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Quantum-gas microscopy of Hubbard systems

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Neutral atoms trapped in optical lattices are a versatile platform to study many-body physics in and out of equilibrium.
Quantum gas microscopes provide an excellent toolbox to prepare, control and detect such systems at the level of individual atoms.
First, I will present our recent work on realizing long-range interacting Ising and Hubbard models for Rubidium atoms in optical lattices. Using off-resonant coupling from ground to Rydberg states, we induce tunable interactions via the excitation light. We probe interactions in different experiments on frozen spin systems and the itinerant regime, where they stabilize initial out-of-equilibrium states. In particular, we also observe the buildup of density-density correlations when probing a one-dimensional extended Hubbard system near equilibrium.
Second, I will introduce a new strontium setup that combines large-scale optical lattices with local control achieved through tweezer arrays. I will present our efforts on loading, cooling, and imaging individual strontium atoms in optical tweezers and lattices, where we obtain high-fidelity and low-loss imaging performance using repulsive Sisyphus-cooling. Combining optical tweezer arrays with lattices opens new perspectives to scale tweezer-based quantum simulators to larger system sizes and offers an alternative preparation route of assembled Hubbard systems in optical lattices with the prospect of combining analog and digital quantum simulation capabilities.

Presenter: ZEIHER, Johannes