Q 31 Poster Fallen und Kühlung

Zeit: Dienstag 16:30–18:30 Raum: Labsaal

Q 31.1 Di 16:30 Labsaal

A bichromatic MOT for Ytterbium atoms — •Florian Baumer, Sven Kroboth, Nils Nemitz, and Axel Görlitz — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

We report on cooling and trapping of Ytterbium (Yb) atoms in a MOT using two different transitions.

In a MOT operating on the $^1S_0 \rightarrow {}^1P_1$ transition at 399nm, all seven stable Yb isotopes have been trapped. For the spinless bosonic Yb isotopes, only Doppler cooling occurs and consequently we observe temperatures as high as several mK (Doppler limit: $\approx 700\ \mu$K). In contrast, the fermionic isotopes ^{171}Yb and ^{173}Yb possess nuclear spin, which makes polarization-gradient cooling possible. We observe MOT temperatures of around 200 μK for ^{171}Yb and below 50 μK for ^{173}Yb.

We recently succeeded in trapping Yb atoms in an additional MOT using the $^1S_0 \rightarrow {}^3P_1$ intercombination line at 556nm. This transition is of special interest, as its small linewidth of 182kHz results in a very low Doppler limit of 4μK. As a next step we plan to transfer the Yb atoms to an optical dipole trap.

Q 31.2 Di 16:30 Labsaal

An ultracold chromium atomic beam for nanofabrication — •Alexander Greiner, Jimmy Sebastian, Inam Mirza, Paul Rehme, Jürgen Stuhler, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut, Pfaffenwaldring 57, 70550 Stuttgart

Chromium nanostructures have been produced by several groups using atom lithography techniques. These experiments exclusively used a thermal chromium beam which leads to a limitation of the achievable structure widths due to chromatic, spherical and Clebsch-Gordan aberrations. Our setup will use a monochromatic ultracold atomic beam for atomic lithography which leads to a strong suppression of the chromatic aberration. In addition, the Clebsch-Gordan aberration is strongly reduced because in our beam, the atoms are optically pumped and magnetically guided in the extreme Zeeman substate. The spherical aberration due to the anharmonicity of the light mask shall be reduced by using multilayer masks in order to minimize the achievable structure widths [1].

The atomic beam is created in a "moving molasses" MOT and is guided via 1.5m long Ioffe bars to the place of deposition. We report on the progress of our experiment.

[1] R. Arun et al, Physical Review A 72, 023417 (2005)

Q 31.3 Di 16:30 Labsaal

Atom guiding in photonic bandgap fibres — •Stefan Vorrath, Peter Moraczewski, Sören Götze, Kai Bongs, and Klaus Sengstock — Universität Hamburg - Institut für Laserphysik, Luruper Chaussee 149, 22761 Hamburg, Germany

Homogeneous, flexible, undisturbed, coherent waveguides for atomic matter waves would be an outstanding basis for experiments in quantum and atom optics. "Conventional" capillary guides demonstrated the feasibility of this goal but light losses and speckle patterns were major obstacles preventing the break through of these concepts. In this project we investigate a new kind of atomic waveguide based on a 2D photonic bandgap fibre which promises to solve these problems as now nearly lossless guiding of light and atoms in the central core of the fibre should be possible. One further option of this setup is the possibility of additional laser cooling perpendicular to the fibre guide offering thereby atom laser applications. We discuss the light field distribution within the photonic bandgap fibre identifying single mode operation as well as simulation of atomic guiding within these modes. We will further report on the current status of the experiment and discuss possible applications.

Q 31.4 Di 16:30 Labsaal

Coherently controlled mesoscopic transport — •Christoph Weiss — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany

A weakly interacting Bose-Einstein condensate is initially situated in the first of a series of wells. Numerical calculations show that, by adding especially designed time-dependent potential modulations [1], the condensate can be transported through the wells in a controlled way [2].

