Master 2 thesis & PhD proposal

Arrays of Dy atoms for studies of collective spontaneous emission: a "dissipative quantum simulator"

Quantum Optics – Atoms group (https://atom-tweezers-io.org)
Laboratoire Charles Fabry, Institut d'Optique, Palaiseau, France

Proposal for a **Master 2 thesis**, to be followed by a **PhD** (starting date: **spring 2022**).
Supervisors: I. Ferrier-Barbut (igor.ferrier-barbut@institutoptique.fr), A. Browaeys (antoine.browaeys@institutoptique.fr).
Internship allowance: **Yes**

The goal of this project is to develop an experimental platform trapping **arrays of single dysprosium atoms**. These arrays will be used to study and control collective spontaneous emission and subradiance in an ensemble of two-level atoms, benefiting from the specificities of the atomic structure of Dy. The structuring of atomic arrays in optical tweezers creating a configurable quantum simulator has been invented by our group [**1,2**]. Here, the interaction will be the resonant dipole interaction that exists between atoms driven by resonant light, which exhibits both a real (conservative) and imaginary (dissipative) part. The exchange of excitation that results from the interaction naturally implements an interacting spin system where the two atomic states are mapped onto the two states of a spin-1⁄2. The imaginary part modifies spontaneous emission and can lead to a strong increase of the lifetime of the ensemble: **subradiance**. To reach strong interaction effects, the interparticle distance must be shorter than the wavelength of the transition between the two levels.

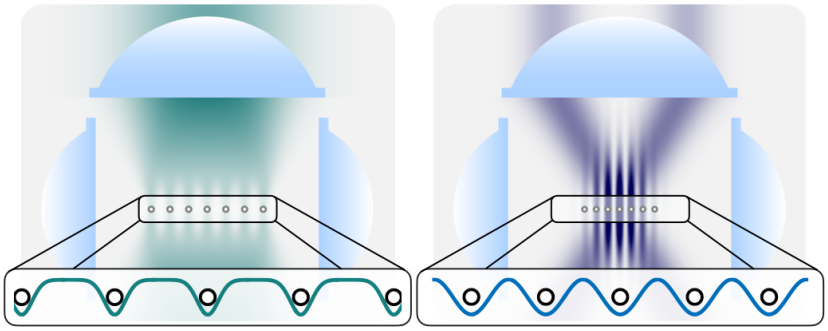

Fig 1: Creation of arrays with small spacing

Single Dy atoms will be trapped in individual optical tweezers before transfer to an accordion lattice with variable spacing to compress the array and reach sub-wavlength spacing.

We have started a new experimental setup for cooling and trapping Dy. It will allow to obtain sub-$\lambda/2$ spacing and enable probing and addressing at the single atom level. **In the internship we propose**, we will optimize the atomic source to create a magneto-optical trap of Dysprosium. We will then implement the first single atom tweezers of dysprosium. This Master 2 internship will be followed by a funded PhD pursuing the creation of sub-wavelength arrays and perform the first studies of collective spontaneous emission in such arrays based on recent proposals [3, 4].

References

[1] D. Barredo *et al.*, Science **354**, 1021 (2016).
[2] D. Barredo *et al.*, Nature **561**, 79 (2018).
[3] A. Asenjo-Garcia *et al.,* Phys. Rev. X **7**, 031024 (2017).
[4] S. Masson *et al.*, Phys. Rev. Lett. **125**, 263608 (2020).