Q 58: Quantum Gases: Fermions III

Time: Friday 14:30–16:30 Location: P 204

Q 58.1 Fri 14:30 P 204

Spin chains of strongly interacting one-dimensional multi-component gases — •Frank Deuretzbacher[1], Daniel Becker[2], Johannes Bjerlin[3], Stephanie Reimann[3], and Luis Santos[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstrasse 2, 30167 Hannover — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [3]Mathematical Physics and NanoLund, LTH, Lund University, SE-22100 Lund, Sweden

Strongly interacting one-dimensional multicomponent gases form spin chains without the need for an optical lattice [1,2]. Such spin chains have been realized in Selim Jochim's group in Heidelberg with few two-component fermions [3]. The spin configurations of the spin chains may be detected through tunneling measurements and measurements of the occupancies of the single-particle trap levels and of the momentum distributions [4]. Finally, we show that strongly interacting one-dimensional Bose-Fermi mixtures form tunable XXZ spin chains [5]. The various phases of the XXZ model may be realized by tuning the interactions between the bosons and the bosons and fermions independently.

[1] F. Deuretzbacher *et al.*, Phys. Rev. Lett. 100, 160405 (2008)
[2] F. Deuretzbacher *et al.*, Phys. Rev. A 90, 013611 (2014)
[3] S. Murmann *et al.*, Phys. Rev. Lett. 115, 215301 (2015)
[4] F. Deuretzbacher *et al.*, Phys. Rev. A 94, 023606 (2016)
[5] F. Deuretzbacher *et al.*, arXiv:1611.04418 (2016)

Q 58.2 Fri 14:45 P 204

Revealing "hidden" antiferromagnetic correlations in hole-doped Hubbard chains via string correlators — •Timon Hilker[1], Guillaume Salomon[1], Martin Boll[1], Ahmed Omran[1], Jayadev Vijayan[1], Joannis Koepsell[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institute für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, München

In 1D quantum many-body systems the elementary excitations split into an independent spin and density sector. A microscopic observation of this phenomenon is so far elusive. Here we report on the observation of a striking consequence of spin-charge separation in 1D Fermi-Hubbard chains via the full measurement of both spin and density distributions. Our analysis in terms of string operators reveals "hidden" antiferromagnetic spin correlations masked by the holes in the doped system in direct analogy to hidden order in spin-1 Haldane chains. This allows us to restore Heisenberg correlations in the spin sector of the system independent of the density sector by studying "squeezed space", which effectively removes the holes separating the spins.

Our measurements demonstrate the power of quantum gas microscopes for the study of doped Hubbard systems that can be directly transferred to two dimensional systems.

Q 58.3 Fri 15:00 P 204

Transport of ultracold fermions through a mesoscopic one-dimensional lattice — •Martin Lebrat[1], Dominik Husmann[1], Samuel Häusler[1], Laura Corman[1], Sebastian Krinner[1], Pjotrs Grišins[2], Thierry Giamarchi[2], Jean-Philippe Brantut[1], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zurich, 8093 Zürich, Switzerland — [2]Department of Quantum Matter Physics, University of Geneva, 1211 Genève, Switzerland

Conductance is one of the simplest measurable quantities revealing the conducting or insulating nature of a physical system, and yet an intricate non-local property sensitive to quantum interferences at a microscopic level. In our cold-atom setup, such a conductance measurement can be performed by connecting two macroscopic reservoirs of ultracold fermions to a smaller structure engineered by light potentials, and probing the current created by a atom number difference between the reservoirs.

In this talk, we report on the transport of degenerate ^{6}Li atoms through a structure tailored in a bottom-up approach: using a Digital Micromirror Device to project up to nine consecutive scatterers inside a one-dimensional constriction, a lattice can be formed one site at a time. We observe the emergence of a band gap, originating from interferences among the scatterers. The coherent character of transport can be investigated by independently changing the lattice length and the temperature. The presence of a gap is robust against attractive interparticle interactions, hinting at the persisting fermionic character of the strongly correlated gas present in the 1d lattice.

Q 58.4 Fri 15:15 P 204

Measuring density and spin correlations in the two dimensional Hubbard model — •Jan Henning Drewes[1], Luke Miller[1,2], Eugenio Cocchi[1,2], Chun Fai Chan[1], Nicola Wurz[1], Marcell Gall[1], Daniel Pertot[1], Ferdinand Brennecke[1], and Michael Köhl[1] — [1]Physikalisches Institut, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany — [2]Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, United Kingdom

We experimentally study the emergence of correlations between ultracold fermionic atoms in a two dimensional optical lattice. For strong interactions and low temperatures from a comparison of local density fluctuations and thermodynamic quantities we observe the suppression of non-local density correlations indicating the localization of atoms in the Mott insulator. In the spin sector we observe the emergence of anti-ferromagnetic spin correlations and determine the uniform magnetic susceptibility of the two-dimensional Hubbard model from simultaneous in-situ absorption imaging of both spin components. At half filling and strong interactions our data can be described by the Heisenberg model of localized spins with anti-ferromagnetic correlations. Moreover, utilizing control over the trap shape we are able to engineer the entropy distribution within the system.

Q 58.5 Fri 15:30 P 204

Modulation spectroscopy of ultracold fermions in optical superlattices — •Karla Loida, Jean-Sébastien Bernier, and Corinna Kollath — Uni Bonn, Nussallee 14-16, 53115 Bonn

We study the excitation spectrum of the ionic Hubbard model. The ionic Hubbard model consists of three terms: a nearest-neighbor tunneling, an onsite interaction and an alternating energy offset between even and odd sites. It was originally introduced for the description of condensed matter systems, e.g. mixed stacked organic compounds, and can be cleanly realized by ultracold fermionic atoms confined to an optical superlattice. Its phase diagram in one dimension has attracted considerable theoretical interest. In the limits of predominating energy offset or onsite interaction strength, the ground state is a band insulator or Mott insulator, respectively. In between a narrow so-called bond-ordered wave phase has been predicted which spontaneously breaks site-inversion symmetry. The excitation spectrum of the ionic Hubbard model has attracted much less attention so far. We exert a time-periodic modulation and study the exact time-dependence in different phases within the time-dependent density matrix renormalization group method. Our study is motivated by the possibilities of experimental probing in cold atomic gas experiments where our choice of perturbation corresponds to lattice amplitude modulation spectroscopy of superlattice geometry.

Q 58.6 Fri 15:45 P 204

Quantum simulation of strong field phenomena in optical lattices — •Nikodem Szpak — Faculty of Physics, University of Duisburg-Essen, Germany

Ultracold atoms in optical lattices present a fascinating possibility of studying strong field phenomena for analogue quantum fields, usually not accessible in direct experiments. We review the methods used for the design of such optical systems with tailor made effective properties as well as possible observables. We concentrate on preparation of optical lattices with position and time-dependent tunneling parameters for creation of extremely strong electromagnetic and gravitational fields and on the possibilities of simulation of dynamical and spontaneous pair creation.

Q 58.7 Fri 16:00 P 204

Detecting topological order in finite-temperature and driven dissipative systems — •Dominik Linzner and Michael Fleischhauer — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

We propose a conceptual detection scheme of topological invariants for thermal and driven, dissipative gaussian systems. In closed systems topological order can be measured by means of quantized transport which coincides with a quantized winding of the polarization. This connection breaks down for mixed states, e.g. in the presence of a finite temperature. While in previous work [1] we have identified that the winding of the polarization is still quantized in open systems and can therefore be used to classify topological order, the same no longer holds true for transport properties. We show, however, that an auxiliary system at T≈0 coupled to the finite-temperature or driven system can inherit its topological properties. Thus a non-trivial winding of the polarization in the open system leads to a quantized particle transport in the auxiliary system. This allows us to detect topological order in open systems. [1] D. Linzner, L. Wawer, F. Grusdt and M. Fleischhauer, Phys. Rev. B **94**, 201105(R) (2016)

Q 58.8 Fri 16:15 P 204

Thermoelectric effects at an atomic quantum point contact
— •Laura Corman, Dominik Husmann, Martin Lebrat, Samuel Häusler, Jean-Philippe Brantut, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zürich, 8093 Zürich, Switzerland

Thermoelectricity describes the phenomenon by which a temperature gradient triggers the appearance of a chemical potential gradient and vice versa. It is of great technological importance for cooling materials (Peltier effect) or power generation (Seebeck effect), but it is also a fundamental probe of the physics of the medium in which the energy and particle currents are created. Thermoelectric effects have already been studied with cold atoms using a two-dimensional constriction [1].

In this presentation, we experimentally study those effects on our mesoscopic transport setup using ultracold fermionic lithium. These effects are affected by the properties of both the constriction and the reservoirs. First, we reduce the dimensionality of the constriction: two temperature imbalanced reservoirs are connected via a one to few mode channel, which is similar to the condensed matter quantum point contact systems. In addition, we can vary the interaction strength to reach the strongly interacting, unitary regime where the evolution of particle and energy currents are strongly modified compared to the weakly interacting case.

[1] J.P. Brantut, et al. "A thermoelectric heat engine with ultracold atoms." Science 342(6159), 713-715 (2013).