International Conference on Multi-Condensate Superconductivity and Superfluidity in Solids and Ultra-Cold Gases
14 - 18 May 2018 (Trieste, Italy)

Supersolidity of Ultracold Lattice Gases with Rydberg Dressing

Walter Hofstetter
Goethe-Universität Frankfurt am Main

Recent experiments have shown that (quasi-)crystalline phases of Rydberg-dressed quantum many-body systems in optical lattices are within reach. While conventional neutral atomic lattice gases lack strong long-range interactions, these arise naturally in Rydberg systems, due to the large polarisability of Rydberg atoms. For bosonic ensembles, a wide range of quantum phases have been predicted, including a devil's staircase of lattice-incommensurate density waves and more exotic lattice supersolid orders.

Guided by results in the "frozen" gas limit, we study the ground state phase diagram at finite hopping amplitudes and in the vicinity of resonant Rydberg driving, while fully including the long-range tail of the van der Waals interaction. Simulations within real-space bosonic dynamical mean-field theory (RB-DMFT) yield an extension of the devil's staircase into the supersolid regime, where the competition of condensation and interaction leads to a sequence of crystalline phases.

In an alternative setup, we consider two-component atoms on a square lattice, where one species is weakly dressed to an electronically high-lying (Rydberg) state, generating a tunable, soft-core shape long-range interaction. We find that interspecies on-site interactions can stabilize a pronounced region of supersolid phases. This is characterized by two distinctive types of supersolids, where the bare species forms supersolid phases that are immersed in strongly correlated quantum phases, i.e., a crystalline solid or supersolid of the dressed atoms. We show that the interspecies interaction leads to a rotonlike instability in the bare species and therefore is crucially important to the supersolid formation.