Master 2 Internship Proposal

Control of spontaneous emission with trapped circular Rydberg atoms for quantum simulation

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Cavity Quantum Electrodynamics group (www.cqed.org)

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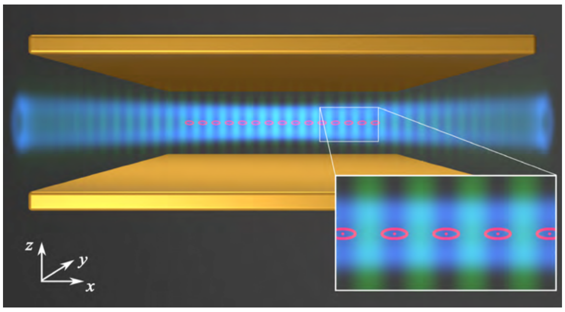
Thesis possibility after internship: **YES**
Funding: **YES**

Scientific context:

The current ultimate goal of the Cavity QED group (Kastler-Brossel Laboratory, Paris) is the realization of a novel quantum simulator platform based on a chain of circular Rydberg atoms and its benchmarking by the exploration of the phase diagram of a 1D spin chain. The corresponding proposal is presented in details in Phys. Rev. X **8**, 011032 (2018). Circular levels have a large principal and maximum orbital and magnetic quantum numbers. These states unite the remarkable features of Rydberg levels with a simpler level structure and a much longer intrinsic lifetime. These properties make circular Rydberg atoms very promising candidates to implement quantum simulations of different physical condensed-matter processes which are out of reach for the classical numerical integration even on modern super-computers and their clusters. However, the realization of long (up to 40 atoms) chains ready to be efficiently used in a quantum simulator requires much longer atom lifetimes, on the order of several minutes. This demand can be fulfilled by passing two basic milestones: the realization of a Rydberg atom chain trapped at laser intensity minima by the ponderomotive energy of the atoms' nearly-free electron and the enhancement of the atom lifetime (inhibition of their spontaneous relaxation) by placing the atoms in a plane-parallel capacitor with millimetre spacing, as schematically shown in the figure.



Artist's view of a laser-trapped circular Rydberg atom chain inside a spontaneous-emission inhibiting capacitor.

Internship:

The goal of the internship is the assembling of a new experimental setup aiming on trapping and protecting chains of circular Rydberg atoms. During his/her internship in the group, the intern student will participate in the assembling and testing of different components of the experimental system. Under the guidance of senior colleagues, he/she will learn various experimental technics, like optical systems for laser control, electronics and microwaves, cryogenics and ultra-high vacuum, etc.

Future thesis:

The main task of the future PhD project is to realize a prolonged trapping and efficient protection of a chain of circular Rydberg atoms inside a cryogenic environment. The significant part of the project will be devoted to the development and adaptation of various experimental protocols for atom trapping and detection. After the spontaneous inhibition of single Rydberg atoms is reached, the project will go for the next global milestone: preparation and protection of a long 1-D chain of several tens of atoms.