A 34: Ultracold Atoms: Trapping and Cooling II (with Q)

Time: Thursday 14:30–16:15 Location: P/H2

A 34.1 Thu 14:30 P/H2

Trapping atoms with laser written waveguides — Dario Jukić, Thomas Pohl, and •Jörg Götte — Max-Planck-Insitut für Physik komplexer Systeme, Dresden

We show how simple waveguide structures written into fused silica with femtosecond lasers, can be operated to trap Caesium atoms in the evanescent field in close proximity to the fused silica to air interface. The use of the fundamental mode of red detuned light and two spatial modes of blue detuned light allows us to balance the attractive surface forces and to create a stable potential minimum a few hundred nanometers from the surface of the waveguide. The process is very flexible, cost effective and allows for the realisation of a variety of complex trapping geometries. Using counter propagating waves we can realise optical conveyor belts with this design which is why our setup lends itself ideally for integration in optical atom chips.

A 34.2 Thu 14:45 P/H2

Loading atoms into hollow-core fibers — •Lachezar Simeonov[1], Micha Ober[2], Thorsten Peters[1], and Reinhold Walser[2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstrasse 6, 64289 Darmstadt, Germany — [2]Institut für Angewandte Physik Technische Universität Darmstadt Geb. S2/09, 2. Stock, Zimmer 104 Hochschulstrasse 4A D-64289 Darmstadt, Germany

Loading cold Rb atoms at temperature 120 μK out of a magneto-optical trap (MOT) into a hollow-core photonic crystal fiber (7 μm core diameter) [1] promises interesting scenarios for strong light-atom coupling. To simulate the loading procedure and to optimize the coupling efficiency, we use a 3-dimensional Quantum-Monte-Carlo wave function simulation [2]. In this contribution, we discuss basic aspects of this simulation, modelling Rb atoms as a two-level system. We describe the non-equilibrium relaxation of a thermal ensemble subject to laser cooling in phase space and present results.

[1] F. Blatt, T. Halfmann, and T. Peters, Opt. Lett., Vol.39, No. 3 (2014).

[2] C. W. Gardiner, P. Zoller, Quantum Noise, a handbook of Markovian and non-Markovian quantum stochastic methods with applications to quantum optics, 2. enl. ed.- Springer, 2000

A 34.3 Thu 15:00 P/H2

Double-EIT Cooling: A Quicker Route to the Ground State — Jannes Wübbena[1], Nils Scharnhorst[1], Stephan Hannig[1], •Ian D. Leroux[1], and Piet O. Schmidt[1,2] — [1]QUEST Institute for Experimental Quantum Metrology, Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [2]Leibniz Universität Hannover, 30167 Hannover

Laser cooling using the Lorentzian scattering resonances of (effective) two-level atoms suffers from a fundamental conflict between low equilibrium temperatures, which require narrow cooling resonances, and fast cooling, which requires frequent scattering to remove entropy from the atom's motion and broad resonances to address multiple motional modes at once. In multi-level atoms, coherences between levels can be used to design non-Lorentzian scattering spectra that selectively suppress heating processes. This allows laser cooling with a speed and bandwidth typical of Doppler cooling to equilibrium temperatures normally only reached through slow sideband cooling on narrow transitions. We demonstrate that so-called double-EIT cooling, based on a tripod level scheme, can be used to cool a $^{40}Ca^{+}$ ion to the motional ground state several times faster than optimised sideband cooling. Such fast cooling has important applications in state-of-the-art optical frequency standards, which we briefly discuss.

A 34.4 Thu 15:15 P/H2

Mechanical and electronic energy eigenstates of neutral Rb atoms in deep optical lattices — •Andreas Neuzner, Matthias Körber, Olivier Morin, Stephan Ritter, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Optical lattices allow for tight three-dimensional confinement of neutral atoms in quasi-harmonic potentials and have become a standard tool in experimental quantum optics. Applications range from fundamental topics like metrology to applications in quantum communication and quantum information processing. In this talk we present an experimental characterization of the motional and internal energy eigenstates of optically trapped ^{87}Rb atoms. We implement different spectroscopy techniques based on non-destructive hyperfine state detection using an optical cavity. Applying this technique, we observe and explain a series of effects like the decoupling of the hyperfine spin due to a tensor lightshift and mechanical effects associated with a small non-orthogonality of the lattice axes. The observed effects are generally of high experimental relevance. Furthermore, we succeed to exploit the latter for optical cooling of a single atom into the two-dimensional mechanical groundstate in an environment with restricted optical access.

