Quantum engineering with 2D arrays of single Rydberg atoms

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Quantum spin Hamiltonians can describe a large variety of condensed matter systems such as quantum magnets, super solids, or high-temperature superconductors. During the last decade several platforms, including cold atoms/ions, superconducting circuits or polar molecules, have been explored to simulate those models that are otherwise difficult to solve analytically, and cannot generally be simulated classically, even for a few tens of particles.

In our approach, we exploit van der Waals [1] and dipole-dipole interactions [2,3] between single Rydberg atoms in fully configurable 2D arrays to engineer different type of spin Hamiltonians. We have performed proof-of-principle experiments where we study the coherent dynamics of spin excitations in systems of three Rydberg atoms. We show that their dynamics are accurately described by parameter-free theoretical models and we analyze the role of the small remaining experimental imperfections [1,3]. In larger arrays of a few tens of spins (Fig. 1), either fully ordered or disordered, we measure the coherent evolution of the particles interacting under an Ising-type Hamiltonian after a quantum quench.

Our results open exciting possibilities in quantum magnetism to study, for example, the role of disorder and the emergence of geometry-induced frustration in such systems.

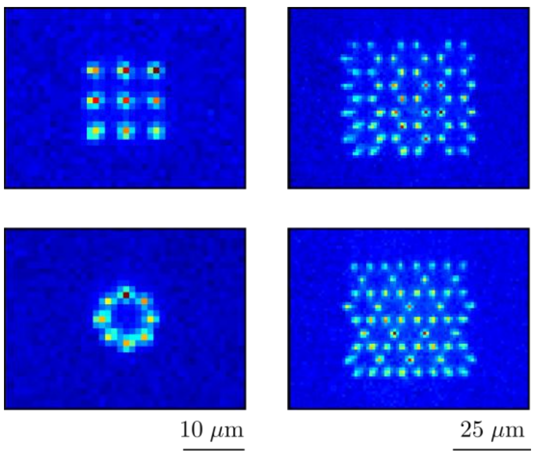

Figure 1: Fluorescence images of single atoms trapped in microtrap arrays with different geometries [4].

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between two single Rydberg atoms at an electrically-tuned Förster resonance, Nat. Phys. **10**, 914 (2014).

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