Q 20 Poster Fallen & Kühlung

Zeit: Montag 11:00–12:30 Raum: Poster HU

Q 20.1 Mo 11:00 Poster HU

Magnetische Mikrofallen mit zweilagigen Leiterbahnstrukturen — •Michael Ingrisch[1], Philipp Treutlein[1], Tilo Steinmetz[1], Theodor W. Hänsch[1] und Jakob Reichel[1,2] — [1]Max-Planck-Institut für Quantenoptik und Sektion Physik der Ludwig-Maximilians-Universität München, Germany — [2]Laboratoire Kastler Brossel de l'ENS, Paris, France

Mit magnetischen Mikrofallen für neutrale Atome, sog. Atomchips, eröffnen sich neue Möglichkeiten der Quanteninformationsverarbeitung und interferometrischen Präzisionsmessung. So ist es beispielsweise vorstellbar, mit einer großen Zahl von atomaren Qubits in Mikrofallen auf dem Chip parallel Gatteroperationen durchzuführen. Für interferometrische Messungen können maßgeschneiderte Potentiale zur kohärenten Aufspaltung von Bose-Einstein Kondensaten erzeugt werden.

Die Realisierung der für diese Anwendungen benötigten komplexen Potentiale wird durch mikroskopischen Leiterbahnen in mehreren voneinander isolierten Schichten auf dem Chip möglich. Die üblichen lithographischen Verfahren zur Herstellung von mikrometergroßen Strukturen sind hier jedoch nur eingeschränkt anwendbar, da die zur Erzeugung der Potentiale notwendigen Ströme vergleichsweise hoch sind und daher relativ dicke Leiterbahnen erfordern. Außerdem werden hohe Anforderungen an die isolierende Zwischenschicht gestellt: Sie soll einerseits möglichst dünn sein, aber andererseits gut planarisieren, um die zweite Leiterbahnebene herstellen zu können.

Wir stellen ein Verfahren vor, mit dem wir zweilagige Atomchips mit den gewünschten Strukturen herstellen können.

Q 20.2 Mo 11:00 Poster HU

Dunkelresonanzen zur Lokalisierung von einzelnen Ionen — C. Lisowski, •M. Knoop, C. Champenois, G. Hagel, M. Vedel und F. Vedel — Université de Provence, Centre de Saint Jérôme, Case C21, F-13397 Marseille Cedex 20

Mikrobewegung, verursacht durch in der Falle auftretende Störfelder, kann das Anregungsspektrum eines einzelnen gespeicherten Ions stark verzerren. Eine hohe Mikrobewegungsamplitude verringert den Kontrast von Dunkelresonanzen am Dreiniveau-Atom [1]. Der gemessene Kontrast hängt zudem von der Geometrie der Laserstrahlen ab. In unserem Experiment vergleichen wir den Einsatz von ko- oder kontrapropagierenden Lasern sowohl experimentell als auch numerisch als Sonde zur Kompensation der überschüssigen Mikrobewegung eines gespeicherten Ca^+-Ions.

[1] C. Lisowski et al., *arxiv*:physics/0407135

Q 20.3 Mo 11:00 Poster HU

Position control of atoms in a cavity — •Bernhard Weber, Stefan Nussmann, Markus Hijlkema, Axel Kuhn, and Gerhard Rempe — MPI für Quantenoptik, Hans-Kopfermann-Str.1, 85748 Garching

Controlling the motional degrees of freedom of single atoms is the basis for deterministic atom-photon or atom-atom interactions. The system we present allows for precise tuning of the coupling of a single atom to the field of an high finesse optical resonator. This is realized by the use of a far off-resonant dipole trap with a standing wave geometry perpendicular to the cavity axis. The trapping scheme starts with the transfer of cold Rb atoms from a MOT into the cavity mode by means of a guiding dipole trap. When the atoms arrive, we change the trap potential to a standing wave geometry with its focus inside the cavity and select only those atoms trapped inside the cavity mode volume. The atoms are observed via the emission into the cavity mode when pumped from the side, so that the measured intensity is proportional to the atom-cavity-coupling. Turning a glass plate in the optical path of the standing-wave trap changes the position of the antinodes containing atoms, so the coupling to the cavity mode is tunable. This mechanism can be used to select one out of several atoms distributed along the trap axis and position it deterministically inside the cavity mode. This kind of system can provide a quantum register for quantum computing with atoms individually adressable via the cavity.

