A 35: Ultra-cold atoms, ions and BEC VII (with Q)

Time: Thursday 14:00–16:00 Location: B 305

A 35.1 Thu 14:00 B 305

Magneto-optical trapping of dysprosium — •Thomas Maier, Holger Kadau, Matthias Schmitt, Michaela Nickel, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Strongly dipolar quantum gases enable the observation of many-body phenomena with anisotropic, long-range interaction. Rotonic features, 2D stable solitons and the supersolid state are some of the exotic many-body phenomena predicted for such quantum gases. Recent generation of degenerated bosonic [1] and fermionic dysprosium [2] and bosonic erbium [3], both elements with large magnetic dipole moment, are promising candidates to observe these mentioned effects.

We report on progress in our experiment to achieve degenerate dysprosium quantum gases. Dysprosium is the element with the highest magnetic moment and offers a non-spherical symmetric groundstate $^5I_8$. In the present stage, we realized a magneto-optical trap (MOT) for dysprosium on a broad cooling transition at 421 nm. Future perspectives are to implement a narrow-line MOT on the 626 nm cooling transition, similar to the work in [3].

[1] M. Lu *et al.*, Phys. Rev. Lett. **107**, 190401 (2011)
[2] M. Lu *et al.*, Phys. Rev. Lett. **108**, 215301 (2012)
[3] K. Aikawa *et al.*, Phys. Rev. Lett. **108**, 210401 (2012)

A 35.2 Thu 14:15 B 305

Dissipative Binding of Lattice Bosons through Distance-Selective Pair Loss — Cenap Ates, Beatriz Olmos, •Weibin Li, and Igor Lesanovsky — School of Physics and Astronomy, The University of Nottingham, Nottingham NG7 2RD, United Kingdom

We show that in a gas of ultracold atoms distance selective two-body loss can be engineered via the resonant laser excitation of atom pairs to interacting electronic states. In an optical lattice this leads to a dissipative master equation dynamics with Lindblad jump operators that annihilate atom pairs with a specific interparticle distance. In conjunction with coherent hopping between lattice sites this unusual dissipation mechanism leads to the formation of coherent long-lived complexes that can even exhibit an internal level structure which is strongly coupled to their external motion. We analyze this counterintuitive phenomenon in detail in a system of hard-core bosons. While current research has established that dissipation in general can lead to the emergence of coherent features in many-body systems our work shows that strong nonlocal dissipation can effectuate a binding mechanism for particles.

A 35.3 Thu 14:30 B 305

Atomic Coherence in a Superconducting Coplanar Resonator — •Patrizia Weiss, Helge Hattermann, Simon Bernon, Daniel Bothner, Martin Knufinke, 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 devices have proved suitable for fast qubit operations and quantum gates. However, their coherence times are still limited to a few μs. Therefore hybrid quantum systems have attracted considerable interest. One promising system is composed of superconductors and cold atoms, in which the atomic ensemble takes the role of a quantum memory and is coupled to a superconducting resonator that acts as a quantum bus.

Here we report on the preparation and coherence times of atomic ensembles in a superconducting coplanar resonator on an atom chip. The superconducting structures are based on niobium thin films at 4.2 K. Atoms are trapped by persistent currents in the resonator ground planes. We are able to produce large BECs of up to 10^6 atoms. The coherence of atomic superposition states is investigated by means of Ramsey interferometry. We find atomic coherence times on the order of $T_2 \sim 10$ s. We report on progress towards coupling of the atoms to the mode of a cavity.

A 35.4 Thu 14:45 B 305

Millikelvin System for Cold Atom Superconductor Hybrid Quantum Devices — •Florian Jessen, Martin Knufinke, Petra Vergien, Malte Reinschmidt, Helge Hattermann, Simon Bernon, Simon Bell, Daniel Cano, Dieter Kölle, Reinhold Kleiner, and József Fortágh — Center for Collective Quantum Phenomena, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

Hybrid quantum systems based on ultracold atoms and superconducting devices are promising candidates for fundamental physics as well as quantum information especially superconducting quantum circuits require millikelvin temperatures for their operation and sufficiently long coherence time. Towards realisation of the cold atom/superconductor quantum interface we installed cold atoms setup into a delution refrigerator reaching a base temperature of 50mK. We report on the operation of this system.

