradigmatic models for non-reciprocal quantum systems[3]. This internship can naturally evolve into a PhD Thesis at the interface between nonequilibrium quantum dynamics, open quantum systems, statistical physics and quantum information.

[1] R. Fazio, J. Keeling, L. Mazza, M. Schiro, arXiv:2409.10300

[2] R. D. Soares, M. Schiro, arXiv:2406.10135

[3] T. Nadolny, C. Bruder, M. Brunelli, arXiv:2406.03357

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