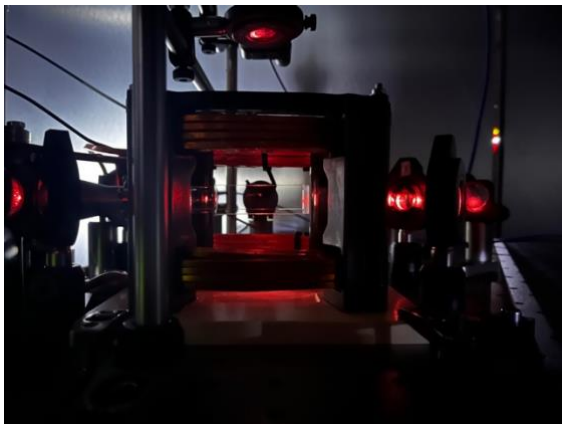
Master thesis proposal

Quantum optics group, Laboratoire Charles Fabry, Institut d'Optique, Palaiseau

Light-matter interactions in superradiant Rb ensembles

Keywords: Atomic physics, light-matter interaction, quantum optics



The long-term goal of this project is to study the collective interaction between quantum light and atomic ensemble. This many-body problem has still, to date, no general solution and advances must be guided by experimental studies. Besides its fundamental interest, it is deeply connected to the development of quantum technologies based on atom-light interfaces.

Here, we operate a new cold atom setup that produces **dense ensembles of Rb** atoms. Our atomic clouds are in the regime where the interatomic distance is comparable to the wavelength of the 780 nm transition of Rb. The atoms then exhibit a **collective coupling to the electromagnetic field**, which results in pronounced difference of the collective response to light with respect to that expected for independent atoms. In recent years, we have studied the modification of **collective spontaneous emission**: subradiance [1] and superradiance [2,3], as well as the properties of the emitted light [4].

Recently, we made a **striking observation of the collective mode** in which the clouds cooperatively emit during superradiance [5]. These studies were performed on two-level atoms, hence on a single polarization. In this Master thesis project, we plan to study superradiance in multilevel systems using the Zeeman structure of Rb, resolving the decay channel and light polarization. In the future, we will characterize the light statistics during superradiance, study photon correlations between modes, and study the interaction of the ensemble with quantum light.

Contacts:
Antoine Browaeys, antoine.browaeys@institutoptique.fr
Igor Ferrier-Barbut, igor.ferrier-barbut@institutoptique.fr

References

[1] G. Ferioli *et al*., Phys. Rev. X **11**, 021031 (2021).
[2] G. Ferioli *et al*., Phys, Rev. Lett. **127**, 243602 (2021).
[3] G. Ferioli *et al*., Nature Physics **19**, 1345-1349 (2023).
[4] G. Ferioli *et al*., Phys. Rev. Lett. **134**, 153602 (2025)
[5] A. Gavalda, *et al.* ArXiv:2607.08421 (2026)