Q 62: Ultracold atoms: Manipulation and detection

Time: Friday 11:00–12:30 Location: F 142

Q 62.1 Fri 11:00 F 142

Direct synthesis of light polarization for state-dependent transport of atoms — •Carsten Robens, Andreas Steffen, Anna Hambitzer, Noomen Belmechri, Andrea Alberti, Wolfgang Alt, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn,Wegelerstr. 8,53115 Bonn

Coherent control of individual atoms in optical lattices have recently proven to be a key asset in simulating physical phenomena, spanning from quantum transport effects typical of solid state physics to artificial gauge fields.

We report on a new approach to transport neutral atoms state-dependently in a spin-dependent optical lattice. The scheme is based on direct synthesis of light polarization by employing RF sources integrated with acousto-optic modulators for phase control.

The optical lattice is formed by superimposing two circularly polarized lattices. An optical phase-locked loop allows us to control with interferometric precision the phase difference between the two lattices. The phase directly corresponds to the relative displacement of the two lattices.

Applying this method to a digital atom interferometer [1], we envisage macroscopic splitting over spatial distances up to 10mm, about a million times larger than the size of each component of the split atom.

[1] A. Steffen, A. Alberti, W. Alt, N. Belmechri, S. Hild, M. Karski, A. Widera and D. Meschede, PNAS109, 9770 (2012)

Q 62.2 Fri 11:15 F 142

Coherent manipulation of cold cesium atoms in a nanofiber-based two-color dipole trap — •Daniel Reitz, Rudolf Mitsch, Clement Sayrin, Philipp Schneeweiss, and Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien, Atominstitut, Stadionallee 2, A-1020 Wien, Austria

We have recently demonstrated a new experimental platform for trapping and optically interfacing laser-cooled cesium atoms. The scheme uses a two-color evanescent field surrounding an optical nanofiber to localize the atoms in a one-dimensional optical lattice 200 nm above the nanofiber surface. In order to use this fiber-coupled ensemble of trapped atoms for applications in the context of quantum communication and quantum information processing, non-classical states of the atomic spins have to be prepared and should live long enough to allow one to apply successive quantum gates. The close proximity of the trapped atoms to the nanofiber surface and the strong polarization gradients of nanofiber-guided light fields are potentially important sources of decoherence. Here, we present our latest experimental results on the coherence properties of atomic spins in our nanofiber-based trap. Using a microwave field to drive the clock transition, we determine inhomogeneous and homogeneous dephasing times by Ramsey and spin echo techniques, respectively. Our results constitute the first measurement of the coherence properties of atoms trapped in the vicinity of a nanofiber and represent a fundamental step towards establishing nanofiber-based traps for cold atoms as a building block in a quantum network.

Q 62.3 Fri 11:30 F 142

Atom lens without chromatic aberrations — •Maxim A. Efremov[1], Polina V. Mironova[2], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQST), Universität Ulm, 89081 Ulm, Germany — [2]Theoretische Quantendynamik, Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt

We propose a lens for atoms with reduced chromatic aberrations and calculate its focal length and spot size. In our scheme a two-level atom interacts with a near-resonant standing light wave formed by two running waves of slightly different wave vectors, and a far-detuned running wave propagating perpendicular to the standing wave. We show that within the Raman-Nath approximation and for an adiabatically slow atom-light interaction, the phase acquired by the atom is independent of the incident atomic velocity.

Q 62.4 Fri 11:45 F 142

Optomechanics with an atomic array in a cavity — •Oxana Mishina and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany

Cold atomic ensembles inside an optical cavities are good candidates for exploring quantum aspects of optomechanical coupling. An interesting perspective emerges in the configuration when the atoms are confined by an external periodic potential inside a high-finesse resonator. We present a theoretical model describing the optomechanical coupling of the atomic array with a single mode light in a cavity and investigate cooling of the atomic motion to the ground state of the individual wells. We reproduce the dynamics observed in [1]. Moreover, we investigate further experimental regimes and find that arrays with tens of atoms can be cooled down to the ground state within few milliseconds for accessible experimental parameters. These results set the starting point for the exploration of the light-phonon interface and possibly novel quantum states of motion.

[1] Optomechanical Cavity Cooling of an Atomic Ensemble M.H., Schleier-Smith, I.D. Leroux, H. Zhang, M.A. Van Camp, and V. Vuletić, Phys. Rev. Lett. 107, 143005 (2011)

Q 62.5 Fri 12:00 F 142

Heterodyne spectroscopy of single atom motional states inside a high-finesse cavity — •René Reimann, Wolfgang Alt, Tobias Kampschulte, Sebastian Manz, Natalie Thau, 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 experiments connected to the field of quantum information. In our system insight to the motional states of single atoms coupled to a high finesse optical resonator is gained by the means of optical heterodyne detection. Measuring the beat signal between a fixed-frequency local oscillator beam and the light interacting with the coupled atoms, we are able to map the atomic motional state to the frequency domain in a non-destructive way. Analysing the spectra we discuss different experimental imperfections and estimate the intra-cavity atomic temperature within the frame of a simple model.

Q 62.6 Fri 12:15 F 142

Optimal control of effective Hamiltonians — •Albert Verdeny Vilalta[1], Cord A. Müller[2], and Florian Mintert[1] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs University of Freiburg, Freiburg 79104, Germany — [2]Centre for Quantum Technologies, National University of Singapore, Singapore 117543, Singapore

Periodically driven Hamiltonians can be approximately described by a time-independent effective Hamiltonian if the driving is sufficiently fast. There exist, however, many different drivings that result in the same effective Hamiltonian. Using optimal control techniques, we investigate which driving yields the best approximation to the dynamics induced by a desired effective Hamiltonian. The viability of our approach is proven for the simplest example of a driven three-level Lambda system, and shall ultimately help to improve the precision of quantum simulations.