Master 2 thesis & PhD proposal

Quantum simulation with Arrays of single Rydberg atoms

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: A. Browaeys (antoine.browaeys@institutoptique.fr) and T. Lahaye (thierry.lahaye@institutoptique.fr).
Internship allowance: **Yes**

Over the past few years, our group has developed a versatile experimental platform for quantum simulation of spin models, based on arrays of single atoms trapped in optical tweezers, and strongly interacting with each other when excited to Rydberg levels. We generate defect-free atomic arrays of up to 200 atoms with almost full control of the geometry in one, two and three dimensions [1,2]. Interactions between Rydberg atoms allow us to implement Ising [3], XY [4,5], and more recently XXZ [6] spin Hamiltonians.

We use this platform to explore experimentally, in close collaboration with theory colleagues around the world, various fundamental problems of many-body quantum physics, such as the ground state properties (see Fig. 1 below) and the dynamics of quantum magnets, or the realization of topological phases of matter such as Dirac spin liquids for instance.

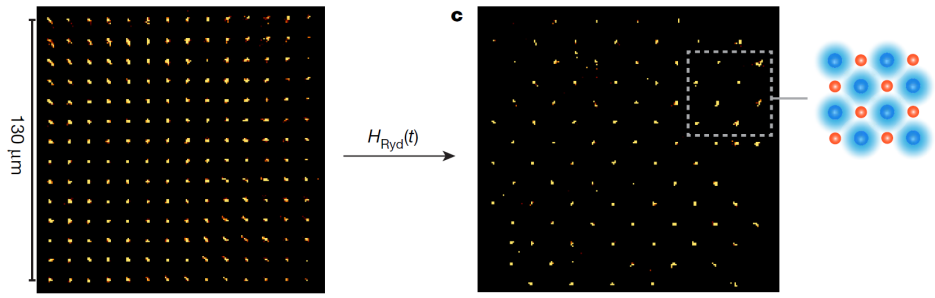

Fig. 1: *Preparation of the antiferromagnetic ground state of the Ising model in a 196-atom square array* [3].

The proposed project will consist (1) in upgrading the experimental setup to continue improving its performance in terms of number of atoms, fidelity of quantum operations, and diagnostic tools to characterize quantum corre, and (2) in using it for the studies mentioned above, in particular the study of topological matter. The work will be essentially experimental, but may include some modelling, in collaboration with our theory colleagues.

References

[1] D. Barredo *et al.*, Science **354**, 1021 (2016).
[2] D. Barredo *et al.*, Nature **561**, 79 (2018).
[3] P. Scholl *et al.*, Nature **595**, 233 (2020).
[4] S. de Léséleuc *et al.*, Science **365**, 775 (2019).
[5] V. Lienhard *et al.*, Phys. Rev. X **10**, 021031 (2020).
[6] P. Scholl *et al.*, arXiv:2107.14459 (2021).