PhD position: Superradiance on ytterbium clock transition for frequency metrology

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Candidates should apply before 15th of May, and provide their CV and at least one recommendation letter. We are looking for candidates with experience in optics, electronics and/or quantum physics. Candidates should have a B2 level in English. Speaking French is recommended but not necessary.

Context: With the advent of optical atomic clocks, precision measurements have entered a new era. Fractional frequency accuracies have reached the 18th decimal, and are now providing key insights into faint fundamental phenomena. Yet, the current limitations of traditional, "passive", optical clocks are now challenging to overcome, and new optical frequency keepers are emerging. Among them, one exciting perspective is to realize superradiant lasers. They are based on cold atoms with a narrow-linewidth optical transition coupled to a high-finesse Fabry-Perot cavity. Superradiance emerges as the constructive quantum interference between the various decay paths from a many-body fully excited state to the ground state. A superradiant laser uses directly the enhanced atomic emission inside the cavity as the ultra-stable signal.

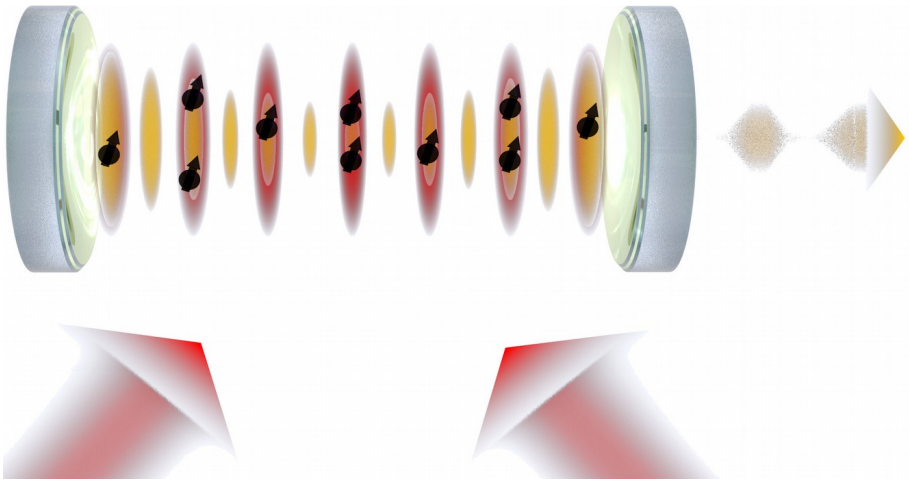

Figure 1: Sketch of superradiant laser setup emitting pulses. Atoms will be pumped into the excited state of the clock transition and emit superradiant pulses. In black: atoms, in yellow: optical cavity mode; in red: trapping lattice.

The project: The goal of this new project is to exploit quantum coupling between atoms and cavity to observe superradiance with an ytterbium gas. Prior to an actual observation of superradiance, we will perform high-resolution spectroscopy of an ultra-cold ytterbium ensemble coupled to a single mode high finesse Fabry-Perot cavity to evaluate the influence of the cavity on the transition frequency. The next objectives will focus on the first observation of superradiance on the clock transition of ytterbium. A sketch of the experiment is indicated in Fig. 1.

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The metrological aspects, including frequency stability characterization and efforts towards a continuous superradiant laser will represent an important part of the project. However, fundamental aspects such as squeezing and other collective phenomena such as the effect of interactions can also be explored.

This PhD proposal is mainly experimental, but if the PhD student wishes so, several theoretical aspects can be investigated. These include for instance prediction of smart optical pumping schemes for atomic state preparation, or advanced theoretical description of the system.

The lab: FEMTO-ST is a research institute focusing on various topics, ranging from energy storage to optics and time and frequency. Our group is part of the very active OHMs team of the time and frequency department (https://teams.femto-st.fr/equipe-ohms). It is at the origin of the Oscillator-IMP EquipEX, and therefore benefits from a complete time and frequency metrology infrastructure, ranging from masers to optical frequency combs and ultra-stable cavities. The OHMS group has a long tradition of excellence, and is particularly renowned for its ultra-stable oscillators. The superradiant laser project is in line with this tradition, as it is targeting the future of ultra-stable oscillators.

Besançon: Besançon is a UNESCO world heritage city, located in the heart of Franche-Comté, at the foot of Jura, and is a heaven for nature enthusiasts. It is a university metropolis, with more than 20,000 students and a very active cultural life. EIPHI-BFC graduate school provides specific courses for PhD students and offers opportunities for short-term scientific missions during the PhD in order to strengthen international collaborations (http://gradschool.eiphi.univ-bfc.fr/).

Grant: The PhD fellowship is provided for three years by CNRS, EIPHI graduate school and Région Bourgogne Franche-Comté. The gross salary is 1800€/month. During second and third year, PhD students can choose to teach 64h/year and receive an extra ~200€/month.

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