Q 58: Ultrakalte Atome (Einzelne Atome)

Zeit: Freitag 11:00–12:30 Raum: 3B

Gruppenbericht Q 58.1 Fr 11:00 3B

Quantum nonlinearity with one atom dressed by two photons — •Ingrid Schuster, Alexander Kubanek, Andreas Fuhrmanek, Thomas Puppe, Pepijn Pinkse, Karim Murr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

The strong-coupling regime of cavity QED has proven to be a rich pond of optical phenomena at the level of single atoms and photons. We experimentally demonstrate that such a system exhibits a nonlinear intensity response when a single atom is made to interact not with one, but with two photons at the same time. This nonlinearity is explained by quantum mechanics and is expected to vanish in the limit of many intracavity atoms. It originates from the energy-level structure of the system, which consists of a ladder of doublets with anharmonic level splitting. The first doublet is visible in low-intensity spectroscopy, where it leads to the well-known vacuum-Rabi or normal-mode splitting. For stronger driving, we find a resonance stemming from excitation of the second doublet, at a frequency which is distinct from the normal modes because of the anharmonicity of the energy level spectrum. Since we access the resonance by driving a two-photon transition, we see a mainly quadratic response with respect to the probe intensity. Our experiment opens up new avenues for the controlled generation of multi-photon states.

Q 58.2 Fr 11:30 3B

Experimentelle Demonstration einer deterministischen Einzelionenquelle für die nm-genaue Implantation von Ionen in Festkörper — •Wolfgang Schnitzler, N. M. Linke, J. Eble, F. Schmidt-Kaler und K. Singer — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm

Wir haben mittels einer Ionenfalle eine universelle deterministische Einzelionenquelle realisiert [1]. In einer segmentierten linearen Falle werden zunächst kalte $^{40}Ca^{+}$ Ionenkristalle gefangen, anschließend deterministisch aus der Falle extrahiert und mit einer Erfolgsquote von über 90% auf einen 25cm entfernten Detektor geschossen. Die Streuung der kinetischen Energie der Ionen liegt dabei unter 0,1%. Auch das Laden und Extrahieren gemischter Kristalle wurde bereits erfolgreich durchgeführt. Für die nm-genaue Implantation planen wir, die räumliche Auflösung der extrahierten Ionen mittels einer elektrostatischen Einzellinse weiter zu optimieren. Diese können dann zur Implantation von P in Si oder zur Erzeugung von NV-Farbzentren in Diamant genutzt werden, welche optisch manipuliert werden können. Solche Systeme stellen Kandidaten zur Realisierung eines skalierbaren Festkörper-Quantencomputers dar [2,3]. Die elektrischen Eigenschaften von Halbleiterbauelementen können durch die deterministische Implantation einzelner Ionen ebenfalls verbessert werden [4].

[1] J. Meijer et. al., Appl. Phys. **A 83**, 321 (2006)
[2] B. Kane, Nature **393**, 133 (1998)
[3] F. Jelezko et. al., Phys. Rev. Lett. **93**, 130501 (2004)
[4] T. Shinada et. al., Nature **437**, 1128 (2005)

Q 58.3 Fr 11:45 3B

State-Selective Transport of Single Caesium Atoms — •Michał Karski, Leonid Förster, Daniel Döring, Florian Grenz, Arne Härter, Wolfgang Alt, Jai-Min Choi, Artur Widera, and Dieter Meschede — Institute for Applied Physics, University of Bonn

The state-selective quantum transport of single neutral atoms in optical lattices offers a promising alternative to implement basic modules of advanced schemes in the context of quantum engineering. These range from the implementation of so called quantum walks, utilizing fundamental quantum effects involving spatial quantum interference to the preparation of so-called cluster states using coherent cold collisions as an inter-qubit interaction.

We investigate systems of single Caesium atoms stored, one by one, in a state-dependent one-dimensional optical lattice. It is formed by a superposition of two standing wave dipole traps with right- and left-handed circular polarisation respectively. They can be shifted with respect to each other. With an appropriate wave length, each of the two lattices couples to a different hyperfine state. Therefore, atoms prepared in these qubit states can be transported in opposite directions. Using microwave pulses in the presence of magnetic field gradients, the internal states can be separately manipulated.

We present the current state of the experimental realisation of a one-dimensional quantum transport for Caesium atoms, focussing on the experimental setup and the tools for the preparation and manipulation of individual qubit states and their spatial detection.

Q 58.4 Fr 12:00 3B

Measuring the coupling strength of single atoms to the field of a high-finesse optical resonator — •Sebastian Reick, Wolfgang Alt, Tobias Kampschulte, Mkrtych Khudaverdyan, Karim Lenhard, Karsten Schörner, and Dieter Meschede — Institut für Angewandte Physik, Wegelerstr. 8, -53115 Bonn

The long-term goal of our experiment is the realisation of quantum information processing using neutral atoms. Since they are not coupled to each other or to the environment by a dipole force, which is an advantage in terms of coherence times, coherent interaction of two or more atoms has to be achieved by other means, e.g. by photon exchange.

In our experiment, we store atoms in a standing wave dipole trap, which can be utilised as an optical conveyor belt to move the atoms into the mode of a high-finesse optical resonator. We control the number of atoms loaded into the dipole trap and - with sub-micron precision - the transport distance. We aim at the realisation of coherent interaction between two atoms, placed both at the centre of the cavity field. The calculated parameters of our experimental setup $((g_{\max}, \kappa, \gamma) = 2\pi(18, 0.43, 2.61)\text{MHz}, g^2/(2\kappa\gamma) = 146)$ show that we are in the strong coupling regime.

An important prerequisite for this experiment is the precise knowledge of the coupling strength between one atom and the cavity field g. Furthermore, g should be maximised and kept constant over the interaction time. We report on our results to measure the coupling strength between single atoms and the field of our high-finesse resonator.

Q 58.5 Fr 12:15 3B

Cold Atoms On Nanostructures — •Carsten Weiss[1,2], Reinhold Walser[1], Wolfgang P. Schleich[1], and József Fortágh[2] — [1]Institut für Quantenphysik, Universität Ulm — [2]Physikalisches Institut, Universität Tübingen

A single-walled carbon nanotube (SWCNT) mounted on a lithographically fabricated chip defines a nearly perfect mechanical nano-oscillator. At common temperatures of a cryogenically cooled chip surface it performs large classical oscillations. By exposing it to ultra-cold alkali atoms we want to study the elastic and inelastic scattering by the SWCNT. In particular, we will present simulations for the interaction between a nanotube and a polarizable ^{87}Rb atom.

[1] J. Fortágh, and C. Zimmermann, Rev. Mod. Phys.**79**, 235 (2007)
[2] R. A. Jishi *et al.*, Chem. Phys. Lett. **209**, 77 (1993)
[3] R. Fermani *et al.*, arXiv:quant-ph/0703155v2
[4] I. Wilson-Rae *et al.*, Phys. Rev. Lett. **92**, 75507 (2004)
[5] M. D. LaHaye *et al.*, Science **304**, 74 (2004)