Q 42: Ultrakalte Atome (Manipulation und Detektion / Quantengase)

Zeit: Donnerstag 14:00–16:00 Raum: 1C

Gruppenbericht Q 42.1 Do 14:00 1C

Direct observation of individual atoms in an optical lattice — •Tatjana Gericke, Peter Würtz, Daniel Reitz, Tim Langen, and Herwig Ott — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz

Ultracold atoms in optical lattices have demonstrated to be an interesting system to study quantum phenomena such as quantum phase transitions and strongly correlated many-body systems. The lattice spacing in such systems ranges from 400 nm to 600 nm. Although many different detection schemes have been developed, a high resolution *in situ* imaging system with single atom sensitivity is still lacking. Our new imaging technique is based on the principles of scanning electron microscopy in combination with electron impact ionization. A 6 keV electron beam with a FWHM of around 200 nm is scanned across the atom cloud and ionizes an atom. The resulting ion is subsequently extracted with the aid of ion optics and detected by a channeltron detector.

We use an all optical BEC approach in a single beam CO_2 optical dipole trap and produce a ^{87}Rb condensate with up to 120000 atoms. The condensate is then loaded into an optical lattice. The optical lattice has a spacing of 604 nm and is formed by two focused laser beams with a wavelength of 854 nm intersecting each other under an angle of 90 degrees. We can observe single lattice sites of the optical lattice with the new imaging technique. The current status of the experiment is presented.

Q 42.2 Do 14:30 1C

State-selective microwave potentials on atom chips — •Max F. Riedel[1,2], Pascal Böhi[1,2], Johannes Hoffrogge[1,2], Theodor W. Hänsch[1,2], and Philipp Treutlein[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München

We report on current results of our experiment with microwave near-fields on an atom chip.

The integrated miniaturized microwave guiding structures on our chip allow the generation of microwave near-fields with unusually strong gradients. Through microwave dressing of hyperfine states, these can be used to create state-selective double-well potentials. Such potentials have applications in quantum information processing, the study of Josephson effects, and could be used to entangle atoms via state-selective collisions.

Q 42.3 Do 14:45 1C

Coupling of Bose-Einstein condensates to mechanical cantilevers on an atomchip — •David Hunger[1,2], Stephan Camerer[1,2], Daniel König[2], Jörg P. Kotthaus[2], Jakob Reichel[3], Theodor W. Hänsch[1,2], and Philipp Treutlein[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, München — [3]LKB, E.N.S., Paris

We report on the current status of our experiment which aims at coupling a BEC on an atomchip to the motion of mechanical oscillators.

We have considered different coupling schemes to realize an interaction between the two systems. The strongest coupling can be realized by a magnetic interaction, which is mediated by a ferromagnetic island on the tip of a nanomechanical cantilever. In this scenario, the resonator motion causes an oscillating magnetic field that can drive atomic spin-flip transitions. In a first experiment we want to use this to probe the thermal motion of the cantilever with the atoms. [P. Treutlein et al., PRL 99, 140403 (2007)]

In an alternative approach we consider a pure mechanical coupling, mediated by a standing wave dipole trap that is realized by reflecting a red detuned laser on the tip of an AFM cantilever. The motion of the cantilever causes motion of the standing wave, being the trap of a BEC. If the oscillation of the cantilever is resonant with the transition to the first excited motional state of the BEC, the transfer of atoms to the excited state can be used to probe the motion of the cantilever.

Q 42.4 Do 15:00 1C

Bose-Einstein Condensation of Dark-State Polaritons in Atomic Vapour — •Johannes Otterbach, Razmik Unanyan, and Michael Fleischhauer — TU Kaiserslautern, Germany

We propose a mechanism for Bose-Einstein condensation (BEC) of dark-state polaritons in an atomic vapour. Dark-state polaritons (DSPs) are created in the Raman interaction of laser fields with atoms and are the basis of phenomena such as ultra-slow, stopped, and stationary light. In contrast to exciton-polaritons they have a very long intrinsic lifetime on the order of milliseconds. Stationary DSPs created by counter-propagating Raman pump fields have a quadratic dispersion profile with a variable mass tensor. Due to the small effective mass of these quasi-particles, the corresponding condensation temperature can be 4 orders of magnitude higher than that of the atomic vapour. After introduction of stationary light dark-state polaritons we discuss their incoherent generation and thermalization and analyze conditions for their condensation. Finally potential methods for an experimental observation of the Bose-Einstein condensation will be discussed.

