A 36: Ultra-cold atoms, ions and BEC IV (with Q)

Time: Thursday 10:30–12:30 Location: BEBEL E34

A 36.1 Thu 10:30 BEBEL E34

Manipulation and Coherence of Ultracold Atoms in Superconducting Coplanar Resonator — •Helge Hattermann, Simon Bernon, Patrizia Weiss, Martin Knufinke, Daniel Bothner, Matthias Rudolph, Reinhold Kleiner, Dieter Koelle, and József Fortágh — Physikalisches Institut and CQ Center for Collective Quantum Phenomena and their Applications, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

Superconducting circuits in the microwave regime are promising candidates for quantum information processing. However, their coherence times are still limited to 100 μs. A possible solution is to create a hybrid quantum system, in which the quantum information is processed by superconducting circuits and the information is coherently transferred and stored in a second quantum system. Due to their long coherence times, ultracold atoms coupled to a superconducting resonator are suitable for such a quantum memory.

Here we report on the preparation and coherence of atomic ensembles in a superconducting coplanar resonator on an atom chip based on niobium thin films at 4.2 K. Atoms are trapped by persistent currents in the resonator ground planes. The coherence of atomic superposition states is investigated by means of Ramsey interferometry. We find atomic coherence times on the order of several seconds. We report on progress towards coupling of the atoms to the mode of a cavity.

S. Bernon *et. al.,* Nat. Commun. **4**, 2380 (2013)

A 36.2 Thu 10:45 BEBEL E34

Measuring the resistive flow above the critical current in an atomic superfluid — •Fred Jendrzejewski, Stephen Eckel, Christopher J. Lobb, William D. Phillips, and Gretchen K. Campbell — Joint Quantum Institute, NIST and the University of Maryland

A superfluid current between two reservoirs, i.e. a source and drain, is persistent even without an external chemical potential difference between the reservoirs. However, above a critical current the superfluid flow becomes unstable and excitations are created, leading to resistive flow. To sustain such a dissipative current, an external chemical potential difference between the source and the drain must be applied.

In this presentation we report on the direct observation of both superfluid and resistive flow through a weak link in a weakly interacting atomic BEC. In our superfluid system, two weak links are used to divide a ring-shaped trap into two regions. Moving the weak links at a constant rate, allows for the creation of controlled flow between the source and the drain. Above a critical value of the weak link velocity, we observe a chemical potential difference between the distinct reservoirs which increases as a function of time. The observed time evolution can be well described in terms of a phenomenological theory incorporating explicitly the creation of excitations in form of phase slips. Such transport measurements will allow for a study of the microscopic origin of the dissipation and paves the way for more complex atomtronic devices like atomic DC squids.

A 36.3 Thu 11:00 BEBEL E34

Field ionization of rubidium atoms near nanotips — •Markus Stecker, Peter Federsel, Hannah Schefzyk, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Germany

Detection of correlations in ultracold quantum gases requires a well suited local single atom detection scheme. For this purpose, we investigate the possibility of using charged nanotips. Due to the strong field enhancement at the tip apex, low voltages are sufficient to field ionize nearby rubidium atoms. As the ionization volume is on the length scale of the tip radius and the ions are detected with single particle resolution, this scheme should allow for local, in-situ investigation of ultracold atomic clouds.

We present the first steps towards this new detection scheme. Using a pulsed electrochemical etching technique, we produce sharp tungsten tips with variable length and nanometer sized tip radii. The field enhancement of the tip is characterized by electron field emission measurements. We demonstrate field ionization of rubidium at a single charged nanotip and investigate adsorption effects. As a next step, cold magneto-optically trapped atoms are ionized close to a tungsten nanotip.

A 36.4 Thu 11:15 BEBEL E34

Towards Graphene Atom Chips — •Christian Koller[1], Amruta Gadge[1], Robert Hollenstein[1,2], Samanta Piana[1], Jessica Maclean[1], Francesco Intravaia[1,3,4], Mark Fromhold[1], and Peter Krueger[1] — [1]MIdlands Ultracold Atom Research Center, UNiversity of Nottingham, NG7 2RD, Nottingham, UK — [2]Vienna Center for Quantum Science and Technology, TU Wien, Atominstitut, Stadionallee 2, 1020 Wie — [3]Max-Born-Institut, 12489 Berlin, Germany — [4]Institut fuer Physik, Humboldt-Universitaet zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

