Q 14 Quantengase III

Zeit: Montag 17:00–18:45 Raum: HVI

Q 14.1 Mo 17:00 HVI

Critical Temperature of Chromium Condensate — •Konstantin Glaum[1], Axel Pelster[2], Hagen Kleinert[1], and Tilman Pfau[3] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany — [3]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We estimate the critical temperature for the ongoing Stuttgart experiment on the Bose-Einstein condensation of chromium [1,2]. Due to the diluteness of the gas, we treat both the short-range, isotropic delta-interaction and the long-range, anisotropic magnetic dipole-dipole interaction perturbatively with the help of Feynman's diagrammatic technique of many-body theory. Depending whether the symmetry axes of the trap and the magnetic dipole-dipole interaction are parallel or perpendicular to each other, the critical temperature is shifted above or below the interaction-free case. The difference of the critical temperatures between both configurations only depends on the magnetic dipole-dipole interaction and can be enhanced by increasing either the number of chromium atoms or the anisotropy of the trap.

[1] A. Griesmaier, J. Werner, S. Hensler, J. Stuhler, and T. Pfau: Phys. Rev. Lett. **94**, 160401 (2005)

[2] J. Stuhler, A. Griesmaier, T. Koch, M. Fattori, S. Giovanazzi, P. Pedri, L. Santos, and T. Pfau: Phys. Rev. Lett. **95**, 150406 (2005)

Q 14.2 Mo 17:15 HVI

Coherence in two dimensional Bose-Einstein condensates — •Peter Krüger, Baptiste Battelier, Marc Cheneau, Sabine Stock, Zoran Hadzibabic, and Jean Dalibard — Laboratoire Kastler Brossel, Ecole Normale Supérieure, 75005 Paris, France

We explore both isotropic and elongated quasi-two dimensional Bose-Einstein condensates held in a combination of optical and magnetic potentials. We have observed phase defects in quasi-2D Bose-Einstein condensates close to the condensation temperature. Either a single or several equally spaced condensates are produced by selectively evaporating the sites of a 1D optical lattice. When several clouds are released from the lattice and allowed to overlap, dislocation lines in the interference patterns reveal nontrivial phase defects.

The phase distribution in elongated 2D condensates is measured as a function of temperature by imaging interference patterns along the direction perpendicular to the long axis of the flat clouds. This allows to determine how the coherence properties of the gas depend on temperature.

Q 14.3 Mo 17:30 HVI

Magnetic coupling of a BEC to a nano-mechanical resonator — •David Hunger[1], Philipp Treutlein[1], Stefan Camerer[2], Daniel König[2], Jörg Kotthaus[2], Theodor W. Hänsch[1], and Jakob Reichel[3] — [1]Max-Planck-Institut für Quantenoptik und Department für Physik der Ludwig-Maximilians-Universität München, Germany — [2]Department für Physik der Ludwig-Maximilians-Universität München, Germany — [3]Laboratoire Kastler Brossel de l'ENS, Paris, France

Atom chips are a well suited toolbox for a new, promising research field: The combination of quantum optics and condensed-matter systems. A first milestone in this direction is to show that a designed, controllable interaction between atoms and nano-structured solid state systems can be established and measured.

We are currently setting up an experiment to couple the thermally induced oscillation of a nano-mechanical beam resonator to a nearby Bose-Einstein condensate via a magnetic interaction. A small island of ferromagnetic material at the center of the beam causes a magnetic dipole field with an oscillating contribution. At the position of the atoms the field oscillation can cause observable trap loss if it is resonant with atomic spin-flip transitions to untrapped magnetic sublevels. Sweeping the static field of the trap and with it the spin-flip resonance reveals the frequency spectrum of the beam.

The experiment provides a new method to measure the room temperature spectrum of nano-resonators, thereby demonstrating the controlled interaction with trapped atoms. Beyond this it allows to study the conditions for coherent coupling of such systems.

Q 14.4 Mo 17:45 HVI

Density distribution and compressibility of a confined Mott Insulator — •Simon Fölling, Artur Widera, Fabrice Gerbier, Torben Müller, Olaf Mandel, and Immanuel Bloch — Institut für Physik der Universität Mainz, 55099 Mainz

We measure the density distribution of an atomic sample in the Mott insulating state of a periodic lattice potential in a variable external confinement. Due to this variable harmonic confinement at a given lattice depth, the in-trap atom density and therefore the average lattice filling factor can be changed for a constant total number of ^{87}Rb atoms . The global profile of the resulting atom distribution in the trap is determined using microwave spectroscopy in a gradient field, while the on-site atom number distribution is probed using coherent spin-changing collisions on multiply occupied sites [1]. The formation of regions with lattice site occupancies $n > 1$ is shown, in accordance with the predictions for the atomic MI state [2]. We investigate the shell structure formation and the associated change in compressibility on the transition from a singly- to a doubly-occupied Mott insulator.

