Q 53 Fallen und Kühlung II

Zeit: Mittwoch 14:30–17:00 Raum: HII

Q 53.1 Mi 14:30 HII

Laser Cooling of an Indium Atomic Beam — •Bernhard Klöter, Jae-Ihn Kim, Claudia Weber, and Dieter Meschede — Institut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn

Laser cooled atomic beams are the method of choice for Atomic Nanofabrication (ANF) where high deposition rates are needed. We have realized 1D transverse cooling of a neutral Indium atomic beam with a cooling scheme which involves five laser wavelengths at 410 nm and 451 nm. We present our systematic studies on these schemes and first results on the deposition of an Indium atomic beam onto a substrate.

Q 53.2 Mi 14:45 HII

High phase space densities in a mixture of ultracold lithium and cesium atoms — •Jörg Lange[1], Leif Vogel[1], Christian Giese[1], Benjamin Müller[1], Stephan Kraft[1], Peter Staanum[1,2], Roland Wester[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany — [2]Institut für Quantenoptik, Universität Hannover, 30167 Hannover, Germany

Due to their capability of simultaneously storing different atomic and molecular species, far-detuned optical dipole traps offer a unique environment to study ultracold atomic and molecular collisions. We trap a mixture of lithium and cesium atoms at very low temperatures in the focus of a CO_2-laser beam. Sympathetic cooling of atomic ^{7}Li by colder Cs atoms has been demonstrated [1], and Cs-Cs_2 collisional rate coefficients have been determined after homonuclear photoassociation in the trap [2].

We present a scheme to reach higher phase space densities by crossing the CO_2-laser with a 1064 nm laser beam and by applying Raman sideband cooling to the Cs atoms prior to molecule formation. Prospects of sympathetically cooling atomic lithium to quantum degeneracy will be discussed as well as the possibility of investigating intermolecular collisions and atom-molecule exchange reactions.

[1] M. Mudrich *et al.*, Phys. Rev. Lett. **88**, 253001 (2002)
[2] S. D. Kraft *et al.*, Phys. Rev. A **71**, 013417 (2005); P. Staanum *et al.*, arXiv:physics/0509123 (Phys. Rev. Lett. in press)

Q 53.3 Mi 15:00 HII

Single trapped Ca^+ ions for frequency metrology — •G. Hagel, M. Knoop, C. Champenois, M. Houssin, M. Vedel, and F. Vedel — Université de Provence, Marseille, France

Due to its natural linewidth below 200mHz, the electric quadrupole transition at 729 nm of a single trapped calcium ion is an excellent candidate for the realization of an frequency standard in the optical domain. The wavelengths for lasercooling (397 and 866nm) and excitation of the clock transition can all be generated from solid-state or even diode lasers. Single ions are trapped in a miniature ring trap. Different scenarios have been employed to cool, immobilize and probe the ion, recent progress of the experiment will be presented.

Q 53.4 Mi 15:15 HII

Blue light fields in strongly-coupled atom-cavity systems — •T. Puppe, I. Schuster, A. Grothe, J. Almer, K. Murr, P.W.H. Pinkse, and G. Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

A fundamental system of matter-light interaction is realized by a single atom strongly coupled to the field mode of a small high-finesse cavity. The experimental study of quantum effects as well as the implementation of quantum information processing schemes requires a well-controlled atomic position to ensure persistent strong coupling. Cavity cooling proved capable of improving the axial localization of the atom [1], thereby compensating for inevitable heating in this setting due to cavity-mediated momentum diffusion [2].

We propose to implement blue-detuned laser fields in addition to a red intracavity dipole trap. The freedom gained in tailoring the position dependent Stark shift can be used to achieve effective guiding and detection of single atoms as well as strong localization in the trap. In addition, the blue fields allow to explore a new parameter regime which is compatible with cavity cooling in axial and radial directions.

[1] P. Maunz, T. Puppe, I. Schuster, N. Syassen, P.W.H. Pinkse, and G. Rempe, Nature **428**, 50 (2004).
[2] K. Murr, P. Maunz, P.W.H. Pinkse, T. Puppe, I. Schuster, D. Vitali and G. Rempe arXiv/quant-ph 0512001 (2005).

Q 53.5 Mi 15:30 HII

Vacuum-Stimulated Cooling of Single Atoms in Three Dimensions — •Markus Hijlkema, Stefan Nussmann, Karim Murr, Bernhard Weber, Simon Webster, Holger Specht, Axel Kuhn, and Gerhard Rempe — Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Control of light-matter interactions at the single-atom and single-photon level can be achieved in the strong coupling regime of cavity quantum electrodynamics, where atom and cavity form a single entity. With our experimental setup we are able to capture, cool and hold a single atom at rest inside a microcavity, ensuring a strong and constant atom-cavity coupling on a timescale of several seconds. To provide a trapping potential, we use a far off-resonant standing wave dipole trap perpendicular to the cavity axis, where each antinode of the standing wave provides three dimensional confinement.[1] We have now discovered that the orthogonal arrangement of the trapping laser, the cavity vacuum and an additional cooling laser gives rise to a unique combination of friction forces acting on the atom along all three directions. This novel three dimensional cooling scheme allows us to easily catch and cool a single atom into the dipole trap inside the high-finesse cavity. We show that a simple theoretical model based on a two-level atom can explain the origin of these forces.[2] Inside the trap,very low temperatures are reached, leading to average single-atom trapping times exceeding 15 seconds, unprecedented for a strongly coupled atom under permanent observation.
[1] Nußmann et al. Phys. Rev. Lett. 95 173602 (2005) [2] Nußmann et al, Nature Physics 1 , 120 (2005)

