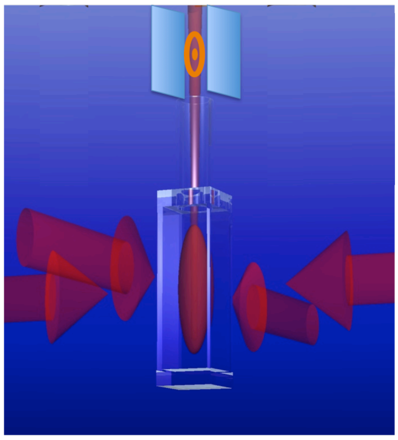
PhD Position

Quantum metrology with circular Rydberg states at room temperature

Laboratoire Kastler Brossel, Collège de France, Paris
Cavity Quantum Electrodynamics group (www.cqed.org)

Supervisors:
Michel Brune (michel.brune@lkb.ens.fr)
Sébastien Gleyzes (gleyzes@lkb.ens.fr)

Thesis possibility after internship: **YES**
Funding: **EU ITN grant (if eligible)**



Principle of the experiment. The Rydberg atom are excited from a beam of slow atom inside an electrode structure that partially decouples the atom from the thermal background that would decrease the atomic lifetime.

Scientific context:
Rydberg atoms are energy levels with gigantic properties that make them a promising system for quantum technology [1]. Their huge electric dipole, their large angular momentum makes them of great interest to measure electric and magnetic field [2]. Using quantum control method, it should be possible to observe Ramsey fringes between levels with 100 µB difference in magnetic moment. This is two orders of magnitude larger than other single particle sensor, like NV center or trapped ion.
However, the ultimate sensitivity of a quantum sensor also depends on the interrogation time of the Ramsey fringes, which is limited by the coherence time of the probe system. To that end, circular Rydberg levels are particularly interesting, as they have very long lifetime. Unfortunately, as these sates are very sensitive to thermal background, their use has been mostly limited so far to cryogenic environment.
Nevertheless, the lifetime of an atomic level depends on the density of mode of the electromagnetic field to which the atom is coupled. By engineering the electromagnetic environment of the atom, it should be possible to limit the effect of the atomic decay induced by the thermal photons and observe long coherence time of circular Rydberg atom at room temperature.

PhD Thesis:
The purpose of the PhD thesis will be to prepare circular Rydberg atom inside an electrode structure that inhibits the spontaneous emission, in order to increase the lifetime of the

[1] A. Signoles, E.K. Dietsche, A. Facon, D. Grosso, S. Haroche, J.-M. Raimond, M. Brune et S. Gleyzes, Coherent transfer between low-angular momentum and circular Rydberg states, Phys. Rev. Lett. 118, 253603 (2017).
[2] A. Facon, E. K. Dietsche, D. Grosso, S. Haroche, J.-M. Raimond, M. Brune et S. Gleyzes, A sensitive electrometer based on a Rydberg atom in a Schrödinger cat state, Nature, 532, 262 (2016)

atom at room temperature. The atoms will be excited from the beam produced by a 2D-MOT that crosses the electrode structure. We will prepare a quantum superposition of two circular Rydberg level with opposite magnetic moment. The relative phase between the two components of such superposition is highly sensitive to the magnetic field, allowing us to determine its amplitude with a very high precision. Measuring the phase accumulated during the 1 ms time of flight of the atom across the electrode structure would allow us an integrated sensitivity of the order of a few pT/√Hz, comparable to the best sensitivity achievable with single particle magnetic sensors.