A 10: Ultracold atoms II: Single atoms (with Q)

Zeit: Dienstag 14:00–15:45 Raum: Audi-B

A 10.1 Di 14:00 Audi-B

Cavity cooling of cesium atoms: experiments in the bad cavity limit — •Arne Wickenbrock, Piyaphat Phoonthong, Lyubomir Petrov, and Ferruccio Renzoni — Department of Physics and Astronomy, Univerity College London, WC1 5BT London, UK

When an atom is placed in an optical cavity, its scattering properties may be significantly modified [1]. Based on this, new mechanisms of laser cooling were proposed [2-4]. In contrast to the standard laser cooling techniques, cooling by coherent scattering inside an optical resonator does not require a closed optical transition. This might expand the range of ultracold particles to more complex structured atoms and molecules.

We report on a series of experiment exploring cavity cooling in the bad-cavity limit. We prepare a cloud of ultracold cesium atoms in the centre of a leaky, near-confocal cavity. Then we pump the cavity with resonant laser light for a certain time and measure the achieved temperature as a function of atom-cavity detuning and laser intensity. [1]E. M. Purcell, Phys. Rev. 69, 681 [2]Horak P., Hechenblaikner G., Gheri K. M., Stecher H., Ritsch H., Phys. Rev. Lett.79, 4974 [3]Vuletic V., Chu S., Phys. Rev. Lett. 84, 3787 [4]P. Domokos and H. Ritsch, J. Opt. Soc. Am. B 20, 1089 (2003)

A 10.2 Di 14:15 Audi-B

Towards a guided atom interferometer based on a superconducting atom chip — Tobias Mueller, Xing Wu, •Anushyam Mohan, Azar Eyvazov, Yu Wu, and Rainer Dumke — Division of Physics & Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore

We evaluate the realization of a novel geometry of a guided atom interferometer based on a high temperature superconducting microstructure [1]. The interferometer type structure is obtained with a guiding potential realized by two current carrying superconducting wires in combination with a closed superconducting loop sustaining a persistent current. We present the layout and realization of our superconducting atom chip. By employing simulations we discuss the critical parameters of the interferometer guide in particular near the splitting regions of the matter waves. In the talk, we present the actual status of the experiment.

[1]: T. Müller et al, New J. Phys.10, 073006, (2008)

Gruppenbericht A 10.3 Di 14:30 Audi-B

Quantum jumps and continuous spin measurement in a strongly coupled atom-cavity system — •Tobias Kampschulte, Wolfgang Alt, Mkrtych Khudaverdyan, Sebastian Reick, Alexander Thobe, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, D-53115 Bonn

In our experiment we transport a predetermined small number of cold caesium atoms into a high-finesse optical resonator using an optical dipole trap. By monitoring the transmission of a probe laser beam resonant with the cavity we are able to measure the atomic spin continuously and observe quantum jumps between the two hyperfine ground states.

Utilizing this non-destructive method, we measure the single atom vacuum Rabi splitting via detection of the atomic state. Moreover, we experimentally demonstrate conditional dynamics of the internal states of two atoms, simultaneously coupled to the cavity field.

A reduction of the intra-cavity scattering rate would enable a quantum nondemolition measurement of the atom number as is required for probabilistic multi-atom entanglement schemes.

A 10.4 Di 15:00 Audi-B

Manipulation of atoms with optical tweezers — Lukas Brandt, Cecilia Muldoon, •Edouard Bains, and Axel Kuhn — Universtiy of Oxdord, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK

The controlling and positioning of single atoms [1,2] has been the dream for the past decades. This is of interest for quantum engineering and quantum computation. The ultimate goal is to position single atoms with nanometric precision, for example for positioning single atoms into optical cavities [3]. Furthermore arbitrary potential landscapes can be created, so the dynamics of individual atoms can be controlled and observed. By realising controlled collision collisions entangled cluster states can be realised as a resource for one-way quantum computing [4]. We present a new scheme which allows to arbitrarily and independently manipulate the positions and motional properties of single trapped atoms. Cold atoms are loaded from a magneto optical surface trap [5] into an array of dipole-force traps, which act like optical tweezers. This array of dipole-force traps is generated by imaging the intensity distribution of a spatial light modulator with an isoplanatic optical system [6] into the vacuum chamber and is thus forming the optical tweezers.

[1] Miroshnychenko et al, Nature 442, 151 (2006)
[2] Beugnon et al, Nature Physics 3, 696 (2007)
[3] Nußmann et al, PRL 95, 173602 (2005)
[4] Raussendorf and Briegel, Phys. Rev. Lett. 86, 5188 (2001)
[5] Wildermuth et al, Phys. Rev. A 69, 030901 (2004)
[6] Brainis er al, Opt. Com. accepted

A 10.5 Di 15:15 Audi-B

Efimov states in atom-molecular collisions — •Maxim A. Efremov[1], Lev Plimak[1], Misha Yu. Ivanov[2], Gora V. Shlyapnikov[3], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik, Universität Ulm, D-89069, Germany — [2]Steacie Institute for Molecular Sciences, NRC Canada, ON Ottawa, K1A 0R6 Canada — [3]Laboratoire de Physique Theorique et Modeles Statistiques, CNRS, Universite Paris Sud, 91405 Orsay, France

Scattering of a heavy atom off a weakly bound molecule comprising an identical heavy and a light atom is considered. We focus on the experimentally favorable situation in which the heavy atoms are bosons and the light ones are fermions, and the molecules exist in a cold boson-fermion mixture due to an interspecies Feshbach resonance. The total cross section of atom-molecular scattering is calculated in the Born-Oppenheimer approximation. In the limit of slow incident atom the total cross section as a function of the heavy-light s-wave scattering length (in experimental terms, as a function of the applied magnetic field) is shown to exhibit a series of resonances, providing a physically clear manifestation of the Efimov states in the three-body collision. Measurement of the cross section can therefore be an efficient and precise tool for scanning the effective potential in the three-body problem.

A 10.6 Di 15:30 Audi-B

Deterministische ultrakalte Ionenquelle nahe dem Heisenberg Limit — •Wolfgang Schnitzler, R. Fickler, N. M. Linke, 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 [1,2]. In einer segmentierten Falle werden kalte $^{40}Ca^{+}$ Ionenkristalle gefangen, anschließend deterministisch aus der Falle extrahiert und mit einer Erfolgsquote von 90% in einem Abstand von 29cm detektiert. Die absolute Geschwindigkeitsfluktuation liegt unter 6.3m/s bei einer mittleren Geschwindigkeit von 19.47km/s und einer Strahldivergenz von 600μrad. Wir zeigen anhand von numerischen Simulationen, dass unsere Quelle in Kombination mit einer elektrostatischen Einzellinse in der Lage sein wird, einzelne Ionen mit nm Auflösung in Festkörper zu implantieren. 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 [3,4]. Die elektrischen Eigenschaften von Halbleiterbauelementen können durch die deterministische Implantation einzelner Ionen ebenfalls verbessert werden [5].

[1] J. Meijer et al., Appl. Phys. A **83**, 321 (2006)
[2] J. Meijer et al., Appl. Phys. A **91**, 567 (2008)
[3] B. Kane, Nature **393**, 133 (1998)
[4] F. Jelezko et al., Phys. Rev. Lett. **93**, 130501 (2004)
[5] T. Shinada et al., Nature **437**, 1128 (2005)