INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Charles Fabry
CNRS identification code: UMR8501 du CNRS
Internship director'surname: BROWAEYS Antoine
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Internship location: IOGS, 2 avenue Augustin Fresnel, 91120 Palaiseau

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: Group funding or ED scholarship

Quantum simulation of XY spin models using Rydberg atom arrays

Summary:
Over the past few years, our group has developed a versatile experimental platform for the quantum simulation of spin models, based on arrays of single atoms trapped in optical tweezers and interacting strongly with each other when excited to Rydberg levels [1]. We generate defect-free arrays of up to 200 atoms (see figure below), with almost complete control of the geometry in one, two and three dimensions [1]. Interactions between Rydberg atoms allow us to implement spin Hamiltonians such as the Ising [2], XY [1,4], and more recently XXZ models [3].
We use this platform to explore experimentally, in close collaboration with theoretical colleagues, fundamental problems in many-body quantum physics, such as the ground-state properties [4] and dynamics [5] of quantum magnets, or the realization of topological phases of matter such as Dirac spin liquids or long-range XY magnets.
The internship (and the subsequent PhD work) will involve (1) upgrading the experimental set-up to improve its performance in terms of number of atoms, fidelity of quantum operations and diagnostic tools to characterize entanglement, and (2) using it for the studies mentioned above, in particular the study of exotic phases of matter (spin liquids, topological matter, etc.).

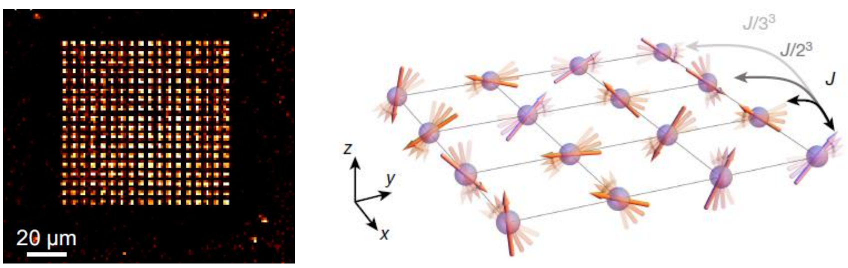

Figure: *left, an example of an array of individual rubidium 87 atoms, arranged in a square lattice; right, a schematic representation of the interacting spin system achievable with such an array.*

References:

[1] A. Browaeys and T. Lahaye, Nature Physics **16**, 132 (2020).
[2] P. Scholl *et al.*, Nature **595**, 233 (2021).
[3] P. Scholl *et al.*, Phys. Rev. X. Quantum **3**, 020303 (2022).
[4] C. Chen *et al.*, Nature **616**, 691 (2023).
[5] G. Bornet *et al.*, Nature **621**, 728 (2023).

Please, indicate which specialties seem to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO