A 31: Quantum gases (Fermions) (joint session A/Q)

Time: Thursday 14:00–16:15 Location: S HS 1 Physik

A 31.1 Thu 14:00 S HS 1 Physik

Dynamical Observation of Spin-Charge Separation in Hubbard Chains — •Jayadev Vijayan[1], Pimonpan Sompet[1], Joannis Koepsell[1], Guillaume Salomon[1], Sarah Hirthe[1], Dominik Bourgund[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Ludwig-Maximilians-Universität, München

Ultracold atoms in optical lattices have emerged as a powerful tool in the quantum simulation of the Fermi-Hubbard model. With access to full spin and density resolution, our quantum gas microscope has enabled the study of the interplay between spin and charge in doped antiferromagnets. In one-dimensinal chains, the phenomenon of spin-charge separation decouples the spin and charge degrees of freedom, encoded in spinons and holons, which propagate at different velocities. We probe this phenomenon by preparing an antiferromagnet and locally quenching it by removing an atom, thereby creating a holon and a spinon. By observing their dynamical evolution, we extract different velocities for these quasi-particles.

A 31.2 Thu 14:15 S HS 1 Physik

Non-Equilibrium Dynamics Induced by Interaction Quenches in Ultra-Cold Fermi Gases — •Andreas Kell[1], Benjamin Rauf[1], Martin Link[1], Kuiyi Gao[1], Alexandra Behrle[1], Timothy Harrison[1], Johannes Kombe[2], Jean-Sebastien Bernier[2], Corinna Kollath[2], and Michael Köhl[1] — [1]Physikalisches Institut, University of Bonn, Bonn, Germany — [2]HISKP, University of Bonn, Bonn, Germany

Ultra-cold Fermi gases with tuneable interactions have gathered much interest in the last decade as an excellent tool for the investigation of the BEC-BCS crossover. The Cooper-pairing dynamics and thermalisation in a strongly interacting Fermi gas are not well understood, as the non-equilibrium dynamics upon a quench of the interaction strength 1/kFa are difficult to study both in theory and in experiment. We present our recent measurement results on the dynamics observed in fast changes of the interaction parameter.

A 31.3 Thu 14:30 S HS 1 Physik

Suppression and revival of long-range ferromagnetic order in the multiorbital Fermi-Hubbard model — •Agnieszka Cichy[1], Andrii Sotnikov[2], and Yeimer Zambrano[1] — [1]Adam Mickiewicz University, Poznań, Poland — [2]Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine

The impressive development of experimental techniques in ultracold quantum degenerate gases of alkaline-earth-like (e.g., ^{173}Yb) atoms in recent years has allowed investigation of strongly correlated multiorbital systems. Long-lived metastable electronic states in combination with decoupled nuclear spin give the opportunity to study the Hamiltonians beyond the possibilities of current alkali-based experiments. Motivated by recent experimental progress, by means of dynamical mean-field theory allowing for complete account of SU(2) rotational symmetry of interactions between spin-1/2 particles [1], we observe a strong effect of suppression of ferromagnetic order in the multiorbital Fermi-Hubbard model in comparison with a widely used restriction to density-density interactions. We analyze a connection to the double-exchange model and observe high importance of spin-flip processes there as well. Additional implications on the strongly correlated phases originating from differences between the optical-lattice realizations and interacting electrons in solid state systems are discussed.

[1] A. Sotnikov, A. Cichy, and J. Kuneš, Phys. Rev. B **97**, 235157 (2018).

A 31.4 Thu 14:45 S HS 1 Physik

Exact numerical simulations of periodically-driven one-dimensional extended Hubbard model — •Junichi Okamoto[1], Michael Thoss[1], and Shunske Sato[2] — [1]Institute of Physics, University of Freiburg, Freiburg, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Periodically driven many-body systems offer a new route to realize novel model Hamiltonians via Floquet engineering. Notable examples in cold atom systems are: controlling topology of a band structure [1], creating artificial gauge fields [2], and changing tunneling rate [3]. Here, we study a periodically driven one-dimensional extended Hubbard model with an exact time-dependent Schrödinger equation solver. We find that the rapid oscillation of external fields suppresses the tunneling rate, which leads to a metal-insulator transition. We look at the order parameters and transient conductivity to characterize the transition, and show that these quantities do not necessarily correspond to each other as in the equilibrium situations. Further more, two different definitions of transient conductivity give slightly different results. We also show that such a dynamical transition can be well captured by a Floquet effective Hamiltonian when the driving frequency is large enough.

