Q 48: Ultracold atoms: Traps and cooling

Time: Thursday 11:00–12:30 Location: A 310

Q 48.1 Thu 11:00 A 310

Laser cooling of dense atomic gases by collisional redistribution of radiation — •Anne Sass, Ralf Forge, Peter Moroshkin, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Wegelerstraße 8, 53115 Bonn

We study laser cooling of atomic gases by collisional redistribution of fluorescence, a technique applicable to ultradense atomic ensembles of alkali atoms at a few hundred bar of buffer gas pressure. The cooled gas has a density of more than ten orders of magnitude above the typical values in Doppler cooling experiments of dilute atomic gases. In frequent collisions with noble gas atoms in the dense gas system, the energy levels of the alkali atoms are shifted, and absorption of far red detuned incident radiation becomes feasible. The subsequent spontaneous decay occurs close to the unperturbed resonance frequency, leading to a redistribution of the fluorescence. The emitted photons have a higher energy than the incident ones, and the dense atomic ensemble is cooled. We here report on recent experiments of a Rb-noble gas mixture and on the dependency of the cooling effect as a function of different experimental parameters, e.g. buffer gas pressure and incident laser power. For the future, we expect that redistribution laser cooling can also be applied to molecular gas samples.

Q 48.2 Thu 11:15 A 310

Building and Characterising a 2D-MOT as a Source of Cold Atoms — •Benjamin Gänger, Michael Bauer, Farina Kindermann, Shrabana Chakrabarti, and Artur Widera — TU Kaiserslautern, FB Physik, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany

Analysing the interaction of a single Cs atom with a cloud of ultracold Rb atoms requires many repetitions of the experimental cycle to obtain sufficient statistics. Therefore a high repetition rate is desirable which is limited by the time needed to initially trap and evaporatively cool a gas of atoms. As a first step towards a fast production of an ultracold cloud of atoms a 3D magneto-optical trap (MOT) is loaded by a beam of precooled Rb atoms from a 2D-MOT. For short loading cycles a high loading rate is intended. The designed cooling-laser setup provides up to 5 W optical output distributed over a 3D-MOT and a 2D-MOT with a 110 mm elongated cooling volume. Applying an additional push beam the loading rate reaches up to 10^9 atoms/s. In this setup a steady-state atom number of 2×10^9 atoms is achieved in about 2 seconds. We present an overview of the current setup and first results of the characterisation.

Q 48.3 Thu 11:30 A 310

EIT-control of single-atom motion in an optical cavity — •Tobias Kampschulte[1], Wolfgang Alt[1], Sebastian Manz[1], Miguel Martinez-Dorantes[1], René Reimann[1], Seokchan Yoon[1], Dieter Meschede[1], Marc Bienert[2], and Giovanna Morigi[2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstrasse 8, 53115 Bonn — [2]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken

We demonstrate cooling of the motion of a single atom confined by a dipole trap inside a high-finesse optical resonator. Cooling of the vibrational motion results from EIT-like interference in an atomic Λ-type configuration, where one transition is strongly coupled to the cavity mode and the other is driven by an external control laser. Good qualitative agreement with the theoretical predictions is found for the explored parameter ranges. The role of the cavity in the cooling dynamics is confirmed by means of a direct comparison with EIT-cooling performed in the dipole trap in free space. These results set the basis to the realization of an efficient photonic interface based on single atoms.

Q 48.4 Thu 11:45 A 310

Efficient demagnetization cooling and its limits — •Valentin V Volchkov, Jahn Rührig, Matthias Wenzel, Tilman Pfau, and Axel Griesmaier — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, Stuttgart, 70569 , Germany

Demagnetization cooling of an atomic sample arises from laser cooling of the internal degree of freedom (optical pumping) and the rethermalization of the internal and the external degrees of freedom via dipolar relaxation [1]. It is a cooling scheme that was proposed by Kastler already in 1950 [2] and demonstrated in a proof of principle experiment in 2006 [3]. Here, we present the extension of this work to a larger temperature range. Deep optical potential and strong confinement are used to start the demagnetization cooling at a temperature of $T \approx 100\mu K$. Active magnetic field stabilization allows to circumvent limitation associated with magnetic field fluctuations at temperatures $T < 10\mu K$. Finally, we discuss the reabsorption of scattered light and its effect on the lowest attainable temperature with this technique.

[1]:S. Hensler, A. Greiner, J. Stuhler and T. Pfau, Europhys. Lett. **71**, 918 (2005)

[2]:A. Kastler, Le Journal de Physique et le Radium **11**, 255 (1950).

[3]:M. Fattori, T. Koch, S. Goetz, A. Griesmaier, S. Hensler, J. Stuhler, T. Pfau, Nature Physics **2**, 765 (2006)

Q 48.5 Thu 12:00 A 310

Hardware-in-the-Loop simulation of a strongly coupled atom-cavity system — •Maria Bernard-Schwarz[1], Tatjana Wilk[2], and Martin Gröschl[3] — [1]National Instruments, Germany — [2]MPQ, Germany — [3]TU Wien, Austria

The question whether classical concepts can be adapted to the quantum world is explored. The Hardware-in-the-Loop (HiL) approach is a common tool in industry to test a part of a system before implementing it into the real device. The HiL simulation acts like the real system and is used as a substitute during the development of the control algorithm. The advantage hereby is that the algorithm can be tested and modified even before any part of the real device exists. The system of interest is a strongly coupled atom-cavity system. There are two different specifications to control, first the motion of a two-level atom inside the cavity and second, the internal states of several multilevel atoms in the cavity. For these demands a performance of the HiL simulation of the atom-cavity system in the sub-microsecond range is required. In both cases high performance computing with the help of different platforms such as Real-Time processor, FPGA (Field Programmable Gate Array) and GPU (Graphical Processor Unit) is accomplished. The HiL simulation tools are available within the software platform LabVIEW which is also the platform of the experimental control system. The HiL simulation reproduces the dependency of the photon counts on the atomic position, which is the basis for feedback control on the atomic position.

Q 48.6 Thu 12:15 A 310

Electron guiding on a surface-electrode microwave chip — •Jakob Hammer[1], Johannes Hoffrogge[1], Dominik Ehberger[1], and Peter Hommelhoff[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen

We investigate the guiding of electrons in a miniaturized planar AC-quadrupole guide (linear Paul trap) [1]. Electrons propagating freely along electrodes on a micro-fabricated chip experience a tight transverse harmonic confinement. For our parameters the quantum mechanical ground state of the guiding potential is still resolvable by electron optics. This encourages experiments to prepare electron matter-waves in the transverse motional ground state by matching the wavefunction of an incident electron with the ground state of the microwave guide.

Here we report on our ongoing experimental efforts. We use a single-atom tip electron emitter, a point source producing an exceptionally bright and fully coherent electron beam, to inject electrons into the guide. For collimation of the emitted electron wave packet we have fabricated a micron-scale electrostatic lens. Efficient ground state coupling requires a spot size of 100 nm and an angular spread of 1 mrad of the incoming electron wavefunction. We present the current status of the experiment as well as results from numerical optimization of the electrode layout, which aims at the adiabatic injection of electrons and the design of more complex structures like beam splitting elements.

[1] J. Hoffrogge, R. Fröhlich, M. Kasevich and P. Hommelhoff , Phys. Rev. Lett. 106, 193001 (2011).