Q 42.5 Do 15:15 1C

A Magnetic Ring Trap for Multiply Connected Quantum Gases and Atom Interferometry — Ryan Olf, Edward Marti, Enrico Vogt, •Anton Öttl, and Dan Stamper-Kurn — Department of Physics, University of California, Berkeley, CA 94720

We are currently constructing a novel and improved experimental apparatus to create non-trivial, multiply connected trap geometries for quantum gases and atom interferometry.

For this setup we employ specialized, microfabricated magnetic coils which will generate very smooth and tightly confining trapping fields of torroidal shape. The radius of the magnetic ring trap can be controlled and adjusted over a wide range, from tens of microns to millimeters. We aim to load the ring trap with both rubidium and lithium atoms. This will allow us to explore diverse regimes of matterwave interferometry with fermionic and bosonic atoms of differing interaction strengths and possibly overcome current limitations. A Sagnac-type atom interferometer in a mm-sized ring has the potential to greatly surpass the resolution of existing gyroscopes. However, working with smaller ring radii our goal is to fill the whole ring with degenerate quantum gases and to study the effects of this non-trivial topology on coherence and dynamics of Bose-Einstein condensates.

The ongoing status of the experiment will be presented. We describe the performance of our dual-species oven and Zeeman slower design loading the double MOT and present measurements to demonstrate the quality of our magnetic ring trap.

Q 42.6 Do 15:30 1C

Kollektive Effekte in Ringresonatoren im Quantenregime — •Gordon Krenz, Simone Bux, Sebastian Slama, Philippe Courteille und Claus Zimmermann — Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

In unserem Experiment untersuchen wir die Wechselwirkung zwischen ultrakalten thermischen und Bose-Einstein-kondensierten Atomen und dem Lichtfeld eines High-Finesse-Resonators. Dabei werden ultrakalte ^{87}Rb-Atome in das Modenvolumen eines einseitig gepumpten Ringresonators geladen. Die Umstreuung von Pumplicht durch die Atome gehorcht einer sichselbstverstärkenden Dynamik, die durch einen Anstieg der Intensität des Lichtfeldes in der nicht gepumpten Richtung zu beobachten ist. Dieses Verhalten ist als CARL-Effekt (Collective Atomic Recoil Lasing) bekannt und von unserer Arbeitsgruppe untersucht worden. Die Impulsverteilung der Atome wird durch den CARL-Effekt beeinflusst, da bei der Umstreuung eines Photons ein Impuls der Größe $p = 2\hbar k$ übertragen wird. Beim CARL-Effekt gibt es verschiedene Regime, die sich unter anderem in der Anzahl bei einer Umstreuung gekoppelter Impulszustände unterscheiden. Unsere bisherigen Experimente beschränkten sich auf das semiklassische Regime, bei dem mehrere Impulszustände miteinander gekoppelt sind, was zu einer breiten Impulsverteilung führt. Ein verbesserter Experimentieraufbau soll uns nun die Untersuchung des Quantenregimes ermöglichen, bei dem ausschließlich benachbarte Impulszustände gekoppelt werden.

Q 42.7 Do 15:45 1C

Landau levels of cold atoms in non-Abelian gauge fields — •Andreas Jacob[1], Patrik Öhberg[2], Gediminas Juzeliunas[3], and Luis Santos[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]SUPA, Department of Physics, Heriot-Watt University, Edinburgh, UK — [3]Institute of Theoretical Physics and Astronomy of Vilnius University, Lithuania

Recent proposals have shown that by properly designed laser arrangements or lattice setups it is possible to induce artificial gauge fields, which can even be non-Abelian. In this contribution, we will first discuss simple laser setups that allow the creation of non-Abelian gauge fields. Then the Landau levels of cold atomic gases in non-Abelian gauge fields are analyzed. In particular we identify effects on the energy spectrum and density distribution which are purely due to the non-Abelian character of the fields. In a second part, we discuss non-Abelian generalizations of both the Landau and the symmetric gauge, and how these can be generated.