Q 70: Quantum Gases: Bosons VI

Time: Friday 14:30–16:00 Location: f342

Q 70.1 Fri 14:30 f342

Non-equilibrium steady-states in a driven dissipative superfluid — •Bodhaditya Santra, Ralf Labouvie, Simon Heun, and Herwig Ott — Research Center OPTIMAS and Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Non-equilibrium steady-states constitute fix points of the phase space dynamics of classical and quantum systems. They emerge under the presence of a driving force and lie at the heart of transport phenomena such as heat conduction or current flow.

We experimentally study the steady-states of a driven-dissipative Josephson junction array, realized with a weakly interacting Bose Einstein condensate residing in a one-dimensional optical lattice [1]. Engineered losses on one site act as a local dissipative process, while tunneling from the neighboring sites constitutes the driving force. We characterize the emerging steady-states of this atomtronic device. With increasing dissipation strength the system crosses from a superfluid state, characterized by a coherent DC Josephson current into the lossy site to a resistive state, characterized by an incoherent hopping transport. For intermediate values of the dissipation, the system exhibits bistability, where a superfluid and a resistive branch coexist. We also study the relaxation dynamics towards the steady-state, where we find a critical slowing down, indicating the presence of a non-equilibrium phase transition.

[1] R. Labouvie, B. Santra, S. Heun, H. Ott, arXiv:1507.05007

Q 70.2 Fri 14:45 f342

Studying quench dynamics in an ultracold quantum gas by near-field interferometry — •Christian Baals, Bodhaditya Santra, Ralf Labouvie, and Herwig Ott — Research Center OPTIMAS and Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The effect of interferometric self-imaging in the near-field, also known as Talbot effect, has been exploited in many areas of research since its discovery in the 19th century. In our experiment the temporal Talbot effect is used to measure the coherence length of a matter-wave field. A Bose-Einstein condensate of Rb-87 is loaded adiabatically into a 1D or a 3D optical lattice. Subsequently, the lattice potential is switched off and on again for a short time. The momentum distribution is observed in absorption images after time-of-flight where the width of the central peak serves as a measure of coherence. For a superfluid this width shows oscillations where the period corresponds to the Talbot time. In the Mott-insulating regime these oscillations disappear but can be restored by quenching the system to the superfluid regime before the pulse is applied. With increasing waiting time between the quench and the pulse the coherence length increases which can directly be seen by the appearance of oscillations in the measurement signal.

Q 70.3 Fri 15:00 f342

Observation of symmetry-broken momentum distributions: matter-wave diffraction during time-of-flight expansion — •Christoph Ölschläger, Malte Weinberg, Ole Jürgensen, Dirk-Sören Lühmann, Juliette Simonet, and Klaus Sengstock — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The information about quantum gas systems is still commonly inferred from time-of-flight measurements.

Here, we demonstrate that interaction during the time-of-flight expansion can strongly alter the measurement of the initial atomic momentum distribution. We discuss the observation of symmetry-broken momentum distributions for bosonic mixtures in state-dependent honeycomb lattices due to scattering processes within the first milliseconds of the expansion time.

These findings play an inevitable role in a broad range of systems, including state-dependent lattices and superlattices, where the lattice symmetry does not cancel the influence of the scattering processes on the interference pattern. In addition, the interactions during a free expansion can indeed be used as an interferometric probe to reveal novel quantum phases, such as supersolids.

Q 70.4 Fri 15:15 f342

Topological edge state with ultracold atoms in a spatially variable lattice potential — •Martin Leder[1], Christopher Grossert[1], Till Ockenfels[1], Maximilian Genske[2], Achim Rosch[2], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Universität Bonn — [2]Institut für Theoretische Physik, Universität zu Koeln

An electronic topological insulator has a bulk energy band gap like an ordinary insulator, but conducting edge states on the surface that are insensitive to material impurities [1]. We report on the observation of a topological edge state located between two spatial regions with different topological phases in an atomic physics experiment. Our experiment is built upon a one-dimensional geometry, and uses four-photon lattice potentials which are realized in an atomic three-level system with two ground states of different spin projections and one spontaneously excited state [2]. Using an additional combination of a magnetic field gradient and a careful momentum preparation of an ultracold rubidium atomic wave packet allows to simulate an effective Dirac equation with a spatially varying mass term. We experimentally observe the trapping of the atoms in a bound state locked to the position of the band crossing between of two spatial regions of different topology in the lattice. Our real space observations give a direct link to the SSH model of the electrical conductance of polyacetylene [3].

[1] M. Z. Hasan and C. L. Kane, Rev. Mod. Phys. **82**, 3045 (2010).
[2] G. Ritt *et al.*, Phys. Rev. A **74**, 063622 (2006).
[3] W. P. Su *et al.*, Phys. Rev. Lett. **42**, 1698 (1979).

Q 70.5 Fri 15:30 f342

Phase diagrams of ultra cold selforganized structures in cavity QED potentials — •Astrid Elisa Niederle, Heiko Rieger, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany

Scattering of photons into an optical resonator by laser-driven atoms can give rise to atomic structures, which emerge from the interplay between drive and cavity losses. These structures match an underlying Bragg order, thus maximizing the number of intracavity photons which in turn mechanically stabilize the atomic density distribution. We analyse the phases of bosonic atoms confined on a plane by an external optical lattice, whose periodicity is commensurate and incommensurate with the wavelenght of a cavity mode. This system can be described by a Bose-Hubbard model with a specific dynamical on-site potential [1]. We determine the ground state properties using local mean field theory complemented by a cluster analysis [2]. We identify the parameter regimes for which this underlying order emerges and show that it can exhibit nontrivial features, to which quantitatively different patterns correspond. In the incommensurate case these phases are all compressible, and for given atomic densities can exhibit superfluidity even at vanishing tunneling. We discuss the corresponding observables and show that these predictions could be tested in existing experiments [3].

[1] Phys. Rev. A **81** (2010) 043407 and Phys. Rev. A **88** (2013) 043618, [2] New. J. Physics **15** (2013) 075029, [3] Nautre **464** (2010) 1301

Q 70.6 Fri 15:45 f342

The effects of curvature in deformed optical lattices — •Nikodem Szpak — Fakultät für Physik, Universität Duisburg-Essen

Special designs of optical lattices, involving complex or unitary matrix-valued tunneling amplitudes, enable for various realizations of effective gauge fields on the lattice. Analogously, local deformations of the optical lattices influencing the real part of the tunneling amplitudes can be interpreted in terms of an effective metric of a curved space. We review some setups, including finite-width laser beams or traps, giving rise to such artificial curvature and discuss interesting phenomena associated with it, like ground state (de)localization or focusing of traveling waves.