Q 20.4 Mo 11:00 Poster HU

Eine magneto-optische Falle zum Kühlen und Fangen von Quecksilber-Atomen — •P. Villwock, M. Sinther und Th. Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, D-64289 Darmstadt

Quecksilber bietet eine Vielzahl interessanter Möglichkeiten für Experimente in einer magneto-optischen Falle. Es wird der derzeitige Fortschritt der experimentellen Realisierung einer Atomfalle für Quecksilber vorgestellt. Der verwendete Kühlübergang liegt bei einer Wellenlänge von 253, 7 nm. Hierzu soll innerhalb einer UHV-Kammer mit einer Einstrahl-MOT ein gekühlter Atomstrahl erzeugt werden, der durch eine differentielle Pumpstufe hindurch in eine magneto-optische Falle gelangt. Alle relevanten Daten zum Kühlen und Fangen von Quecksilber-Atomen werden diskutiert.

Q 20.5 Mo 11:00 Poster HU

Experimental observation of transient velocity-selective coherent population trapping in one dimension — •Frank Vewinger, Frank Zimmer, Klaas Bergmann, and Michael Fleischhauer — Fachbereich Physik, TU Kaiserslautern

We report the observation of transient velocity-selective coherent population trapping (VSCPT)[1] in a beam of metastable neon atoms. The atomic momentum distribution resulting from the interaction with counterpropagating σ_+ and σ_- radiation coupling a $J_g = 2 \leftrightarrow J_e = 1$ transition is measured via the transversal beam profile. This transition exhibits a stable VSCPT dark state between the $|J = 2, m = \pm 1 >$ states, and a metastable dark state containing the $|J = 2, m = \pm 2 >$ and $|J = 2, m = 0 >$ state[2]. The decay of the latter dark state is experimentally observed and its metastability is directly shown by control of the interaction time. We analyze the population dynamics by solving the generalized optical Bloch equations numerically and compare it with the measured distribution.

[1] A. Aspect et al. *PRL* **61**:826 (1988)
[2] F. Papoff et al. *JOSA B* **9**:321 (1992)

Q 20.6 Mo 11:00 Poster HU

An evaporation-free approach to Bose Einstein Condensation of ^{87}Rb — •Jörg Lange[1], Peter Staanum[1,2], Stephan Kraft[1], Roland Wester[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg — [2]Institut für Quantenoptik, Universität Hannover, 30167 Hannover

Bose Einstein Condensation of ^{87}Rb atoms in quasi-electrostatical dipole traps formed by a focussed CO_2-laser beam has been demonstrated in recent experiments [1]. Due to the limited initial number of atoms in such dipole traps, the final atom number in the condensate which is achieved after evaporative cooling is usually quite low.

We present the current status of a new experiment, in which we combine a CO_2-laser trap ($\lambda = 10.6\,\mu$m) with Raman sideband cooling [2] and a tightly focussed dipole trap at 1064 nm to produce a ^{87}Rb-condensate without evaporation.

[1] M. D. Barrett *et al.*, Phys. Rev. Lett. **87**, 010404 (2001), G. Cennini *et al.*, Phys.Rev. Lett. **91**, 240408 (2003)
[2] A. J. Kerman *et al.*, Phys. Rev. Lett. **84**, 439 (2000)

Q 20.7 Mo 11:00 Poster HU

Towards electric trapping of neutral atoms — •T. Rieger, P. Windpassinger, T. Junglen, S.A. Rangwala, P.W.H. Pinkse, and 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 1990ies [1]. Recently, we could show guiding of neutral molecules in time-varying electric fields [2] 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 about 30 μK for typical experimental parameters, imposing pre-cooling in a magneto-optical trap (MOT). A vacuum apparatus was built housing the electrodes for the electric trap and providing optical access. A MOT has been setup $\approx$ 1 cm below the electric trap. The idea is to load the atoms into a magnetic trap and to transfer them over the distance of 1 cm, by lifting the center of the

magnetic trap. We report the status of the experiment.
[1] F. Shimizu and M. Morinaga, Jpn. J. Appl. Phys. **31**, L1721 (1992);
[2] T. Junglen et al., Phys. Rev. Let., **92**, 223001 (2004)

Q 20.8 Mo 11:00 Poster HU

Trapping and cooling of a single atom in an intracavity dipole trap. — •T. Puppe, P. Maunz, I. Schuster, A. Grothe, K. Murr, P.W.H. Pinkse und G. Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

A single atom strongly coupled to the field mode of a small high-finesse cavity represents a fundamental system of cavity-QED. This system is well suited for fundamental studies as well as implementations of quantum information processing protocols. Most of these applications require a good control over the atomic position. Cavity cooling [1] proved capable of improving the localization of the atom [2], thereby compensating for inevitable heating due to near-resonant probing. The measurement of a well-resolved normal-mode splitting [3] documents the warranted strong coupling as required by most applications.

