Q 48: Quantum Gases (Fermions) III

Time: Wednesday 14:00–16:15 Location: K 1.022

Q 48.1 Wed 14:00 K 1.022

Dynamics in the dissipative Fermi-Hubbard model — •Koen Sponselee[1], Benjamin Abeln[1], Marcel Diem[1], Maximilian Hagenah[1], Bodhaditya Santra[1], Klaus Sengstock[1,2], and Christoph Becker[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Excellent isolation from environmental influences is a key requirement of many quantum physics experiments, because dissipation usually leads to decoherence in the quantum world. Counter-intuitively, certain types of dissipation can also drive a quantum system into a highly entangled steady state and are thus useful for quantum state preparation.

Here we report on the realization of the one-dimensional dissipative Fermi Hubbbard model exploiting strong two-body loss processes occurring in excited state collisions of ^{173}Yb atoms. Starting from a Mott-insulating state we induce non-equilibrium dynamics leading to strong initial particle loss. Strikingly, after a transient time, this loss is largely suppressed, which we attribute to the build-up of correlations. Our measurements indicate the formation of highly entangled fermionic many-body states, which could be useful for metrology or quantum simulation.

This work is supported by the DFG within the SFB 925.

Q 48.2 Wed 14:15 K 1.022

Non-Equilibrium Mass Transport in the 1D Fermi-Hubbard Model — •Sebastian Scherg[1,2], Thomas Kohlert[1,2], Henrik Lüschen[1,2], Pranjal Bordia[1,2], Jan Stolpp[1], Jacek Herbrych[3,4], Fabian Heidrich-Meisner[1], Ulrich Schneider[5], Monika Aidelsburger[1,2], and Immanuel Bloch[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität München, Schellingstr. 4, 80799 Munich, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [3]Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996, USA — [4]Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA — [5]Cavendish Laboratory, University of Cambridge, J.J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom

We experimentally and numerically investigate the sudden expansion of interacting Fermions in a one-dimensional lattice. Focusing on initial states with more than half filling, we observe a phase separation of singlons (quickly expanding particles on singly occupied lattice sites) and doublons (slow particles on doubly occupied lattice sites). We discuss evidence of quantum distillation in the limit of large interactions, occuring if singlons distill out of the doublon cloud, leading to a contraction of the doublon region in the cloud. For initial states with less than half filling, we find a phase of singlons expanding nearly independently of the interaction strength, which is in contrast to the behavior of Bosons. We attribute the weak effect of interactions to a less efficient generation of dynamical doublons due to the Pauli principle.

Q 48.3 Wed 14:30 K 1.022

Microscopic confirmation of fluctuation relations in Hubbard chains — •Timon Hilker[1], Guillaume Salomon[1], Joannis Koepsell[1], Jayadev Vijayan[1], Michael Höse[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institute für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, München

Fluctuation-dissipation relations express fundamental connections between the equilibrium fluctuations of a system, its linear response to an external force and its temperature. Here, we present an experimental confirmation of such a relation for Fermi-Hubbard chains with ultracold ^{6}Li atoms by measuring density-fluctuations, compressibility and temperature simultaneously. With our quantum gas microscope, we have access to all three contributions including the crucial non-local fluctuations between all pairs of sites. Conversely, the relation provides a robust method for a theory-independent measurements of a system's temperature even at strong interactions.

Q 48.4 Wed 14:45 K 1.022

Towards realizing small Fermi-Hubbard type systems atom by atom — •Phillip Wieburg, Martin Schlederer, Thomas Lompe, and Henning Moritz — Institut für Laser-Physik, Universität Hamburg

The development of quantum gas microscopes has enabled the study ultracold atoms in optical lattices with single site, single atom resolution. In these experiments, the gases are typically cooled evaporatively and loaded into a large optical lattice formed by interfering laser beams. Here, we will report on the present status of an experimental setup designed to follow a complementary approach [1] where small Fermi-Hubbard type systems are assembled site by site using optical microtraps.

We have lasercooled K40 atoms to sub-Doppler temperatures using magneto-optical trapping and grey molasses cooling. After magnetic transport to the science region the atoms are loaded into optical lattices for further Raman-sideband cooling. Our setup features two high NA in-vacuo microscopes which will be used to create small scale structures such as 2x2 site plaquettes and to image the atoms. The technique combines fast experimental cycle times with single site addressability and detection and will allow to study the fundamental processes governing the Fermi-Hubbard model in a bottom-up approach.

[1] A.M. Kaufman et al., Physical Review X 2, 041014 (2012).