[1] M. Tarnowski et al., Phys. Rev. Lett. 118, 240403 (2017) [2] J. Struck et al., Nature Physics 9, 738 (2013) [3] C. Sias et al., Phys. Rev. Lett. 100, 040404 (2008)

A 31.5 Thu 15:00 S HS 1 Physik

Dynamics in the Dissipative Fermi-Hubbard Model — •Lukas Freystatzky[1,2], Koen Sponsele[1], Benjamin Abeln[1], Marcel Diem[1], Bastian Hundt[1], André Kochanke[1], Thomas Ponath[1], Bodhaditya Santra[1], Klaus Sengstock[1,2,3], Christoph Becker[1,3], and Ludwig Mathey[1,2,3] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We study the decay dynamics of metastable ^{173}Yb atoms in a one dimensional lattice realizing a dissipative Fermi-Hubbard model. The dynamics are governed by the coherent evolution due to the Hamiltonian as well as an inelastic scattering process leading to two particle losses. We model the system with a Master equation approach and observe that the system is quickly driven into highly correlated Dicke states, which do not show dissipation any more. We observe a qualitatively similar result in experiment, and study the dependence of the particle number of the steady state on various parameters, motivated by the experimental findings.

The creation of strongly correlated states is a robust phenomenon and the dissipation can potentially be used to drive the system to very specific states, offering interesting opportunities for precision measurements.

A 31.6 Thu 15:15 S HS 1 Physik

Density-wave steady-state phase of dissipative ultracold fermions with nearest-neighbor interactions — Jaromir Panas[1], •Michael Pasek[1], Arya Dhar[1,2], Tao Qin[1], Andreas Geissler[1,3], Mohsen Hafez-Torbati[1], Max Erich Sorantin[4], Irakli Titvinidze[4], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Goethe-Universität, 60438 Frankfurt am Main, Germany — [2]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [3]ISIS, University of Strasbourg and CNRS, 67000 Strasbourg, France — [4]Institute of Theoretical and Computational Physics, Graz University of Technology, 8010 Graz, Austria

We investigate the effect of local dissipation on the presence of density-wave ordering in spinful fermions with both local and nearest-neighbor interactions as described by the extended Hubbard model. We find density-wave order to be robust against decoherence effects up to a critical point where the system becomes homogeneous with no spatial ordering. These results should be relevant for future cold-atom experiments using fermions with non-local interactions arising from the dressing by highly-excited Rydberg states, which have finite lifetimes due to spontaneous emission processes.

A 31.7 Thu 15:30 S HS 1 Physik

Easing the sign problem — •Dominik Hangleiter[1], Ingo Roth[1], Daniel Nagaj[2], and Jens Eisert[1] — [1]Freie Universität Berlin, 14195 Berlin — [2]Slovak Academy of Sciences, Bratislava, Slovakia

Quantum Monte Carlo (QMC) methods are the gold standard for studying equilibrium properties of quantum many-body systems – their phase transitions, their ground and thermal state properties. The idea lying at the heart of QMC methods is to sample out expectation values or partition functions by expanding these quantities in a basis. However, such methods face a severe limitation for many quantum

systems, in particular so for fermionic systems. This limitation has been dubbed the 'sign problem' of QMC, referring to the situation in which the distribution to be sampled from is non-positive. Here, we take a systematic approach towards alleviating the sign problem by local basis changes, realising that it is a basis-dependent property. Going beyond previous work on exactly 'curing' the sign problem, we consider the optimization problem of finding the basis in which the sign problem is smallest and refer to this problem as 'easing' the sign problem. We then show that easing the sign problem can be a computationally hard task, even in situations in which finding an exact solution or deciding if such a solution exists is easy.

Invited Talk A 31.8 Thu 15:45 S HS 1 Physik

String patterns in the doped Hubbard model — •Daniel Greif — Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

Quantum simulation is rapidly emerging as a powerful technique to understand the physics of strongly correlated materials. Quantum gas microscopy is perfectly suited to study the Fermi-Hubbard model, a model widely believed to capture the physics of high-temperature superconductivity. In this talk I will discuss how we search for specific patterns within many individual images of realizations of strongly correlated ultracold fermions in an optical lattice. Upon doping a cold-atom antiferromagnet we find signatures of geometric strings, entities suggested to explain the relationship between hole motion and spin order. We compare both our pattern-based and conventional experimental observables to theoretical predictions, and find very good agreement to a geometric theory of strings, as well as to a pi-flux model of spin liquids. Our results demonstrate the potential for pattern recognition and more advanced computational algorithms including machine learning to provide key insights into cold-atom quantum many-body systems.