Here we discuss the possibility to further improve the trapping and cooling of single atoms in an intracavity dipole trap. This would cure the localized heating regions present in previous experiments and improve on the control of the Stark shift at the trap center. Introducing auxiliary blue-detuned laser beams provides additional flexibility which allows to tailor the position-dependent light forces and Stark shift.

[1] P. Horak et al., and H. Ritsch, Phys. Rev. Lett. **79**, 4974 (1997); V. Vuletić and S. Chu, Phys. Rev. Lett. **84**, 3787 (2000).
[2] P. Maunz, T. Puppe, I. Schuster, N. Syassen, P.W.H. Pinkse, and G. Rempe, Nature **428**, 50 (2004).
[3] P. Maunz, T. Puppe, I. Schuster, N. Syassen, P.W.H. Pinkse, and G. Rempe, quant-ph/0406136.

Q 20.9 Mo 11:00 Poster HU

A laser cooled Indium atomic beam for Atomic Nanofabrication — •Bernhard Klöter, Ruby dela Torre, Jae-Ihn Kim, Claudia Weber, Ulrich Rasbach, and Dieter Meschede — Institut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn

Atomic Nanofabrication (ANF) requires highly collimated and intense atomic beams that can be created by laser cooling. We plan to structure an Indium atomic beam by the optical dipole force in an inhomogeneous, near resonant light field which acts as a highly regular and immaterial mask for the atoms. Since Indium atoms can directly be deposited on a substrate, the co-deposition of Indium, Aluminum and Arsenic offers the possibility to produce 3D periodically structured III-V semiconductors by selectively changing the Indium concentration and thus the index of refraction in an $(In_xAl_{1-x})As$ compound during the growth process. The period of the modulation of the index of refraction is consistent with optical wavelengths used in opto-electronics. Our detailed investigations on laser cooling of Indium and first results of ANF with a 1D standing wave will be presented.

Q 20.10 Mo 11:00 Poster HU

Atom Chips in the real World: The role of wire corrugation — •Thorsten Schumm, Jérôme Esteve, Jean-Baptiste Trebbia, Hai Nguyen, Isabelle Bouchoule, Chris Westbrook, and Alain Aspect — Laboratoire Charles Fabry de l'Institut d'Optique, UMR 8501 du CNRS, 91403 Orsay Cedex, France

Atom chips have proven to be a powerfull tool in atom optics. They combine robusteness, simplicity and low power consumption with strong confinement and high flexibility in the design of the trapping geometry. "Real world" limitations of this system are therefore of special interest: losses and heating of atoms close to room temperature metallic surfaces have been theoretically predicted and experimentally observed soon after the first realization of atom chips. An unpredicted phenomenon was the fragmentation of trapped cold atomic clouds or Bose condensates in magnetic microtraps. It has been shown, that this fragmentation is due to static distortions of the curent flow inside the wires, creating a coresponding roughness in the trapping potential. In our work, we present a quantitative analysis of the potential roughness created by micro wires. The trapping potential of a chip trap was probed using cold atoms. We analized the trapping wire and its geometrical edge and surface defects using SEM and AFM techniques. A theoretical model allows us to calculate the potential expected from such a wire. We find good aggreement between the potential rougness measured with atoms and the one calculated from the wire shape, explaining the fragmentation observed in our experimental system by geometrical wire deformations.

Q 20.11 Mo 11:00 Poster HU

Cooling atomic motion in an optical resonator — •Stefano Zippilli[1] and Giovanna Morigi[2] — [1]Abteilung für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany — [2]Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain

We investigate the dynamics of laser cooling of atoms whose dipole transition couples to a mode of a high-finesse optical resonator and is driven by a transverse laser. We show that, in the presence of an external trapping potential, the center-of-mass motion of the atoms can be efficiently cooled to the ground state even when the atomic parameters do not allow for sideband cooling. Our mechanism exploits an interference effect between cavity field and laser, thereby achieving large cooling efficiencies in the strong coupling regime.

