A 19: Cold atoms V - optical lattices (joint session A/Q)

Time: Tuesday 14:00–15:30 Location: K 0.011

A 19.1 Tue 14:00 K 0.011

Two- and four-body spin-exchange interactions in optical lattices — •Bing Yang[1,2], Han-ning Dai[1,2], Andreas Reingruber[1], Hui Sun[1,2], Yu-ao Chen[2], Zhen-Sheng Yuan[2,1], and Jian-Wei Pan[2,1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

Ultracold atoms in optical lattices represent an ideal platform for modeling elementary spin interactions. Here we report on the observations of two- and four-body spin-exchange interactions in an optical superlattice. Using a spin-dependent superlattice, atomic spins can be coherently addressed and manipulated. Bell states are generated via spin superexchange process and their quantum correlations are detected. A minimum toric code Hamiltonian in which the four-body ring-exchange interaction is the dominant term, is implemented by engineering a Hubbard Hamiltonian in disconnected plaquette arrays. Our work represents an essential step towards studying topological matters with many-body systems and the applications in quantum computation and simulation.

A 19.2 Tue 14:15 K 0.011

Multimode Bose-Hubbard model for quantum dipolar gases in confined geometries — Florian Cartarius[1], •Rebecca Kraus[1], Ferdinand Tschirsich[2], Simone Montangero[1,2], Anna Minguzzi[3], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany — [2]Institute for Complex Quantum systems, Universität Ulm, D-89069 Ulm, Germany — [3]Université Grenoble-Alpes, CNRS, Laboratoire de Physique et Modélisation des Milieux Condensés, F-38000 Grenoble, France

We theoretically consider ultracold polar bosonic molecules in a wave guide. The particles experience a periodic potential due to an optical lattice oriented along the wave guide and are polarized by an electric field orthogonal to the guide axis. The array is mechanically unstable by opening the transverse confinement in the direction orthogonal to the polarizing electric field and can undergo a transition to a double-chain (zigzag) structure. For this geometry we derive a multimode generalized Bose-Hubbard model for determining the quantum phases of the gas at the mechanical instability, taking into account the quantum fluctuations in all directions of space. We determine the phase diagrams using exact diagonalization and an imaginary time-evolving block decimation program, where we also investigate the emergence of a Haldane insulating phase. We find that, even for tight transverse confinement, the aspect ratio between the two transverse trap frequencies controls not only the classical but also the quantum properties of the ground state in a nontrivial way.

A 19.3 Tue 14:30 K 0.011

Ground state cooling of Cs atoms in state-dependent optical lattices — •Richard Winkelmann, Gautam Ramol, Stefan Brakhane, Goel Moon, Peng Du, Max Werninghaus, Wolgang Alt, Dieter Meschede, and Andrea Alberti — Institute of Applied Physics, Bonn, Germany

We report on experimental realization of ground state cooling of neutral Cs atoms in state dependent optical lattices, which are realized by fast optical polarization synthesis [1]. Two-dimensional polarization-synthesized optical lattices allow us to employ microwave radiation to couple different motional states in both x- and y-directions; by driving microwave sideband transitions, we succeed to cool atoms into the motional ground state in the xy-plane. A pair of Raman lasers is used to cool atoms in the third dimension, along which atoms are convined by a state-independent optical lattice. We expect to prepare >99% population in the ground state population for each dimension.

Ground state cooling enables both long coherence times and indistinguishability of atoms, which are prerequisites for discrete time quantum walks, the preparation low entropy states via atom sorting [2] and direct measurement of the exchange phase for identical quantum particles [3].

[1] C. Robens et al.,Fast, high-precision optical polarization synthesizer for ultracold-atom experiments., arXiv, 2017. [2] C. Robens et al., Low-entropy states of neutral atoms in polarization-synthesized optical lattices. PRL, 2017. [3] C. F. Roos et al., Revealing quantum statistics with a pair of distant atoms. PRL, 2017.

A 19.4 Tue 14:45 K 0.011

Coupling a finite thermal bath to a many-body localized system — •Antonio Rubio-Abadal[1], Jae-yoon Choi[1], Johannes Zeiher[1], Simon Hollerith[1], Jun Rui[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799 München,

The thermalization of an isolated quantum system can fail in the presence of quenched disorder, even with interactions. This phenomenon, known as many-body localization (MBL), has been recently the focus of much theoretical work, though many open questions still remain regarding its existence in higher dimensions or its robustness to a finite bath coupling. Ultracold atoms in optical lattices have emerged as an extremely suitable platform for the study of MBL, and promise to shed light into some of its properties.

In our experiment, we use a quantum-gas microscope with projected disorder to study the dynamics of a quenched state of bosons in two dimensions, where we observe a remaining memory of the initially prepared state by measuring the evolution of its imbalance. By introducing a second bosonic species unaffected by the disorder potential, a thermal component has been added to the system, and we have measured its effect on the disordered component, which in the presence of a big enough thermal component ultimately loses its imbalance.

A 19.5 Tue 15:00 K 0.011

Exploring the doped Fermi-Hubbard model in low dimensions — •Joannis Koepsell[1], Guillaume Salomon[1], Timon Hilker[1], Jayadev Vijayan[1], Michael Höse[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Univsersität, München

We use ultracold fermionic lithium atoms to realize synthetic one dimensional Fermi-Hubbard chains. With our quantum gas microscope we study emerging antiferromagnetic correlations as a function of doping and magnetization. The local spin and density resolution allows us to observe the change of the wave vector of the spin correlations as a function of density and magnetization. In a quantitative comparison we show that our results can be well described by Luttinger-liquid theory. Finally we report on ongoing studies of the system in the crossover from one to two dimensions.

A 19.6 Tue 15:15 K 0.011

Progress in the cooling of molecules using a magnetic decelerator — Yair Segev, Michael Karpov, •Martin Pitzer, Nitzan Akerman, Julia Narevicius, and Edvardas Narevicius — Department of Chemical & Biological Physics, Weizmann Institute of Science, Rehovot, Israel

Ultracold and dense ensembles of molecules can complement their atomic counterparts in the investigation of various fundamental questions, e.g. in cold chemistry, precision measurements or many-body physics [1].

However, many cooling schemes - especially optical cooling - are much more difficult to implement for molecules than they are for atoms. We report here our recent progress in a different approach, a magnetic decelerator for paramagnetic species [2,3].

A pulsed supersonic expansion provides a cold (around 300 mK) and extremely dense jet of oxygen molecules that are slowed down by a co-moving magnetic trap. After catching these molecules in a superconducting magnetic trap, several cooling schemes such as evaporative or sympathetic cooling can be performed. Due to the high initial particle density of 10^{10}cm^{-3}, we expect to observe collisions of molecules in the rovibrational ground state and study the elastic and inelastic cross sections relevant for cooling towards quantum degeneracy.

[1] Carr, et al., New J. Phys. 11, 055049 (2009)
[2] Akerman, et al., New J. Phys. 17, 065015 (2015)
[3] Akerman, et al., Phys. Rev. Lett. 119, 073204 (2017)