

Q 32 Quantengase I

Zeit: Dienstag 10:45–13:15

Raum: HU Kinosaal

Q 32.1 Di 10:45 HU Kinosaal

Evaporative Cooling in an Optical Dipole Trap — ●ANNA-LENA GEHRMANN¹, JOHANNA NES¹, TOBIAS MÜTHER¹, FALK SCHARNBERG^{1,2}, WOLFGANG ERTMER¹, and GERHARD BIRKL¹ — ¹Institut für Quantenoptik, Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany — ²Centre for Atom Optics and Ultrafast Spectroscopy, Swinburne University of Technology, Hawthorn, VIC 3122, Australia

Cold ensembles and Bose-Einstein condensates (BEC) of rubidium atoms in optical dipole potentials have been studied by several groups in recent years. Most of the experiments using BECs rely on producing the condensate in a magnetic trap with subsequent transfer to the optical potential. Only a small number of groups have also succeeded in achieving quantum degeneracy directly in a dipole trap, predominantly by using the light of a CO₂-laser.

In our approach, we use a solid-state laser which creates a far-detuned dipole trap for ⁸⁷Rb at a wavelength of 1030 nm. This should reduce the complexity of the optical setup, and allows the use of 'more-standard' optical materials and components. We aim at the creation of an all-optical BEC based on a simplified experimental scheme suitable for future generations of BEC setups without magnetic trapping fields.

We have successfully implemented first steps of evaporative cooling in our configuration. To achieve high initial phase-space densities allowing for efficient evaporative cooling, we have optimised the loading process from a magneto-optical trap. Furthermore, we have studied different timing schemes for the evaporation ramps. We report on the status of the experiment.

Q 32.2 Di 11:00 HU Kinosaal

Bose-Einstein condensation of ⁵²Cr — ●AXEL GRIESMAIER, SVEN HENSLER, JÖRG WERNER, JÜRGEN STUHLER, and TILMAN PFAU — 5. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart, Germany

We report on the observation of Bose-Einstein condensation of ⁵²Cr atoms. We start with 300.000 atoms in a crossed optical dipole trap. Lowering the intensity of the horizontal trapping beam to about 5% of its initial value within a few seconds, we evaporatively cool the atoms to degeneracy. Slightly below T_c , the atomic cloud shows the typical bimodal distribution after 5 ms time of flight. Releasing the atoms from an anisotropic trap, we observe the expected change in the aspect ratio of the expanding cloud. We are able to produce nearly pure condensates with more than 20.000 ⁵²Cr atoms.

Q 32.3 Di 11:15 HU Kinosaal

Noise-correlation spectroscopy of ultracold atoms in optical lattices — ●S. FÖLLING, F. GERBIER, A. WIDERA, T. GERICKE, O. MANDEL, and I. BLOCH — Johannes Gutenberg Universität Mainz, 55099 Mainz

Ultracold Atoms in the Mott insulating phase inside an optical lattice do not exhibit phase coherence over multiple lattice sites - in strong contrast to the superfluid phase of the lattice. Therefore, the most immediate signature of the Mott insulating state in these systems is the complete disappearance of any macroscopic interference in the atomic cloud after ballistic expansion.

The atom-atom correlation function however shows the opposite behaviour - in the phase-coherent superfluid state the $g^{(2)}$ function should be flat, whereas the atoms from the Fock states of the Mott insulator exhibit Hanbury-Brown/Twiss-type bunching. As proposed in [1] this should lead to sharp peaks in the density-density correlation function in momentum space at even multiples of the lattice recoil momentum. We report on the characterization of such correlations in ⁸⁷Rb-Mott insulators in an optical lattice.

[1] E. Altman, E. Demler and M. D. Lukin, Phys. Rev. A 70, 013603 (2004)

Q 32.4 Di 11:30 HU Kinosaal

Ein Lasersystem für die Erzeugung schwereloser Bose-Einstein Kondensate — ●ANIKA VOGEL¹, MALTE SCHMIDT¹, KLAUS SENGSTOCK¹, KAI BONGS¹, THILO SCHULDT², WOJCIECH LEWOCZKO² und ACHIM PETERS² — ¹Universität Hamburg, Institut für Laserphysik, Luruper Chaussee 149, 22761 Hamburg — ²Humboldt Universität zu Berlin, Institut für Physik, AG Quantenoptik und Metrologie, Hausvogteiplatz 5-7, 10117 Berlin

