

Simulating spin models on a Rydberg platform

S. de Leseleuc, V. Lienhard, D. Barredo, T. Lahaye and A. Browaeys

Laboratoire Charles Fabry, UMR 8051, Institut d'Optique, CNRS, Univ Paris Sud 11, 2 Avenue Augustin Fresnel, 91127 Palaiseau cedex, France
sylvain.leseleuc@institutoptique.fr

I will present our effort to control the dipole-dipole interaction between single Rydberg atoms to implement various spin Hamiltonians that could be useful for the quantum simulation of various condensed matter problems. Our platform is based on single atoms trapped in an array of optical tweezers generated by holography. With our atom assembler technique, we overcome the random loading of the traps to prepare fully loaded, 2 or 3d, arrays of single atoms [1].

As a first example of spin Hamiltonian, we can implement the quantum Ising model by coupling ground-state atoms to one Rydberg state and use the van der Waals interaction between two Rydberg atoms. I will describe the evolution of the system after a sudden quench of the Hamiltonian, or contrarily after an adiabatic change of the parameters, where we observed the build-up of anti-ferromagnetic correlations between the spins [2].

I will also briefly show how we can control the resonant dipole-dipole interaction between Rydberg states of different parities, which leads to a spin excitation hopping from one atom to another [3]. We have recently developed optical tools to locally control this interaction which opens exciting prospects for the simulation of XY Hamiltonians and topological problems.



Figure 1 : Atom assembly of an atomic array (before / after). This technique, together with the excitation of atoms to Rydberg states, allows the simulation of spin models on systems of various geometries and size.

[1] D. Barredo *et al.*, Science **354** 1021 (2016)

[2] V. Lienhard *et al.*, arXiv :1711.01185

[3] S. de Leseleuc *et al.*, Phys. Rev. Lett. **119** 053202 (2017)