[1] C. Weiss and T. Jinasundera: Phys. Rev. A 72, 053626 (2005).
[2] C. Weiss: *Coherently controlled mesoscopic transport*, to appear in Laser Phys. Lett., DOI 10.1002/lapl.200510084

Q 31.5 Di 16:30 Labsaal

Deterministic Coupling of a Trapped Atom to a High-Finesse Optical Cavity — •Bernhard Weber, Stefan Nussmann, Markus Hijlkema, Holger Specht, Simon Webster, Axel Kuhn, and Gerhard Rempe — MPI für Quantenoptik, Hans-Kopfermann-Str.1, 85748 Garching

We report on an experiment where the position of individual atoms within the mode of a high-finesse optical cavity is precisely adjusted, controlled and observed. Using an orthongonal arrangement of the cavity, a standing-wave dipole-force trap and a pump laser makes it possible to either precisely address one single atom by the cavity, or to simultaneously couple two precisely separated atoms to a higher mode of the cavity [1]. To monitor the coupling of the atoms to the cavity, we observe the photons from the pump beam that are Raman scattered into and then emitted from the cavity. The measured photon emission rate allows us to clearly distinguish between atom numbers 0, 1 and 2. The deterministic control over the atom-cavity coupling is achieved by turning a glass plate in the optical path of the standing-wave trap, resulting in a position shift of the antinodes and the atoms trapped therein. We show that we can deterministically move a single atom into and out of the cavity mode with a repositioning precision of 135nm, and thus freely adjust the coupling.

[1] S. Nußmann et al. Phys.Rev.Lett. 95, 173602 (2005)

Q 31.6 Di 16:30 Labsaal

Fabrication and Characterisation of semiconducting Atom Chips — •Soenke Groth[1], Joerg Schmiedmayer[1], and Israel Bar-Joseph[2] — [1]Universitaet Heidelberg, Germany — [2]Weizmann Insitute of Science, Israel

Due to our fabrication process we managed to combine standard metal wire Atom Chips with semiconducting samples. This enables to trap atoms with non metal wires. The new Atom Chip is a combination of the well known technique of Atom Chips, and a new part, which is fabricated from a semiconductor. Different techniques are required to produce this element and to impelment it onto the Atom Chip. Fabrication and characterisation of these chips are demonstrated. Further more the characterisation of e-beam patterned Atom Chips is shown.

Q 31.7 Di 16:30 Labsaal

Magnetic noise in atom chips: impact of finite wire size — •Bo Zhang and Carsten Henkel — Institut für Physik, Universität Potsdam, Germany

We provide a detailed analysis of spin-flip transitions in atom chips, taking into account complex geometries. We focus on metallic wires of different shapes and cross-sections deposited on dielectric substrates. The finite thickness of a metallic layer has already been shown to significantly improve the atom trap lifetime [1]. Different interpolation formulas and approximations for magnetic field fluctuations in the near field of the wire are compared to exact numerical calculations. Possible methods that can be used are based on (i) surface integral equations combined with boundary elements [2] and (ii) differential equations combined with finite elements [3]. We outline consequences for current experiments.

[1] Zhang, Henkel, Haller, Wildermuth, Hofferberth, Krüger, Schmiedmayer: Eur. Phys. J. D 35 (2005) 97; Sinclair, Curtis, Garcia, Retter, Hall, Eriksson, Sauer, Hinds: Phys. Rev. A 72 (2005) 031603(R)
[2] Rogobete, Henkel: Phys. Rev. A 70 (2004) 063815
[3] see, e.g.: Kalkbrenner, Håkanson, Schädle, Burger, Henkel, Sandoghdar: Phys. Rev. Lett. 95 (2005) 200801

Q 31.8 Di 16:30 Labsaal

Molecular dynamics simulation of evaporative cooling in time dependent potentials — •Axel Griesmaier, Jürgen Stuhler, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

We have developed a fast and effective molecular dynamics simulation of trapped atomic clouds in almost arbitrary time dependent potentials. Using a scaling technique for the atomic properties, we are able to map the evolution of the thermodynamic properties of millions of atoms by simulating only a few hundred particles. The atoms are treated as classical objects which interact solely by simple hard sphere collisions. We have simulated the complete evaporation procedure of our chromium BEC experiment including the transfer from the single beam to the crossed optical dipole trap and compared the results with the experimental data. With only 250 simulated particles, we are able to reproduce the experimental findings with a deviation of only a factor of two in the number of atoms when the phase space density approaches unity. The simulation of the experiment which corresponds to 15s in real time, takes about two hours on a standard up-to-date office PC. We discuss optimal evaporation strategies for crossed optical dipole traps.

