Master 2 thesis & PhD proposal

Generation of non-classical light with dipole-dipole interactions

Quantum Optics – Atoms group (https://atom-tweezers-io.org)
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Proposal for a **Master 2 thesis**, to be followed by a **PhD** (starting date: **spring 2022**).
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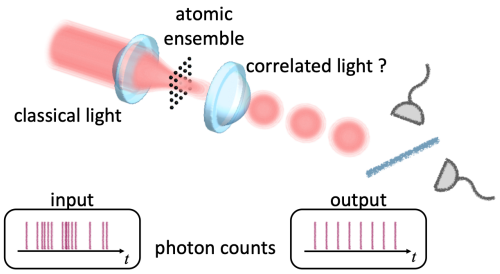
Internship allowance: **Yes**

When light scatterers on an atomic ensemble, it induces atomic dipoles. When the ensemble is dense, these dipoles interact and the whole ensemble collectively scatters or emits light. Our group is the first to study dense atomic ensembles of laser-cooled atoms, and we have observed two prominent collective effects: super-radiance [1], the collective emission of light by a collection of atoms initially all excited, and its counter-part, sub-radiance [2], the existence of collective states with very long lifetime potentially useful for photon storage. The next important question is the nature of the light collectively emitted: does it feature quantum correlations or is the light simply classical? To study this aspect, we will measure the intensity correlation function of the emitted light or of a probe sent through the cloud, using the setup represented in the figure below. If the light is non-classical we will observe antibunching in the photon correlations.



So far, all the experiments we performed on sub and super-radiance relied on dense clouds with random positions of the atoms. Our next step is to partially rebuild the setup to be able to spatially arrange the atoms in regular arrays: this will increase significantly the interactions between the atoms, and will allow us to enter the regime where interactions are large enough that the atoms should be strongly correlated. This regime is essentially unknown and experiments are required to validate the proposed models. The experimental challenge is to place the atoms at distance on the order of the wavelength of the light. We are developing techniques to reach this regime [3].

The goal of the internship is to study the intensity correlation of the light emitted by the random atomic ensemble and to plan the design of the upgrade of the setup to prepare ordered arrays of atoms, which will be built during the PhD following the internship. This project is mainly experimental, and will require design and alignment of optical setups, manipulation of lasers and data analysis.

References

[1] G. Ferioli *et al.*, arXiv:2107.13392 (2021).
[2] G. Ferioli *et al.*, PRX 11, 021031 (2021).
[3] A. Glicenstein *et al.*, PRL **124**, 253602 (2020).