Untersuchungen an Bose-Einstein Kondensaten in Schwerelosigkeit eröffnen neue Möglichkeiten hinsichtlich kleinerer Temperaturen und Dichten bei wesentlich verlängerter Beobachtungszeit. Wir arbeiten im Rahmen einer deutschlandweiten Kollaboration an der Entwicklung eines Lasersystems zur Erzeugung von Rb-Bose-Einstein Kondensaten in Mikrogravitation. Auf dem Weg zur Implementation eines Quantengasexperimentes im Weltraum soll vorerst eine Apparatur für den Test im Fallturm (ZARM Bremen) entwickelt werden. In diesem Vortrag werden das Gesamtkonzept des modularen Lasersystems und die Ergebnisse der ersten Falltests hinsichtlich der mechanischen Stabilität präsentiert. Es werden zwei Konzepte spektroskopiestabilisierter Masterlaser verglichen (FM-Spektroskopie / Doppler freier DAVLL) und ein kombiniertes Slave-lasermodule mit tapered Amplifier vorgestellt. Des Weiteren gehen wir auf Messungen zur Linienbreite der verwendeten DFB Halbleiterlaser bei 780nm ein.

Q 32.5 Di 11:45 HU Kinosaal

Fermionic atoms in a 3D optical lattice: Observing Fermi surfaces, dynamics and interactions — ●THILO STÖFERLE, MICHAEL KÖHL, HENNING MORITZ, KENNETH GÜNTER, and TILMAN ESSLINGER — Institute of Quantum Electronics, ETH Zürich, Hönggerberg, CH-8093 Zürich, Switzerland

We have studied interacting and non-interacting quantum degenerate Fermi gases in a three-dimensional optical lattice. We directly image the Fermi surface of the atoms in the lattice by turning off the optical lattice adiabatically. Due to the confining potential gradual filling of the lattice transforms the system from a normal state into a band insulator which constitutes a high fidelity quantum register. The dynamics of the transition from a band insulator to a normal state is studied and the time scale is measured to be an order of magnitude larger than the tunneling time in the lattice. Using a Feshbach resonance we increase the interaction between atoms in two different spin states and dynamically induce a coupling between the lowest energy bands. We observe a shift of this coupling with respect to the Feshbach resonance in free space which is anticipated for strongly confined atoms.

Q 32.6 Di 12:00 HU Kinosaal

Numerische Untersuchungen zu Bose-Fermi Mischungen in eindimensionalen optischen Gittern — ●ALEXANDER MERING¹, ULRICH SCHOLLWÖCK² und MICHAEL FLEISCHHAUER¹ — ¹Fachbereich Physik, TU Kaiserslautern — ²Institut für Theoretische Physik C, RWTH Aachen

Mischungen aus Bosonen und Fermionen in optischen Gittern werden unter der Annahme niedriger Temperaturen und hinreichend tiefer Gitter durch das Bose-Fermi-Hubbard Modell (BFHM) beschrieben [1].

Mit Hilfe exakter Diagonalisierung sowie eines numerischen Dichtematrix Renormierungsgruppen Verfahrens wird das Phasendiagramm des BFHM bei fester Fermionenzahl und mit bosonischem chemischen Potential berechnet. Es wird die Existenz inkompressibler Bereiche gezeigt, denen Kompositphasen [2] mit $\hat{n}_B + s\hat{n}_F = konst$ (s ganze Zahl) entsprechen.

Mittlere Teilchenzahlen sowie Teilchenzahlfuktuationen und Korrelationen werden berechnet und diskutiert. Weitere Phasen wie Dichtewellen oder Entmischungsphasen werden ebenfalls analysiert.

[1] Albus *et al.*, PRA 68, 023606 (2003)

[2] Fehrmann *et al.*, cond-mat/0307635

Q 32.7 Di 12:15 HU Kinosaal

Solitonen in Fermi-Bose Mischungen — ●K. BONGS¹, S. OSPELKAUS-SCHWARZER¹, C. OSPELKAUS¹, K. SENGSTOCK¹, T. KARPIUK², M. BREWCZYK³ und K. RZAŻEWSKI⁴ — ¹Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — ²Uniwersytet w Białymstoku, ulica Lipowa 41, 15-424 Białystok, Polen — ³Instytut Fizyki PAN, Aleja Lotników 32/46, 02-668 Warszawa, Polen — ⁴Centrum Fizyki Teoretycznej PAN, Aleja Lotników 32/46, 02-668 Warszawa, Polen