Q 31.9 Di 16:30 Labsaal

Momentum Diffusion for Coupled Atom-Cavity Oscillators — •K Murr[1], P. Maunz[1], P. W. H. Pinkse[1], T. Puppe[1], I. Schuster[1], D. Vitali[2], and G. Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Dipartimento di Fisica, Universita di Camerino, I-62032 Camerino, Italy

Strongly coupled atom-cavity systems form a cornerstone in our understanding of light-matter interaction and are promising candidates for implementation of quantum information processing protocols. However, unexpectedly large heating of the atom has been observed in these systems, as expressed by large momentum diffusion coefficients. Those coefficients have been derived before in particular cases, e.g., in Ref. [1], but questions on its origin remain.

We show that an intuitive picture can be obtained [2], in which a fluctuating dipole is coupled to a classical cavity field, and a fluctuating cavity field is coupled to a classical dipole. Actually, the equations for momentum diffusion can be cast in a simple, invariant and symmetric form, regardless of whether the atom or the cavity is excited, and regardless of the spatial structure of the involved light fields. We discuss how the quantum fluctuations of the cavity field itself are responsible for a large part of the heating. Hence, the enhanced diffusion that comes along with strong coupling must be considered as it puts constraints on applications.

[1] P. Horak et al. Phys. Rev. Lett. **79**, 4974 (1997).
[2] K. Murr et al., arXiv/quant-ph 0512001 (2005).

Q 31.10 Di 16:30 Labsaal

Schema zum Frequenzstabilitätstransfer über viele nm — •Arne Wickenbrock, Julian Klinner, Malik Lindholdt und Andreas Hemmerich — Universität Hamburg, ILP, Luruper Chaussee 149, 22761 Hamburg

Im Rahmen von Experimenten zur Laserkühlung in Hoch-Finesse-Resonatoren wird ein Frequenzstabilitätstransfer zwischen zwei 30nm zueinander verstimmten Lasern benötigt. Beide Laser werden mittels einer Pound-Drever-Hall-Regelung auf verschiedene Moden eines hochstabilen Referenzresonator frequenzstabilisiert. Die benötigte Längenstabilität des Resonators resultiert aus der aktiven Temperaturstabilisierung des ULE-Abstandshalters und seiner seismischen/akustischen Entkopplung von äusseren Einflüssen. Diese wird begünstigt durch die vertikale Orientierung des Resonators sowie eine äussere Schale aus Sandstein.

Q 31.11 Di 16:30 Labsaal

Sympathetische Kühlung von doppelt geladenen Ionen — •T. Kwapien[1], W. Sandner[1,2] und U. Eichmann[1,3] — [1]Max Born Institut, Max-Born Str. 2a , 12489 Berlin — [2]TU Berlin, Optisches Institut — [3]TU Berlin, Institut für atomare Physik und Fachdidaktik

Die sympathetische Kühlung von Ionen in Paul-Fallen beschränkte sich bislang im wesentlichen auf Ionen unterschiedlicher Masse. Wir stellen Messungen vor, in denen sympathetische Kühlung auf höhere Ladungszustände angewendet wird. Im Experiment werden mit Hilfe der Laserkühlung zunächst lineare Ketten bzw. kleinere Kristalle von Ca-Ionen in einer linearen Falle gespeichert. Mit einem Femtosekunden-Laser werden dann gezielt einzelne Ionen doppelt ionisiert. Auf Grund der sympathetischen Kühlung verbleiben diese doppelt geladenen Ionen direkt im Kristall. Sie werden entweder durch ihre erhöhte Coulombabstoßung auf die im Kristall befindlichen lasergekühlten Ionen oder durch charakteristische Säkularfrequenzen nachgewiesen. Wir diskutieren neben der Effizienz der sympathetischen Kühlung die auftretenden Schwingungsfrequenzen für größere Ionenkristalle gemischter Ladung. Des Weiteren geben wir einen Ausblick, wie höher geladene Ionen in einen Kristall eingebaut werden und möglicherweise zur Vermessung der Fokusintensität intensiver Laserfelder genutzt werden können.

