Q 61: Quantum Gases: Fermions II

Time: Friday 11:00–13:15 Location: e001

Q 61.1 Fri 11:00 e001

Realizing state-dependent optical lattices for ultracold fermions by periodic driving — •Frederik Görg[1], Gregor Jotzu[1], Michael Messer[1], Daniel Greif[1,2], Rémi Desbuquois[1], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland — [2]Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

Ultracold atoms in optical lattices offer the possibility to engineer specific Hamiltonians with widely tunable properties. Recently, time-modulated optical lattices have been used to dynamically control the atomic tunnelling and to realize effective Floquet lattice Hamiltonians with a non-trivial topological band structure. While previous implementations relied on the physical motion of the lattice potential, this effect can also be realized by a periodic modulation of a magnetic field gradient. As the coupling of an atom to this magnetic field gradient depends on its magnetic moment and therefore its internal state, the effective Hamiltonian is spin-dependent.

We realize a state-dependent lattice for fermionic potassium atoms and characterize the different band structures for each internal state by measuring the expansion rate of an atomic cloud in the lattice and the effective mass through dipole oscillations. Furthermore, we study the heating caused by the periodic driving in an interacting fermionic spin mixture and how it can be suppressed. This method of creating spin-dependent optical lattices can be used to create novel situations, such as systems where one fermionic spin state is pinned to the lattice, while the other remains itinerant.

Q 61.2 Fri 11:15 e001

Experimental reconstruction of the Berry curvature in a topological Bloch band — •Nick Fläschner, Benno Rem, Matthias Tarnowski, Dominik Vogel, Dirk-Sören Lühmann, Klaus Sengstock, and Christof Weitenberg — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Topological properties lie at the heart of many fascinating phenomena in solid state systems such as quantum Hall systems or Chern insulators. The topology can be captured by the distribution of Berry curvature, which describes the geometry of the eigenstates across the Brillouin zone. Employing fermionic ultracold atoms in a hexagonal optical lattice, we generate topological bands using resonant driving and show a full momentum-resolved measurement of the ensuing Berry curvature. Our results pave the way to explore intriguing phases of matter with interactions in topological band structures.

Q 61.3 Fri 11:30 e001

Detecting the BCS order parameter in the dephasing of collective oscillations after a sudden ramp of the lattice depth in a honeycomb lattice — •Marlon Nuske[1], Eite Tiesinga[2], and Ludwig Mathey[1] — [1]Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [2]Joint Quantum Institute and Center for Quantum Information and Computer Science, National Institute of Standards and Technology and University of Maryland, Gaithersburg, Maryland 20899, USA

We obtain the excact time evolution for a mean-field Bardeen-Cooper-Schrieffer (BCS) state after a sudden quench to a large lattice depth, where the dynamics is dominated by interactions between atoms. The quench initiates collective oscillations with frequency $U_f/(2\pi)$ of the momentum occupation numbers and imprints a phase oscillating with the same frequency on the order parameter. Finite hopping after the quench leads to dephasing of the different momentum modes and a subsequent damping of the oscillations. Even for finite temperatures this occurs for a mean-field BCS state, but not for a non-interacting Fermi gas. Measuring the dephasing of collective oscillations of occupation numbers may therefore be used as a signature to detect the BCS order parameter Δ. Finally, we investigate the time evolution of the density-density correlations.

Q 61.4 Fri 11:45 e001

Floquet-Boltzmann equation for periodically driven Fermi systems — •Maximilian Genske and Achim Rosch — Institut für Theoretische Physik, Universität zu Köln, D-50937 Cologne, Germany

Periodically driven quantum systems can be used to realize quantum pumps, ratchets, artificial gauge fields and novel topological states of matter. Starting from the Keldysh approach, we develop a formalism, the Floquet-Boltzmann equation, to describe the dynamics and the scattering of quasiparticles in such systems. The theory builds on a separation of time-scales. Rapid, periodic oscillations occurring on a time scale $T_0 = 2\pi/\Omega$, are treated using the Floquet formalism and quasiparticles are defined as eigenstates of a non-interacting Floquet Hamiltonian. The dynamics on much longer time scales, however, is modeled by a Boltzmann equation which describes the semiclassical dynamics of the Floquet-quasiparticles and their scattering processes. As the energy is conserved only modulo $\hbar\Omega$, the interacting system heats up in the long-time limit. As a first application of this approach, we compute the heating rate for a cold-atom system, where a periodical shaking of the lattice was used to realize the Haldane model [G. Jotzu *et al.*, Nature **515**, 237 (2014)].

Q 61.5 Fri 12:00 e001

Dynamics of Trapped Dipolar Fermi Gases: From Collisionless to Hydrodynamic Regime — •Vladimir Veljić[1], Antun Balaž[1], and Axel Pelster[2] — [1]Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research Center OPTIMAS, Technical UIniversity of Kaiserslautern, Germany

A recent time-of-flight expansion experiment has now unambiguously detected a Fermi surface deformation in a dipolar quantum gas of fermionic erbium atoms in the collisionless regime [1]. Here we follow Ref. [2] and perform a systematic study of a time-of-flight expansion for trapped dipolar Fermi gases ranging from the collisionless to the hydrodynamic regime at zero temperature. To this end we solve analytically the underlying Boltzmann-Vlasov equation in the vicinity of equilibrium by using a suitable rescaling of the equilibrium distribution [3], where the collision integral is simplified within a relaxation time approximation. We also analyze the quench dynamics, which is induced by a sudden rotation of the polarization of the atomic magnetic moments and show that it can be understood in terms of a superposition of the low-lying collective modes. All presented analytical and numerical calculations are relevant for understanding quantitatively ongoing experiments with ultracold fermionic dipolar atoms.

[1] K. Aikawa, et al., Science **345**, 1484 (2014).
[2] F. Wächtler, A. R. P. Lima, and A. Pelster, `arXiv:1311.5100`.
[3] P. Pedri, D. Guery-Odelin, and S. Stringari, Phys. Rev. A **68**, 043608 (2003).

Q 61.6 Fri 12:15 e001

Emergence of orthogonality in the Fermi impurity problem — •Andrea Bergschneider, Michael Dehabe, Jan Hendrik Becher, Vincent M. Klinkhamer, Simon Murmann, Gerhard Zürn, and Selim Jochim — Physikalisches Institut der Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

In quasi-one-dimensional systems, the ground-state wave function of an impurity particle interacting with a Fermi sea is orthogonal to the wave function of the non-interacting system. In this case the squared overlap between the interacting and the non-interacting systems, which is defined as the quasiparticle residue, is zero.

Here, we report on measurements of the residue of a single fermionic impurity particle interacting with an increasing number of majority particles. To probe the system, we flip the spin of the impurity particle by driving a radio frequency (RF) transition. In a previous experiment we used RF spectroscopy to measure the interaction energy in this system while increasing the number of majority particles one atom at a time and thereby observed the crossover from few to many-body physics [1]. Now, we measure how the wave function overlap between initial and final states changes both as a function of interaction strength and the number of majority particles. Our goal is to extend these measurements into the crossover region between few and many-body physics by increasing the number of majority particles and thereby observe the emergence of the orthogonality catastrophe.

[1] Wenz et al. Science 342, 457 (2013)

Q 61.7 Fri 12:30 e001

Many-body localization in the presence of photon scattering — •Henrik Lueschen[1,2], Pranjal Bordia[1,2], Sean