Q 48.5 Wed 15:00 K 1.022

Detection of Entanglement in a Fermi-Hubbard Dimer — •Andrea Bergschneider, Vincent Klinkhamer, Ralf Klemt, Jan Hendrik Becher, Gerhard Zürn, Philipp Preiss, and Selim Jochim — Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg

Entanglement is a defining feature of quantum many-body states and can be used to characterize quantum phases. In itinerant systems, where entanglement emerges naturally through coherent particle motion and interactions, it is notoriously challenging to detect experimentally.

We probe the presence of entanglement in the fundamental unit cell of the Fermi-Hubbard model. Using fermionic Lithium 6 in optical microtraps, we deterministically realize quantum states in a tunable double-well potential. These states are characterized by their spin- and particle resolved correlation functions in position and in momentum space. We observe strong correlations in both degrees of freedom, indicating the high coherence of the two-particle system. We establish witness criteria to certify the presence of entanglement in the Fermi-Hubbard dimer and separately observe the emergence of entanglement between modes and between particles.

Q 48.6 Wed 15:15 K 1.022

Spin-rotation coupling in Feshbach resonances of higher partial waves — •Binh Tran[1], Stephan Häfner[1], Bing Zhu[1], Manuel Gerken[1], Juris Ulmanis[1], Eberhard Tiemann[2], and Matthias Weidemüller[1,3] — [1]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [3]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China

We report evidence for spin-rotation (SR) coupling in an ultracold mixture of fermionic ^{6}Li and bosonic ^{133}Cs by magnetic field dependent atom-loss spectroscopy. For the p-wave (l = 1) Feshbach resonances we observe a triplet structure of different m_l components. We attribute the splitting of the $m_l = \pm 1$ component to electronic SR coupling. The size of the SR coupling constant in the highest vibrational state of LiCs is determined to be $|\gamma| = 0.000566(50)$ in units of the effective rotational constant. The SR-induced splitting is estimated for all other bialkali systems, suggesting that SR coupling has to be considered when classifying the p-wave superfluid phases in spin-polarized fermions.

Q 48.7 Wed 15:30 K 1.022

Design and characterization of a quantum heat pump in a driven quantum gas — •Arko Roy, Daniel Vorberg, and André Eckardt — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany.

We propose a novel scheme for quantum heat pumps powered by rapid time-periodic driving. We focus our investigation on a system con-

sisting of two coupled driven quantum dots in contact with fermionic reservoirs at different temperatures. Such a configuration can be realized in a quantum-gas microscope. Theoretically we characterize the device by describing the coupling to the reservoirs using the Floquet-Born-Markov approximation.

Q 48.8 Wed 15:45 K 1.022

Tuning the Drude Weight of Dirac-Weyl Fermions in One-Dimensional Ring Traps — Manon Bischoff[1], Johannes Jünemann[1,2], Marco Polini[3], and •Matteo Rizzi[1] — [1]Institut für Physik, Johannes Gutenberg-Universität, Mainz, Germany — [2]Graduate School Materials Science in Mainz, Mainz, Germany — [3]Istituto Italiano di Tecnologia, Graphene Labs, Genova, Italy

We study the response to an applied flux of an interacting system of Dirac-Weyl fermions confined in a one-dimensional (1D) ring. Combining analytical calculations with density-matrix renormalization group results, we show that tuning of interactions leads to a unique many-body system that displays either a suppression or an enhancement of the Drude weight – the zero-frequency peak in the ac conductivity – with respect to the non-interacting value. An asymmetry in the interaction strength between same- and different-pseudospin Dirac-Weyl fermions leads to Drude weight enhancement. Viceversa, symmetric interactions lead to Drude weight suppression. Our predictions can be tested in mixtures of ultracold fermions in 1D ring traps.

Ref.: Bischoff, *et al.*, arXiv:1706.02679v1

Q 48.9 Wed 16:00 K 1.022

The resonant state at filling factor 1/2 in chiral fermionic ladders — •Andreas Haller[1], Matteo Rizzi[1], and Michele Burrello[2] — [1]Institute of Physics, Johannes Gutenberg University, 55099 Mainz, Germany — [2]Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark

Helical liquids have been experimentally detected in both nanowires and ultracold atomic chains as the result of strong spin-orbit interactions. In both cases the inner degrees of freedom can be considered as an additional space dimension, providing an interpretation of these systems as synthetic ladders, with artificial magnetic fluxes determined by the spin-orbit terms. In this work, we analyze such a quasi-one-dimensional ladder geometry and characterize the helical state which appears at filling factor 1/2. This state is generated by a gap arising in the spin sector of the corresponding Luttinger liquid and can be interpreted as the one-dimensional (1D) limit of a fractional quantum Hall state of bosonic pairs of fermions. We study its main features, focusing on entanglement properties and correlation functions and support our analytic results with matrix product state simulations.