Current atom chip technology enables trapping of atoms at distances of 10-100 microns from the surface. The limitation on the trapping distance arises from distance-dependent effects like surface forces, Johnson noise or fields generated from the adsorbates. Ultra-close trapping of atoms would improve the resolution of cold-atom based surface probes when they are used to map out current distributions and electric and magnetic fields. We are constructing an experimental system to trap atoms very close to the surface, considering relevant effects that can impede trapping at submicron distances. The basis of these experiments is an atom chip incorporating a thin film. We will position an ultracold cloud of Rb87 atoms, above a graphene sheet supported by a TEM grid, which will allow us to control and shift the cloud precisely to specific grid locations. We will compare the losses from the trap when the cloud is above the metal part and the hollow region of the grid. We will show theoretical calculations and experimental progress.

A 36.5 Thu 11:30 BEBEL E34

Excited-state quantum phase transitions in Dicke superradiance models — •Tobias Brandes — TU Berlin

We derive analytical results [1] for various quantities related to the excited-state quantum phase transitions in a class of Dicke superradiance models in the semiclassical limit. Based on a calculation of a partition sum restricted to Dicke states, we discuss the singular behavior of the derivative of the density of states and find observables such as the mean (atomic) inversion and the boson (photon) number and its fluctuations at arbitrary energies. Criticality depends on energy and a parameter that quantifies the relative weight of rotating versus counterrotating terms, and we find a close analogy to the logarithmic and jump-type nonanalyticities known from the Lipkin-Meshkov-Glick model.

[1] T. Brandes, Phys. Rev. E 88, 032133 (2013).

A 36.6 Thu 11:45 BEBEL E34

Observation of atom-ion charge transfer beyond the Langevin regime — •Amir Mohammadi, Artjom Krükow, Arne Härter, Tobias Schnetzer, Joschka Wolf, and Johannes Hecker Denschlag — Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, D-89069 Ulm, Deutschland

We investigate the interaction of a laser-cooled trapped ion ($^{138}Ba^+$ or $^{87}Rb^+$) with an ultracold cloud of optically confined ^{87}Rb atoms. The ion is held in a linear Paul trap and is immersed in the center of the cold atomic cloud. Due to the interaction potential $\frac{1}{r^4}$ charge transfer collisions usually occur at an energy independent rate [1]. This leads to an energy independent charge transfer rate which has been confirmed experimentally [2, 3]. In our experiments we observe a deviation from this behavior as we find strong energy dependence in the charge transfer rate at kinetic energies in the sub-mK range. At these very low kinetic energies an additional charge transfer channel opens up due to the increasing importance of three-body atom-atom-ion recombination [4]. We present first experimental findings of this novel charge transfer mechanism.

[1] P. Langevin, Ann. Chim. Phys. **5**, 245 (1905)
[2] Andrew T. Grier *et al.*, Phys. Rev. Lett. **102**, 223201 (2009)
[3] Felix H. J. Hall *et al.*, Phys. Rev. Lett. **107**, 243202 (2011)
[4] Arne Härter *et al.*, Phys. Rev. Lett. **109**, 123201 (2012)

A 36.7 Thu 12:00 BEBEL E34

Excited state quantum phase transition in the kicked top — •Victor M. Bastidas[1], Pedro Perez-Fernandez[2], Malte Vogl[1], and Tobias Brandes[1] — [1]Institut für Theoretische Physik, Technis-

che Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Departamento de Fisica Aplicada III, Escuela Superior de Ingenieros, Universidad de Sevilla, Camino de los Descubrimientos s/n, ES-41092 Sevilla, Spain

Our aim in this talk is to describe the excited state quantum phase transition in the quasienergy spectrum of the kicked top. Using a semi-classical approach, we analytically obtain a logarithmic divergence in the density of states, which is a hallmark of a continuous excited state quantum phase transition. We propose a protocol to observe signatures of the phase transition close to the critical quasienergy.

A 36.8 Thu 12:15 BEBEL E34

Noise driven transition in nonlinear lattices — •Alexandru Nicolin and Mihaela Carina Raportaru — Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH), Reactorului 30, Magurele, Romania

The classical Fermi-Pasta-Ulam problem is considered in the context of stochastic stability to show that spatially periodic states that are Lyapunov stable are unstable with respect to stochastic perturbations. We present detailed numerical simulations to show the collapse of the periodic states onto the fundamental states due to stochastic perturbations. Our results are directly relevant for Bose-Einstein condensates loaded into optical lattices where such periodic states have already been realised experimentally and their stability with respect to the interaction with the thermal cloud is yet uncharted territory.