[1] F. Gerbier et al., cond-mat/0511080 (2005)

[2] D. Jaksch et al., Phys. Rev. Lett. 81, 3108 (1998)

Q 14.5 Mo 18:00 HVI

Stoßinduzierte kohärente Spindynamik in einem optischen Gitter — •Artur Widera, Simon Fölling, Fabrice Gerbier, Torben Müller, Olaf Mandel und Immanuel Bloch — Institut für Physik der Universität Mainz; 55099 Mainz, Germany

Die effiziente Erzeugung von atomarer Verschränkung erfordert eine hohe Kontrolle über kohärente Wechselwirkung zwischen Atomen. Wir zeigen, dass spinändernde Stöße zwischen Atompaaren in einem optischen Gitter zu kohärenten Populationsoszillationen des Atompaars zwischen Zeeman-Unterzuständen führen. Diese rein stoßinduzierten Oszillationen können durch ein Rabi-ähnliches Modell beschrieben werden, wobei die Kopplungsstärke (resonante Rabifrequenz) durch fundamentale Differenzen der Streulängen des Atoms gegeben sind. Ferner kann die Verstimmung des Prozesses durch ein externes Magnetfeld eingestellt werden. Die beobachteten langen Kohärenzzeiten machen das System zu einem viel versprechenden Kandidaten für die effiziente Erzeugung von Verschränkung zwischen Atomen.

Q 14.6 Mo 18:15 HVI

Formation of long-range order in a growing Bose-Einstein condensate — •Stephan Ritter, Anton Öttl, Tobias Donner, Thomas Bourdel, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik, ETH Zürich, CH-8093 Zürich, Schweiz

We have experimentally investigated the temporal evolution of long-range order in an ultracold gas of atoms during the formation of a Bose-Einstein condensate (BEC). The growth of a quantum degenerate gas from a thermal vapor is associated with a sharp increase in the peak density of the cloud. Here we investigate how in this process the phase coherence, a characteristic feature of the equilibrium BEC, develops in time. We probe the coherence between two regions of an atomic cloud by continuously output coupling atoms from the two regions simultaneously. The two atomic beams show an interference pattern with a contrast given by the phase coherence between the two output coupling regions. We observe the matter wave interference pattern using a high-finesse optical cavity which serves as a single-atom detector with high quantum efficiency. Therefore, only very few atoms need to be output coupled from the atomic cloud and the coherence of two regions can be monitored without perturbing the formation process.

During the formation, we measure the coherence of two regions of the cloud with variable separation in real-time and simultaneously probe their density. The experimental results of these measurements will be presented.

Q 14.7 Mo 18:30 HVI

Raman-Spektroskopie an ultrakalten Quantengasen in optischen Gittern — •Torben Müller, Artur Widera, Simon Fölling, Olaf Mandel, Fabrice Gerbier und Immanuel Bloch — Institut für Physik, Johannes-Gutenberg Universität Mainz, 55099 Mainz, Germany

Ultrakalte atomare Gase in optischen Gittern bieten die Möglichkeit, fundamentale Fragen der modernen Festkörperphysik, Atomphysik, Quantenoptik und Quanteninformation zu studieren. In diesem Zusammenhang ist es von großem Interesse eine kohärente Kontrolle über die externen Freiheitsgrade des Systemes, in diesem Fall die vibratorischen Freiheitsgrade der im Gitter gebundenen Atome, zu erlangen.

Im Rahmen des vorgestellten Projekts werden Wechselwirkungseigenschaften von ultrakalten Neutralatomen (Rb^{87}) in optischen Potentialen diskutiert. Zur Untersuchung der angeregten Vibrationsniveaus im optischen Gittern verwenden wir stimulierte Raman-Übergänge. Über einen Zwei-Photonen-Prozess wird Population in die ersten Anregungsniveaus des optischen Gitters transferiert. Dabei richten sich die ersten Untersuchungen auf die Stabilität dieser Anregungen, z.B. unter Atom-Atom-Wechselwirkung, in 1D-, 2D- und 3D-Gittern und auf die Charakterisierung der Zerfallskanäle.

Eine solche kohärente Kontrolle der externen Freiheitsgrade würde unter anderem die Untersuchung von neuen komplexeren, stark korrelierten Quantensystemen ermöglichen, wie beispielsweise das Regime von niederdimensionalen gekoppelten Quantenflüssigkeiten [1].

[1] A.Isacsson and S.M. Girvin, *Phys. Rev. A* 72, 053604 (2005)