Master 2 Internship Proposal

Laser trapping of circular Rydberg atoms for quantum simulation

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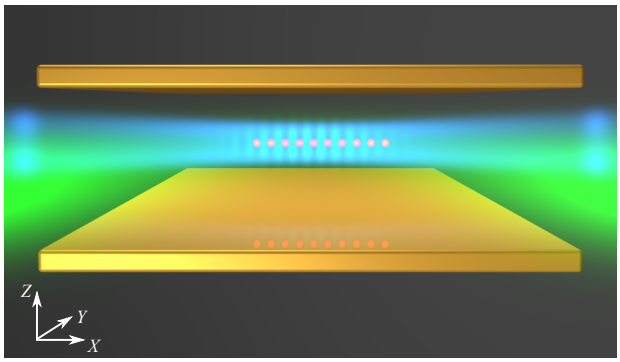
Thesis possibility after internship: **YES**
Funding: **NO**

Scientific context:

The dynamics of a quantum system, particularly in condensed matter, can be utterly complex, due to the huge size of its Hilbert space. **Quantum simulation** aims at emulating this dynamics with a simpler system, of which all parameters are under control and on which all relevant observables can be measured. Quantum simulation is the focus of an intense activity, particularly with cold atoms or trapped ions. We propose to explore an alternate, promising route, based on cold atomic ensembles in **highly-excited Rydberg levels**, strongly coupled by van der Waals dipole-dipole interaction. The final goal is to realize a vacancy-free chain of high-angular-momentum (circular) Rydberg atoms trapped in an optical lattice. The atoms are placed inside a spontaneous-emission-inhibiting structure, thereby making the trapping of tens of atoms during several seconds possible. This will enable unprecedented capabilities for a quantum simulator, with the observation of the dynamics of the system over several hundred thousands of interaction cycles.



Circular Rydberg atoms are trapped in a blue-detuned dipole trap inside a spontaneous-emission inhibiting structure. We aim at the realisation of quantum simulations with tens of atoms during several tens of seconds.

Internship:

The intern will participate to the realization of the **first enabling steps of the quantum simulator**. The inhibition structure will be designed and installed into the existing experimental setup. Individual circular Rydberg atoms, laser-trapped inside this structure will then exhibit significant lifetimes, on the order of a few minutes. **The measurement of this lifetime** is the key objective of the internship.

The success of the experiment will trigger the realization of the full quantum circulator. Our activity in the following years will focus on the trapping of several circular Rydberg atoms inside the inhibition structure, the detailed study of their interaction, the demonstration of the full tunability of the simulated condensed-matter Hamiltonian and the preparation of the defect-free spin-chain.

Reference: T. L. Nguyen *et al.*, arXiv:1707.04397