We derive an equation for the center-of-mass motion in the Lamb–Dicke limit by adiabatically eliminating the internal degrees of freedom. The theoretical predictions are discussed for experimental parameters and are compared to a numerical simulation of the full quantum mechanical model.

Q 20.12 Mo 11:00 Poster HU

Simultaneous Trapping of Three Atomic Species: The Triple MOT — •Matthias Taglieber, Arne-Christian Voigt, Florian Henkel, Sebastian Fray, Theodor W. Hänsch und Kai Dieckmann — Max-Planck-Institute for Quantum Optics, Hans-Kopfermann-Str. 1, D-85748 Garching and Faculty of Physics, Ludwig-Maximilians-University Munich, Schellingstrasse 4/III, D-80799 Munich

We started a new experiment for the production of ultracold fermionic quantum gases and Bose-Fermi mixtures. The production scheme is based on loading of a multiple-species magneto-optical trap (MOT) with fermionic lithium from a Zeeman slower and fermionic potassium as well as bosonic rubidium from vapor dispensers. In a next step, the atoms will be magnetically trapped and transferred [1] from the MOT chamber into a UHV chamber, where the fermions will be sympathetically cooled by rubidium. We present the status of the experiment and show experimental results on the simultaneous magneto-optical trapping of ^6Li, ^{40}K, and ^{87}Rb. Furthermore, we relate to applications for non-interacting fermions and for two-component fermionic quantum gases in the strongly interacting regime.

[1] M. Greiner et al., Phys. Rev. A, **63**, 031401 (2001)

Q 20.13 Mo 11:00 Poster HU

Sympathetic Cooling of Helium and Molecular Hydrogen Ions — •Bernhard Roth, Peter Blythe, Ulf Fröhlich, Helmut Wenz, and Stephan Schiller — Heinrich-Heine-Universität Düsseldorf

Few-body Coulomb systems belong to the most fundamental in physics, and have been central in the development of quantum mechanics, relativistic quantum mechanics, QED and nuclear physics. Helium and molecular hydrogen ions are interesting systems, e.g. for precision tests of QED and measurement of fundamental constants. As one of the simplest molecules, HD^+ is particularly suitable to test theories of molecular structure. One important aspect in future precision experiments will be the availability of trapped ultracold helium and molecular hydrogen ions, in order to minimize the influence of Doppler broadening and allow a precise study of systematic effects.
We have generated ultracold ensembles of $^3He^+$, $^4He^+$, and of various molecular hydrogen isotopes, by sympathetic cooling using laser-cooled $^9Be^+$ in a linear rf-trap. Stable ion plasmas in an ordered state (Coulomb crystal) containing several 100 localized sympathetic particles and up to 6.000 Be^+ ions at temperatures of <20 mK were obtained. We have studied the properties of these mixed-species ion plasmas, both for spheroidal and ellipsoidal symmetry, as well as chemical reactions between the atomic coolants and neutral light molecules. The experimental results are compared to molecular dynamics simulations. The present work also indicates the feasibility of cooling and trapping highly charged atomic ions using $^9Be^+$ as coolant.

Q 20.14 Mo 11:00 Poster HU

Metastable Ca Atoms in a Magnetic Quadrupole - Ioffe Trap — •Dirk Hansen, Janis Mohr, Ciprian Zafiu, and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Alkaline-earth-metal atoms provide a unique combination of interesting spectroscopic features connected to their two valence electrons. The resulting singlet and triplet states offer strong principle fluorescence lines well suited for laser cooling as well as narrow-band intercombination transitions that can be used for refined laser cooling schemes. The metastable $^3P_2$, $m_J = 2$ state is an interesting candidate for magnetic trapping and possibly the formation of a Bose-Einstein-Condensate (BEC); production of magnetically trapped metastable samples at low temperatures was previously demonstrated in our group [1-2].

In this poster we report on current developments of the experiment: optimized loading of the magnetic quadrupole trap, transfer into a tight Joffe-Pritchard trap, forced RF-evaporation. The prospects of reaching BEC through evaporative cooling are discussed and compared to recent theoretical results [3-4] on the scattering properties of Calcium.