Q 31.12 Di 16:30 Labsaal

Towards a high efficiency photon counter — •Harald Kübler[1], Andreas Chromik[1], Bernd Kaltenhäuser[1], Atac Imamoglu[2], Tilman Pfau[1], and Jürgen Stuhler[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Institut für Quantenelektronik, ETH Höggerberg, Wolfgang-Pauli-Str. 16, CH-8093 Zürich, Switzerland

We present progress towards a high efficiency photon counter based on storage of light as proposed in [1]. Our goal is to count photons that reach the detector in a well defined time slice with an efficiency of over 99%. For this, we want to make use of the interaction between bichromatic light and ultracold atoms with a Λ-type level structure. In particular, we want to use Rubidium atoms in a CO2-laser dipole trap, where n incoming photons will transfer n atoms into a certain state by a collective STIRAP-type process. These atoms will be detected afterwards by fluorescence with a state of the art photodiode. The atoms work as a linear amplifier for small photon numbers which will enable us to achieve high detection and counting efficiency. High efficiency photon detectors/counters may be used for tests of *Bell's inequality* and are useful for quantum teleportation and quantum cryptography. In combination with a single photon sources they may also be used to realize simple and robust linear optical quantum computers.

[1] A. Imamoglu, Phys. Rev. Lett. 89, 163602 (2002)

Q 31.13 Di 16:30 Labsaal

Towards electric trapping of neutral atoms — •T. Rieger, P. Windpassinger, T. Junglen, S.A. Rangwala, P.W.H. Pinkse und G. Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching.

The idea of electric trapping of neutral atoms in time-varying electric fields was already proposed in the early nineties [1]. Recently, we could show trapping of neutral molecules in electrostatic fields [2] and guiding in time-varying electric fields [3] with a similar technique. The perspective of sympathetic cooling of molecules with atoms led us to design an experiment for trapping neutral atoms in time-varying electric fields.

Simulations predict a trap depth of 80 μK, imposing pre-cooling in a magneto-optical trap. A vacuum apparatus was built housing the electrodes for the electric trap and providing optical access. A magneto-optical trap has been setup ≈ 2 cm besides the electric trap. The idea is to load the atoms in a magnetic trap and to transfer them over the distance of 2 cm by mechanically moving the trap coils with a piezo-electric translation stage. We report the status of the experiment.

[1] F. Shimizu and M. Morinaga, Jpn. J. Appl. Phys. **31**, L1721 (1992);
[2] T. Rieger et al., Phys. Rev. Lett., **95**, 173002 (2005)
[3] T. Junglen et al., Phys. Rev. Lett., **92**, 223001 (2004)

Q 31.14 Di 16:30 Labsaal

UV light-induced atom desorption for large — •Oliver Topic, Thorsten Henninger, Carsten Klempt, Wolfgang Ertmer, and Jan Arlt — Institut fuer Quantenoptik, Universit*at Hannover, Welfengarten 1, 30167 Hannover

We show that light-induced atom desorption (LIAD) [1] can be used as a flexible atomic source for large ^{87}Rb and ^{40}K magneto-optical traps. The use of LIAD at short wavelengths allows for fast switching of the desired vapor pressure. This is interesting effect for experiments in a single vacuum chamber, because it permits long trapping and coherence times. The wavelength dependence of the LIAD effect for both species was explored in a range from 253 nm to 630 nm in an uncoated quartz cell. Only a few mW/cm^2 of near-UV light produce partial pressures that are high enough to saturate a magneto-optical trap at 3.5×10^9 ^{87}Rb atoms or 7×10^7 ^{40}K atoms. Loading rates as high as 1.2×10^9 ^{87}Rb atoms/s and 8×10^7 ^{40}K atoms/s were achieved without the use of a secondary atom source. After the desorption light is turned off, the pressure quickly decays back to equilibrium with a time constant as short as $200 \mu s$, allowing for long trapping lifetimes after the MOT loading phase.

[1] C. Klempt, T. van Zoest, T. Henninger, O. Topic, E. Rasel, W. Ertmer and J. Arlt *cond-mat/0509241, accepted in PRA*