A 56: Ultracold atoms and molecules II (with Q)

Time: Friday 14:00–15:30 Location: DO26 208

A 56.1 Fri 14:00 DO26 208

3D motional ground state cooling of a single atom inside a high-finesse cavity — •Natalie Thau, Wolfgang Alt, Tobias Macha, Lothar Ratschbacher, René Reimann, Seokchan Yoon, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn

Tight control and knowledge of the motional states of single atoms are a prerequisite for many cavity-QED experiments. In our system single cesium atoms coupled to a high finesse optical cavity are cooled close to the 2D motional ground state by means of resolved Raman sideband cooling [1,2]. We drive Raman transitions between two hyperfine ground states, where the blue detuned intracavity dipole trap acts as one of the two perpendicular adjusted Raman beams. Thereby we strongly suppress motional carrier transitions along the cavity axis and implement effective cooling. A Raman spectrum is recorded by mapping out the population of the motional ground states to one hyperfine ground state by Raman transitions for different two-photon detunings. Each time the atomic state is efficiently detected with the cavity as a non-destructive measurement tool. Currently, we expand the scheme to reach 3D ground state cooling.

[1] A. Boca *et al.*, Phys. Rev. Lett. **93**, 233603 (2004)
[2] A. Reiserer *et al.*, Phys. Rev. Lett. **110**, 223003 (2013)

A 56.2 Fri 14:15 DO26 208

Efficient demagnetization cooling and its limits — •Jahn Rührig, Tobias Bäuerle, Tilman Pfau, and Axel Griesmaier — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, Stuttgart, 70569 , Germany

We present the latest data on the demagnetization cooling of a dipolar chromium gas and discuss the limitations regarding reabsorption of optical pumping photons and light assisted collisions. Demagnetizaiton cooling utilizes dipolar relaxations that couple the internal degree of freedom (spin) to the external (angular momentum) to efficiently cool an atomic cloud [1]. Optical pumping into a dark state constantly recycles the atoms that were promoted to higher spin states. The net energy taken away by a single photon is very favorable as the lost energy per atom is the Zeeman energy rather than the recoil energy. The cooling scheme was proposed by Kastler already in 1950 [2] and demonstrated in a proof of principle experiment in 2006 [3].

[1]:S. Hensler et al. , Europhys. Lett. 71,918 (2005).
[2]:A. Kastler, Le Journal de Physique et le Radium 11, 255 (1950).
[3]:M. Fattori et al. , Nature Physics 2, 765 (2006).

A 56.3 Fri 14:30 DO26 208

Continuous loading of a mesoscopic atom chip — •Ilka Geisel, Jan Mahnke, Andreas Hüper, Wolfgang Ertmer, and Carsten Klempt — Institut für Quantenoptik, Leibniz Universität Hannover

While microscopic atom chips enhance cooling rates significantly, they typically suffer from smaller atomic ensembles. Our aim is to combine the advantages of atom chips with those of conventional BEC experiments by using a mesoscopic wire structure to provide the magnetic fields for magneto-optical and magnetic trapping.

This structure consists of millimeter-scale wires and is used to create a quadrupole field for a magneto-optical trap [1] and a flexible magnetic trapping potential, connected by a magnetic guide. The magnetic trapping region is shielded from the magneto-optical trap and thus provides better vacuum conditions and perfect stray light protection.

We investigate continuous loading mechanisms of a magnetic trap [2]. We demonstrate the production of a continuously replenished ultracold atomic cloud. Due to continuous evaporation, the cloud has an increasing number of atoms and a decreasing temperature until reaching a final equilibrium.

[1] S. Jöllenbeck, Phys. Rev. A 83, 043406 (2011)
[2] C. F. Roos, Europhys. Lett. 61, 187 (2003)

A 56.4 Fri 14:45 DO26 208

Ground state cooling in an 1D optical lattice — •Ricardo Gomez, Carsten Robens, Isabelle Boventer, Jonathan Zopes, Wolfgang Alt, Andrea Alberti, and Dieter Meschede — Institut für Andgewante Physik (IAP), Bonn, Germany

Discrete-time quantum walks of neutral atoms in optical lattices allows to experimentally investigate complex transport phenomena, where the single constituents are allowed to coherently interact with each other [1].

We report on the ground state cooling of neutral atoms in the ground state of a 1D optical lattice. Microwave and Raman sideband cooling are used as cooling mechanisms for the axial and radial direction, respectively. To achieve a tight confinement in the radial direction, we use a blue-detuned doughnut-shaped dipole trap overlapped to the optical lattice.

The preparation in the motional ground state opens the way to use onsite coherent collisions between atoms to realize interacting quantum walks.

[1] A. Ahlbrecht, A. Alberti, D. Meschede, V. B. Scholz, A. H. Werner, and R. F. Werner, Molecular binding in interacting quantum walks, New J. Phys. 14, 073050 (2012)

A 56.5 Fri 15:00 DO26 208

Simultaneous D_1 line sub-Doppler laser cooling of fermionic ^{6}Li and ^{40}K – Experimental results and theory — •Franz Sievers[1], Norman Kretzschmar[1], Diogo Fernandes[1], Daniel Suchet[1], Michael Rabinovic[1], Saijun Wu[2], Lev Khaykovich[3], Frédéric Chevy[1], and Christophe Salomon[1] — [1]Laboratoire Kastler Brossel, ENS/UPMC/CNRS, 75005 Paris, France — [2]Department of Physics, College of Science, Swansea University, SA2 8PP Swansea, United Kingdom — [3]Department of Physics, Bar-Ilan University, 52900 Ramat-Gan, Israel

We report on simultaneous sub-Doppler laser cooling of fermionic ^{6}Li and ^{40}K on the D_1-transition. We compare the experimental results to a numerical simulation of the cooling process using a semi-classical MonteCarlo wavefunction method. The simulation takes into account the three dimensional optical molasses setup and the vectorial interaction between the polarized light and single atoms at the D_1-manifold spanned by the hyperfine Zeeman sub-levels. We find that the simulation and experimental results are in good qualitative agreement.

The D_1-molasses phase largely reduces the temperature for both ^{6}Li and ^{40}K, with a final temperature of 44 μK and 20 μK respectively. For both species this leads to a phase-space density close to 10^{-4}. These conditions are well suited to directly load an optical dipole trap or magnetic traps.

Furthermore, we explore a potential application of D_1-cooling for ^{6}Li in a lattice trap enabling a quantum gas microscope similar to the case of ^{87}Rb.

A 56.6 Fri 15:15 DO26 208

Thermodynamics and redistributional laser cooling in dense gaseous ensembles — •Katharina Knicker, Stavros Christopoulos, Peter Moroshkin, Anne Sass, Lars Weller, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn

Laser cooling via collisional redistribution of fluorescence is a very efficient cooling technique applicable to ultradense gaseous ensembles. A high pressure environment ensures frequent collisions of optically active rubidium atoms with a noble buffer gas which shift the atomic resonances, allowing for absorption of a far red-detuned irradiated laser beam. Subsequent spontaneous decay occurs closer to the unperturbed resonances resulting in the extraction of kinetic energy of the order of k_BT during each cooling cycle. The induced temperature changes are determined through thermal deflection spectroscopy and can be as high as 500K. Kennard-Stepanov analysis of the pressure-broadened absorption and fluorescence spectra allows for the determination of temperature changes in a non-interacting manner. Further investigations include redistributional cooling of molecular systems.