[1] J. Grünert, S. Ritter, and A. Hemmerich, Phys. Rev. A 65, 041401(R) (2002)

[2] D. Hansen, J. Mohr, A. Hemmerich, Phys. Rev. A 67, 021401(R) (2003)

[3] V. Kokoouline, R. Santra, and C. H. Greene, Phys. Rev. Lett. 90, 253201 (2003)

[4] A. Derevianko, Phys. Rev. Lett. 87, 023002 (2001)

Q 20.15 Mo 11:00 Poster HU

Bose-Einstein-Kondensate in kombinierten Chip-Fallen — •Andreas Günther, Philipp Wicke, Sebastian Kraft, József Fortágh und Claus Zimmermann — Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

Wir stellen kombinierte Mikrofallen vor, in denen einerseits eine hochpräzise Kontrolle der Position und Schwerpunktsbewegung eines Bose-Einstein-Kondensats möglich ist, andererseits durch die Anwendung dünner Potentialbarrieren Interferenzexperimente durchgeführt werden können. Die dreidimensionale Positionierung des Bose-Einstein-Kondensats erfolgt im magnetischen Wellenleiterpotential eines Träger-Chips. An der Oberfläche des Träger-Chips befinden sich weitere fein strukturierte Mikrochips mit atomoptischen Elementen. Im magnetischen Gitterpotential eines Mikrochips mit der Periode von vier Mikrometer wird Bragg-Reflexion beobachtet und ein interferometrischer Kraftsensor realisiert. Das experimentelle System wird durch ein Einzelatomdetektor erweitert, der in der Mikrofalle integriert ist.

Q 20.16 Mo 11:00 Poster HU

Neue Kühlverfahren für einen Magnesiumfrequenzstandard — •K. Moldenhauer, T. E. Mehlstäubler, N. Rehbein, V. Michels, H. Stoehr, J. Friebe, E. M. Rasel und W. Ertmer — Inst. f. Quantenoptik, Univ. Hannover, Welfengarten 1, 30167 Hannover

Die hochpräzise Zeitmessung findet eine direkte Anwendung in Feldern wie der Steuerung von Satelliten, GPS und der Messung der Variation von Naturkonstanten. Der Übergang vom heutigen Cs-Frequenzstandard auf Mikrowellenbasis hin zu optischen Frequenzstandards verspricht eine Steigerung der Stabilität um 2-3 Größenordnungen [1]. Ziel unseres Experimentes ist die Realisierung einer optischen Uhr auf Basis von ultrakalten Magnesiumatomen. Da die Restbewegung der Atome die erreichbare Genauigkeit limitiert [2], werden gegenwärtig zwei neue, auf zweistufigen Anregungsprozessen basierende Kühlmethoden, untersucht. Im ersten Fall handelt es sich um einen inkohärenten Prozess (quenching), der das Kühlen auf der hochverbotenen Interkombinationslinie ermöglicht. Hierzu werden neue Ergebnisse der Spektroskopie der Quenchlinie vorgestellt. Das zweite Verfahren nutzt kohärente Prozesse, um die Linienbreite des MOT-Übergangs zu verringern. Hier wurden sowohl Heiz- als auch Kühleffekte beobachtet. Weiterhin wurde an der Entwicklung leistungsfähigerer Laserquellen gearbeitet: Zur Spektroskopie des Uhrenübergangs bei 457 nm wurde ein frequenzverdoppelter Scheibenlaser aufgebaut und zur effizienten UV-Erzeugung der MOT-Strahlung bei 285 nm wurden optisch kontaktierte BBO-Kristalle mit Walkoff-Kompensation getestet.

[1] G. Wilpers et al., *Phys. Rev. Lett.,* **89** 23 (2002)

[2] J. Keupp, Dissertation, Universität Hannover (2003)

Q 20.17 Mo 11:00 Poster HU

A low cost scheme for transferering frequency stability over nm intervals — •Kai Jentson — Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg

In the course of experiments in laser cooling in a high finesse cavity, we encouter the problem of transferring the frequency stability of a diode laser across the several nm wide frequency intervall. The 780 nm output of a diode laser is stabilized to a longitudinal mode of a high finesse (100.000, 50 kHz line width) referenz cabity RC1 by a fast (4 Mhz bandwidth) injection current feedback. The cavity RC1 is stabilized by means of a PZT-mounted mirror to the output of a second diode laser emitting at 786 nm wich itself is stabilized to a second high finesse (180.000 , 20 kHz line width) referenz cavity RC2 by a fast injection current feedback. Spectroscopy of RC2 with the 780 nm diode gives us information on the achieved relative frequenzy stability of the two diodes.