A 35.5 Thu 15:00 B 305

Semiclassical dynamics of ultracold Bosons in multiple wells — •Lena Simon and Walter Strunz — Institut für theoretische Physik, TU Dresden

We aim to shed light on the transition from a nonequilibrium to an equilibrium state of an interacting bosonic manybody system. We investigate the dynamics of an ensemble of Bosons in a multiple well potential, which has been initially set up in a nonequilibrium state. The Bosons display interesting dynamics, gouverned by the interplay of tunneling and the interaction amongst the particles. The dynamics are investigated by solving the full Schroedinger equation for a Bose-Hubbard-model, and by means of the so called (semiclassical) Herman-Kluk propagator. The results are also compared to the often applied mean-field approximation.

A 35.6 Thu 15:15 B 305

Noise correlations of two-dimensional Bose gases — •Vijay Pal Singh and Ludwig Mathey — Zentrum fuer Optische Quantentechnologien and Institut fuer Laserphysik, Universitaet Hamburg, D-22761 Hamburg, Germany

We analyze the density-density correlations of the expanding clouds of weakly interacting two-dimensional (2D) Bose gases below and above the Berezinskii-Kosterlitz-Thouless (BKT) transition. Such a system has two thermal phases in equilibrium, defined through the long-range order of the two-point correlation function. In the course of a time-of-flight expansion, both thermal and quantum fluctuations present in the trapped system transform into density fluctuations. The spectrum of density distributions shows an oscillatory shape controlled only by the scaling exponent of the quasi-condensed phase (below the transition) and by the correlation length (above the transition). This exponent can be extracted by analyzing the evolution of the spectrum of density distributions as a function of the expansion time. The positions of the spectral peaks show a scaling behavior with the expansion time. How these features can be extracted in experiment will be discussed as well.

A 35.7 Thu 15:30 B 305

Quasi-particle excitation spectra of general quantum lattice systems via the 1/Z expansion — •Patrick Navez, Konstantin Krutitsky, Friedemann Queisser, and Ralf Schützhold — Fakultät für Physik, Universität Duisburg-Essen, Duisburg, Germany

We investigate general quantum lattice systems such as the Bose and Fermi Hubbard models or the Heisenberg spin model using the 1/Z expansion method [1,2] where Z is the coordination number. This method provides a general framework for deriving linearized equations of motion for quasi-particle excitation operators, which yield the excitation spectra, for example. Their solutions determine the one-site reduced density matrix and the two-sites reduced correlation density matrix, which are given in terms of bilinear expectation values of the quasi-particle excitation operators (displaying the quantum fluctuations). We illustrate the powerfulness of these general concepts for several examples such as particle-hole operators in the Mott phase of the Bose and Fermi Hubbard models (which lower the ground state energy by virtual tunneling) or the Heisenberg model (where virtual magnon excitations of opposite spin reduce antiferromagnetism) and compare our findings with the results found in the literature.

1 P. Navez, R. Schützhold, Phys. Rev. A 82, 063603 (2010)

2 F. Queisser, K. Krutitsky, P. Navez, R. Schützhold,

arXiv:1203.2164

A 35.8 Thu 15:45 B 305

Local Detection of Quantum Gases in Real Time — •Peter Federsel, Markus Stecker, Simon Bell, Hannah Schefzyk, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Deutschland

In this talk, we describe a novel scheme for local single-atom detection in trapped clouds of ultracold atoms. The scheme is based on local field ionization of atoms and subsequent ion detection. The ionization takes place in the locally enhanced near-field at the tip of a charged nanowire. Field strengths of up to 10^{10} V/m can be achieved, sufficient for field ionization of nearby rubidium atoms. The detection scheme is fully compatible to state-of-the-art atomchip experiments and includes ion-optics for extracting and guiding the ions to the sensitive single ion detector. We will show first results on this new detection scheme, including measurements on the tips field enhancement, characterization of the ion optics and field-ionization of thermal atoms.