Interacting Laser-Trapped Circular Rydberg Atoms

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Rydberg atoms, i.e., atoms with a high principal quantum number *n*, are particularly well suited to the quantum simulation of interacting spins, thanks to their strong dipole-dipole interactions, even at a few micron distance. While regular arrays of hundreds of Rydberg atoms have been used in several experiments, the effective simulation time is ultimately limited to a few µs by the ~100µs lifetime of the employed laser-accessible Rydberg levels.

Circular Rydberg atoms, with maximal orbital momentum, have a natural lifetime that reaches several 10ms [1]. Quantum simulation with circular Rydberg atoms could then be run over unprecedented timescales [2], making it possible to study slow spin dynamics, that escape both numerical and current quantum simulations. To benefit from these long lifetimes, however, makes laser-trapping of circular Rydberg atoms mandatory [3].

Here, I will present our latest experimental results regarding the laser-trapping of individual circular Rydberg atoms in a regular array of optical tweezers and the observation of their dipole-dipole interactions.

We use so-called bottle optical beams as hollow optical tweezers (Figure 1) to ponderomotively trap individual circular Rydberg atoms with *n*=52. We demonstrate their laser-trapping over several milliseconds, limited by their 130µs lifetime in our room-temperature setup, and observe their oscillations in the traps. To this end, we have developed an optical detection method of circular Rydberg levels, that is both level and spatial selective [4]. We also use this method to characterize the dipole-dipole interaction between two nearby laser-trapped circular Rydberg atoms [5].

Our results open a new route for quantum technologies with Rydberg atoms, allowing one to exploit the unique properties of the circular levels.

References

[1] T. Cantat-Moltrecht et al, PRR 2 (2020) 022032 (R)
[2] T. L. Nguyen et al, PRX 8 (2018) 011032
[3] C. Cortiñas et al, PRL 124 (2020) 1123201
[4] B. Ravon et al, in preparation (2023)
[5] P. Méhaignerie et al, in preparation (2023)

Figures

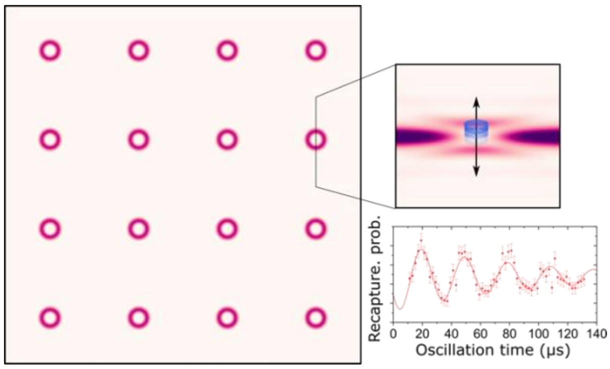

Figure 1: Individual circular Rydberg atoms are trapped in an array of optical bottle beams.