Wir stellen ein Konzept zur Erzeugung heller Solitonen in eindimensionalen atomaren Quantengasmischungen vor [1]. Insbesondere studieren wir theoretisch die Entstehung heller Solitonen in einem Bose-Einstein Kondensat, das in einen "Fermi-See" eingebettet ist am Beispiel von ⁸⁷Rb und ⁴⁰K. Dieses System wird durch ein "intrinsisches"

Wechselspiel von attraktiven Bose-Fermi und repulsiven Bose-Bose Wechselwirkungen bestimmt. Dies erlaubt es das Regime stabiler Solitonen durch Einstellung der relativen Teilchenzahlen oder alternativ durch Nutzung von Inter-Spezies Feshbach Resonanzen zu erreichen. Neben der Bildung von einzelnen Solitonen und von Solitonzügen diskutieren wir mögliche Effekte der Fermi-Statistik.

[1] T. Karpiuk, M. Brewczyk, S. Ospelkaus-Schwarzer, K. Bongs, M. Gajda, and K. Rzazewski, *Soliton Trains in Bose-Fermi Mixtures*, Phys. Rev. Lett. **93**, 100401 (2004).

Q 32.8 Di 12:30 HU Kinosaal

Optical Feshbach resonances — •KLAUS WINKLER¹, MATTHIAS THEIS¹, GREGOR THALHAMMER¹, RUDOLF GRIMM^{1,2}, and JOHANNES HECKER DENSCHLAG¹ — ¹Institut für Experimentalphysik, Universität Innsbruck, Austria — ²Institut für Quantenoptik und Quanteninformatik, Innsbruck, Austria

We demonstrated optical tuning of the scattering length in a Bose-Einstein condensate as predicted by Fedichev et al. [1]. In our experiment atoms in a ⁸⁷Rubidium condensate were exposed to laser light tuned close to the transition frequency to a molecular state. The optical coupling of the atomic scattering state to the molecular state gives rise to what is called an optical Feshbach resonance. We showed that the optical Feshbach resonance can be induced via one or two photon transitions. While for the one photon transition we coupled to an excited molecular state [2], we used a stimulated Raman scheme for the two photon case to couple to the molecular ground state [3]. By controlling the power and the detuning of the lasers we were able to change the atomic scattering length over a wide range. We identified Bragg spectroscopy as a fast method (<100μs) to measure the scattering length of the atoms in view of rapid laser-driven atomic losses.

[1] P.Fedichev et al., Phys.Rev.Lett. 77, 2913 (1996)

[2] M. Theis et al., Phys.Rev.Lett. 93, 123001 (2004)

[3] G. Thalhammer et al., cond-mat 0409552 (2004)

Q 32.9 Di 12:45 HU Kinosaal

Interaction of Impurity Atoms in Bose-Einstein Condensates — •ALEXANDER KLEIN and MICHAEL FLEISCHHAUER — Fachbereich Physik, TU Kaiserslautern

The interaction of two spatially separated impurity atoms through phonon exchange in a Bose-Einstein condensate is studied within a Bogoliubov approach. The impurity atoms are held by deep and narrow trap potentials and experience level shifts which consist of a mean-field part and vacuum contributions from the Bogoliubov-phonons. In addition there is a conditional energy shift resulting from the exchange of phonons between the impurity atoms. Potential applications to quantum information processing are discussed.

Q 32.10 Di 13:00 HU Kinosaal

Strongly interacting Fermions and molecule formation in a 3D optical lattice — •HENNING MORITZ, THILO STÖFERLE, KENNETH GÜNTER, CHRISTIAN SCHORI, MICHAEL KÖHL, and TILMAN ESSLINGER — Institute of Quantum Electronics, ETH Zürich, Hönggerberg, CH-8093 Zürich, Switzerland

The exploration of quantum degenerate gases of fermionic atoms is driven by the ambition to get deeper insight into long-standing problems of quantum many-body physics, such as high temperature superconductivity. For most models describing quantum many-body phenomena in materials, the underlying lattice structure is a key ingredient.

We have loaded degenerate fermionic potassium atoms into such a periodic potential created by a 3D optical lattice and observed the Fermi surfaces and dynamics of the system (see talk by T. Stöferle). We will report on the behaviour of the spin mixture in the vicinity of a Feshbach resonance. The reversible formation of molecules in the lattice and recent experiments will be discussed.