M2 Internship

Quantum metrology with circular Rydberg states at room temperature

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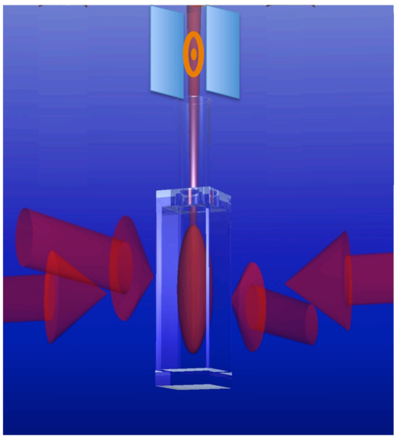
Thesis possibility after internship: **YES**
Funding: **EU ITN grant (if eligible)**

Scientific context:



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.

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 fields [2]. Using quantum control methods, 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 sensors, like NV centre or trapped ion.

However, the ultimate sensitivity of a quantum sensor also depends on the interrogation time of the Ramsey sequence, 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.

Internship:

The main decay channel for a circular Rydberg atom of principal quantum number *n* is to emit or absorb a photon at the frequency of the transition between the circular state *n* and

[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)

the circular state of principal quantum number $n \pm 1$. The purpose of the internship will be to design an electrode structure that suppresses the mode density of the electromagnetic field around those frequencies. We will then send across that structure a beam of laser-cooled atom, from which we will prepare circular Rydberg atoms, in order to measure its lifetime, at room temperature, when it is between the electrodes.