Q 53.6 Mi 15:45 HII

Grundlagen einer optischen Magnesium-Atomuhr — •Nils Rehbein, Jan Friebe, Tanja E. Mehlstäubler, Karsten Moldenhauer, Matthias Riedmann, Ernst M. Rasel und Wolfgang Ertmer — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

Aufgrund seiner ultraschmalen Übergänge stellt Magnesium einen vielversprechenden Kandidaten für die Realisierung einer optischen Atomuhr dar. Beim ^{24}Mg Uhrenübergang (457 nm) wurde eine spektroskopische Auflösung von bis zu 290 Hz erreicht. Für den Magnesium-Frequenzstandard lässt sich daraus eine Kurzzeitstabilität von $8*10^{-14}$ in 1 s ableiten [1]. Diese Werte werden hauptsächlich durch die Restbewegung der Atome limitiert. Bei ^{24}Mg sind die Standardmethoden der sub-Doppler-Kühlung nicht anwendbar. Daher werden von uns verschiedene neue Kühlverfahren untersucht. Wir berichten über den Fortschritt beim Quenchkühlen und Zwei-Photonen-Kühlen [2,3,4,5]. Die Erzeugung sehr viel höherer Lichtleistungen bei der Wellenlänge des MOT-Kühlübergangs (285 nm) ergibt deutlich höhere Atomzahlen. Daher wurden neue Verfahren der Frequenzverdoppelung mittels optisch kontaktierter, walk-off kompensierter BBO-Kristalle untersucht [6].

[1] J. Keupp et al., Eur. Phys. J. D 36, 289-244 (2005)
[2] T. Binnewies et al., Phys. Rev. Lett. 87, 123002 (2001)
[3] T.E. Mehlstäubler et al., J. Opt. B 5, 183 (2003)
[4] R.L. Cavasso Filho et al., J. Opt. Soc. Am. B 20, 994 (2003)
[5] W.C. Magno et al., Phys. Rev. A 67, 043407 (2003)
[6] J. Friebe et al., akzeptiert von Opt. Com.

— 30 min. Pause —

Q 53.7 Mi 16:30 HII

Multi-channel collisions of cold metastable calcium atoms — •Dirk Hansen and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

We present measurements of elastic and inelastic collision rates of metastable calcium in a miniaturized Ioffe trap. The results are compared to recent theoretical calculations [1] that predict unusually large inelastic rates which even exceed the elastic ones. According to [1], the collisions are determined by partial waves with high angular momenta even at low temperatures. The ensembles in our experiment were prepared between 0.5 mK and 2.5 mK by 1-dim Doppler cooling or by adiabatic adjustment of the trap compression. By disturbing the aspect ratio of the sample and measuring its reequilibration we can deduce the cross-dimensional relaxation parameter. The two-body loss parameter is determined from trap decay measurements. Both types of experiments yield nearly equal values for these parameters between 2×10^{-10} and 5×10^{-10} cm^3/s and are slightly above [1]. As a consequence, evaporative cooling in a magnetic trap can be ruled out as an option to reach the quantum degenerate regime. The elastic rates are clearly above the unitarity limit for S-wave scattering and confirm the multi-channel character of the collision.

[1] V. Kokoouline, R. Santra, and C. H. Greene, PRL 90, 253201 (2003)

Q 53.8 Mi 16:45 HII

Atom detection with a chip-based fiber Fabry-Pérot cavity — •Yves Colombe[1], Tilo Steinmetz[1,2], David Hunger[1], Philipp Treutlein[1], Theodor W. Hänsch[1], and Jakob Reichel[2] — [1]Max-Planck-Institut für Quantenoptik und Sektion Physik der Ludwig-Maximilians-Universität, Munich, Germany — [2]Laboratoire Kastler Brossel de l'ENS, Paris, France

Single-atom detection capability is a requirement in many quantum information processing schemes. In this talk we report on our progress towards single-atom detection on a microchip. We have developped a miniaturized optical Fabry-Pérot resonator that is integrated on an atom chip, only 200μm away from the surface. The cavity is formed by concave mirrors glued at the ends of two optical fibers facing each other. It has a length of 27μm and a finesse of about 1000. We magnetically trap and transport rubidium atoms on the chip over an 8mm distance, from the MOT loading region to a magnetic trap nearby the cavity. The atomic cloud is then evaporatively cooled to temperatures in the microkelvin range, and tranferred to the resonator's mode in a controlled way. The magnetically trapped atoms are detected by monitoring the transmission of the cavity. We have been able to detect clouds of about 10 atoms. With bigger atomic ensembles, we have also observed dispersive signals due to the refractive index of the atoms, as well as absorptive optical bistability.