Master 2 thesis & PhD proposal

Dissipative quantum simulation with sub-wavelength atom arrays

Quantum Optics – Atoms group (https://atom-tweezers-io.org)
Laboratoire Charles Fabry, Institut d'Optique, Palaiseau

Proposal for a Master 2 thesis to be followed by a PhD.

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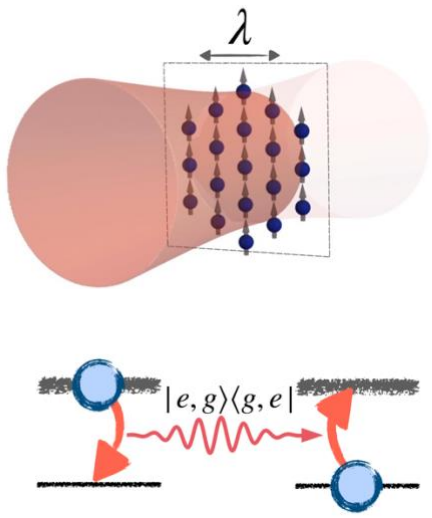
Internship allowance: Yes

The goal of this thesis project is to develop a quantum simulator for dissipative quantum-many problems, to emulate many-body ensembles with intrinsic collective dissipation and with external driving by a classical or quantum field. The platform we will develop during this internship, to be followed by a PhD, will be based on structured ensembles of atoms held in microscopic optical traps (tweezers), and interacting with near-resonant laser light.



The structuring of atomic arrays in optical tweezers creating a configurable quantum simulator has been invented by our group. The collective effects will be here induced by the resonant dipole interaction between the atoms, which exhibits both a real and imaginary part. The exchange of excitation that results from the interaction naturally implements an interacting spin system where the two atomic states are mapped onto the two states of a spin 1⁄2 (see figure). This system is thus a quantum simulator for dissipative spin systems. To reach strong interactions, the interparticle distance must be shorter than the wavelength of the transition between the two levels, here around 780 nm for Rb atoms.

This internship will take place on an existing cold rubidium setup, with high-numerical-aperture lenses in vacuum. The topic of the internship will be to generate an optical tweezer array with light close to a blue transition of Rb at 420nm in order to reduce the diffraction limit. Using a spatial light modulator (SLM) we will generate a configurable array with interparticle distance of a few hundred nm, thus shorter than the wavelength of the main transition in Rb at 780nm. During the PhD that will follow we will put the optical tweezer array in place on the experiment and implement the experimental protocol to deterministically fill it with single atoms. We will then perform the first experiments in the strongly interacting regime.