M2 Internship / PhD offer

Laboratory: Laboratoire de Physique des Lasers
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Continuous superradiant laser with a laser-cooled atomic beam

Atomic clocks are vital components for many applications in our modern society, such as the operation of GPS and the synchronization of telecommunication networks. Clocks are also used to bolster investigations of fundamental physical phenomena, such as the detection of low-frequency gravitational waves.

Recently, a new type of clock has been proposed: the active clock using superradiant lasing. Instead of shining a very stable laser onto ultracold atoms to probe the atom resonance frequency (and thus measure time), the clock would operate by letting the atoms themselves emit light. Much like in a laser, cold atoms would be prepared in an excited state, then placed between two mirrors forming a cavity. The atoms then coherently emit light into the cavity mode. However, unlike a traditional laser, the light frequency will mostly be set by the atoms themselves, and not by the cavity. The light coherence will be set by a collective synchronization of the atomic dipoles with each other - a process called superradiance. Thus, in addition to its significance as a new clock architecture, this system is interesting from a fundamental point of view: it is an example of an open-dissipative system in which correlations of quantum nature may naturally arise.

We have built a prototype for such a cold-atom-based superradiant laser. We want to tackle the unresolved issue of sustaining continuously a superradiant emission, thus harnessing its full potential as a clock. Our design is based on an effusive beam of strontium atoms inside a vacuum chamber, slowed, cooled, guided continuously up to an optical cavity, there to emit light in a superradiant fashion. The construction of the apparatus is completed, and we expect to acquire full control over the atomic velocity distribution in the next few months. The internship will thus be devoted to characterizing the signs of collective interaction between atoms and cavity (i.e., performing cavity-enhanced spectroscopy), and searching for superradiance signals in beat note spectroscopy. Throughout the PhD project, we will investigate the light properties to understand how the emitters synchronize their oscillations, and how the light coherence is related to correlations between all atomic emitters. Our experiment will have the unique capability to explore several distinct superradiant emission regimes, that will be identified through the spectral and correlation properties of the light and of the atoms. In collaboration with metrology experts, we will contribute to assessing the metrological interest (i.e., “performance” criteria to act as a clock) of atomic-beam continuous superradiant lasers.

Our group runs three experiments dedicated to the study of collective phenomena between atomic spins or dipoles. The two other experiments study quantum degenerate gases of interacting spinful atoms. The new team member will develop his work in connection with the entire team, developing a general culture in atomic physics and many-body physics.

Group webpage: https://gqm.lpl.univ-paris13.fr/

Possibility to go on with a PhD ? YES
Envisaged fellowship ? Ecole Doctorale, DIM Quantip