A 34.5 Thu 15:30 P/H2

Measuring heating rate of ions in a planar ion trap with variable ion-surface separation — •Ivan Boldin, Alexander Kraft, and Christof Wunderlich — University of Siegen, 57068 Siegen, Germany

Planar electrode ion traps are considered to have great potential for quantum information science as: a) they are relatively easy to scale up and allow for complex electrode structures that might be needed for future quantum processors; b) ions can be trapped tens of micrometers above the surface, therefore strong static and oscillating field gradients can be imposed on ions and utilized in the realization of microwave qubit processing.

While reducing the ion-surface separation is advantageous for stronger field gradients and hence faster quantum gates, it also increases undesired interactions with the electrode surface. This heating is one of the major sources of decoherence and its mechanism is not well understood so far. In order to better understand this mechanism it is of interest to know how it depends on the ion-surface separation. Here we present the results of such heating rate measurements.

We have built a planar electrode ion trap in which the ion-surface distance can be varied in the range of 45 - 155 um by applying additional RF voltage to the central electrode. We measure the heating rates by recooling method i.e. allowing ion to heat up for a certain time and suddenly switching on the laser cooling and measuring the photon scattering rate over time. Fitting this curve with the theoretical allows estimation of the heating rate.

A 34.6 Thu 15:45 P/H2

Atomfalle zum isotopenselektiven Einfang von optisch angeregten Kryptonatomen — •Carsten Sieveke[1], Markus Kohler[1], Peter Sahling[1], Simon Hebel[1], Friderike Göring[1], Ergin Simsek[1], Christoph Becker[2] und Klaus Sengstock[2] — [1]ZNF, Universität Hamburg — [2]ILP, Universität Hamburg

Das nahezu ausschließlich in Kernspaltungsprozessen entstehende Isotop Kr-85 ist aufgrund seiner chemischen Trägheit hervorragend geeignet, als Indikator für die Entdeckung nuklearer Wiederaufbereitungsaktivitäten eingesetzt zu werden. Die äußerst geringen Konzentrationen dieses Spurengases nach seiner Freisetzung in die Atmosphäre erfordern eine hochsensitive Nachweismethode.

1999 wurde am Argonne National Laboratory eine neue Möglichkeit (Atom Trap Trace Analysis, ATTA) entwickelt, die Konzentration dieses Isotops in Luftproben der Größenordnung 10 Liter zu bestimmen. Das Mindestprobenvolumen und der Probendurchsatz wurde technisch durch die Notwendigkeit einer Elektronenstoßanregung vorgegeben.

Vorgestellt wird eine Weiterentwicklung dieser Methode, bei der die Elektronenstoßanregung durch eine optische Anregung ersetzt wird, um die Limitierung von Probengröße und -durchsatz zu überwinden. Diese basiert auf einer Kombination von 2D- und 3D-MOT, deren Funktionsweise und physikalische Eigenschaften demonstriert werden.

A 34.7 Thu 16:00 P/H2

Implementation of Λ-enhanced gray-molasses cooling for ^{40}K — •Matthias Tarnowski, Nick Fläschner, Dominik Vogel, Benno Rem, Christof Weitenberg, and Klaus Sengstock — Institut für Laserphysik, Uni Hamburg

Sub-Doppler cooling is an important step to reach quantum degeneracy in atomic gases. It has recently been demonstrated that the Λ-enhanced gray-molasses scheme leads to much lower temperatures than expected for alkali atoms. Here, we present a detailed study of a blue-detuned gray-molasses cooling scheme for fermionic ^{40}K on the D_1 transition. We find that the Raman resonance condition between the cooling and repumping frequency in a Λ-type system has indeed to be fulfilled to observe the anticipated narrow feature of very low temperatures around the resonance. With optimal parameters we achieve a temperature of 6 μK. In combination with repumping and optical pumping on the D_1 transition we realize efficient loading of a K-Rb mixture into a magnetic trap and fast subsequent evaporation. We significantly reduce the cycle time of our experimental sequence compared to cooling on the D_2 transition. Our results demonstrate ideal starting conditions for all-optical production of potassium degenerate gases.