

## Q 38 Fallen &amp; Kühlung I

Zeit: Dienstag 11:15–13:00

Raum: HU 2002

Q 38.1 Di 11:15 HU 2002

**Double-EIT ground-state laser cooling without blue-sideband heating** — ●JÖRG EVERS and CHRISTOPH H. KEITEL — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Electromagnetically induced transparency (EIT-) cooling is a promising technique for cooling trapped atoms or ions to the motional ground state, which relies on atomic coherence and interference effects [1]. In this talk, we discuss a laser cooling scheme based on double-EIT, making use of a four-level setup in tripod configuration [2]. The additional fourth atomic state is coupled by a strong coupling laser field to the upper state of the usual three-level setup of single-EIT cooling. This effectively allows to create two EIT structures in the absorption spectrum of the system to be cooled, which may be controlled by the coupling laser field parameters to cancel both the carrier- and the blue-sideband excitations. In leading order of the Lamb-Dicke expansion, this suppresses all heating processes. As a consequence, the double-EIT scheme can be used to lower the cooling limit by a factor of order of the Lamb-Dicke parameter squared as compared to single-EIT cooling. We also extend the study to multiple-EIT schemes with more than two EIT structures, which for example allows to cool at two different trap frequencies simultaneously.

[1] G. Morigi, J. Eschner and C. H. Keitel, *Phys. Rev. Lett.* **85**, 4458 (2000); C. F. Roos, D. Leibfried, A. Mundt, F. Schmidt-Kaler, J. Eschner, and R. Blatt, *Phys. Rev. Lett.* **85**, 5547 (2000).

[2] J. Evers and C. H. Keitel, *Europhys. Lett.* **68**, 370 (2004).

Q 38.2 Di 11:30 HU 2002

**Detection of Ultracold Groundstate Molecules with a Time of Flight Mass Spectrometer** — ●STEPHAN KRAFT<sup>1</sup>, PETER STAANUM<sup>1,2</sup>, JÖRG LANGE<sup>1</sup>, ROLAND WESTER<sup>1</sup>, ANDREA FIORETTI<sup>3</sup>, and MATTHIAS WEIDEMÜLLER<sup>1</sup> — <sup>1</sup>Physikalisches Institut, Universität Freiburg, 79104 Freiburg — <sup>2</sup>Institut für Quantenoptik, Universität Hannover, 30167 Hannover — <sup>3</sup>Istituto per i Processi Chimico-Fisici, C.N.R., 56124 Pisa, Italy

In the field of ultracold molecules selective detection of vibrational levels in the  $^1\Sigma$  and  $^3\Sigma$  electronic ground states is a crucial factor. For this purpose we have implemented in our Li and Cs photoassociation experiment a pulsed dye laser for state-selected resonant enhanced multiphoton ionisation (REMPI) detection in combination with a Wiley McLaren type time of flight mass spectrometer [1]. Using electrodes with perfect optical access for the magneto-optical trap we have achieved a mass resolution of about  $\frac{M}{\Delta M} \sim 200$ .

With this resolution we are able to distinguish easily between atomic Cs<sup>+</sup> (mass: 133 u) and molecular LiCs<sup>+</sup> (mass: 140 u) ions. In this talk, we describe the new TOF spectrometer and present results of the detection of ultracold ground state molecules.

[1] W. C. Wiley and I. H. McLaren, *Rev. Sci. Inst.* **26**, 1150 (1955)

Q 38.3 Di 11:45 HU 2002

**Controlling the coupling of a single atom to a cavity** — ●MARKUS HIJLKEMA, STEFAN NUSSMANN, BERNHARD WEBER, AXEL KUHN, and GERHARD REMPE — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, D85748 Garching bei München, Germany

We report on an experiment where single cold rubidium atoms trapped in an optical lattice can be coupled to an optical cavity in a controlled way.

Starting from a magneto-optical trap (MOT) cold atoms are loaded into a far detuned optical dipole trap and guided to a cavity where they are stored in a standing wave dipole trap perpendicular to the cavity axis. The atoms in the optical lattice are excited by laserlight incident from the side. As soon as an atom is both excited and coupled to the cavity it emits photons into the cavity, and these can be observed as they leak out of the cavity. In this way, the coupling of an atom to the cavity can be directly observed.

In order to control the coupling of an atom to the cavity, a rotatable glass plate is placed in the optical path of the far detuned dipole trap. Tilting the glass plate induces a change in the optical path length of the trapping laser beam, and thus the standing wave propagates slowly along the beam, moving the trapped atoms in or out of the cavity mode, as we can observe in our experiments. Our control over atom-cavity coupling should enable us to create a quantum register of qubits, each individually addressable by the cavity.

Q 38.4 Di 12:00 HU 2002

**Cavity QED zero-point fluctuations** — ●KARIM MURR, PETER MAUNZ, PEPIJN PINKSE, THOMAS PUPPE, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

In the early days of laser cooling it was shown that an atom in free space, even in the internal ground state, will spread due to its interaction with a laser. This effect is a signature of the zero-point fluctuation of the atomic dipole coupled to the gradient of the radiation field.

We discuss how in a confined space such as in cavities, the zero-point fluctuation of the cavity field itself plays a crucial role that could dominate the fluctuation of the atomic dipole, in particular within a high-finesse optical cavity.

The power of our analysis relies on its simplicity; it provides a conceptual unification between free space and cavity diffusion at low saturation.

Q 38.5 Di 12:15 HU 2002

**Atomoptische Isotopenselektion in der hochauflösenden Resonanzionisations-Massenspektrometrie** — ●DIRK TIEDEMANN, PHILIPP SCHUMANN, CHRISTOPHER GEPPERT und KLAUS D.A. WENDT — Institut für Physik, Johannes Gutenberg-Universität Mainz

Zur Steigerung der bereits extrem hohen Isotopenselektivität und der Empfindlichkeit der hochauflösenden Resonanzionisations-Massenspektrometrie wird ein Verfahren der Atomoptik getestet. Durch transversales Laserkühlen soll der anzuregende Atomstrahl isotopenselektiv gebündelt werden. Dabei wird sowohl die Effizienz erhöht als auch eine gleichzeitige Steigerung in der Unterdrückung von Nachbarisotopen erzielt. Im Rahmen dieses Vortrags werden vorbereitende Messungen zum Abdampfverhalten des Atomofens sowie erste Tests zum Einsatz der transversalen Laserkühlung vorgestellt. Das entwickelte Verfahren wird zum Ultrapurennachweis seltener Isotope über nachfolgende resonante Ionisation der nachzuweisenden Elemente in bis zu 3 Schritten an einem Quadrupol-Massenspektrometer eingesetzt. Der gegenwärtige Status des Experiments erlaubt den Nachweis von Ca-41 mit einer relativen Häufigkeit von  $> 10^{-13}$ , eine weitere Steigerung um ein bis zwei Größenordnungen ist für Fragestellungen aus Biomedizin und Kosmochemie wünschenswert.

Q 38.6 Di 12:30 HU 2002

**Optische Multiphotonen-Gitter** — ●GUNNAR RITT, MARTIN WEITZ, GIOVANNI CENNINI und CARSTEN GECKELER — Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

Wir schlagen ein neues Verfahren vor, das es erlaubt, beliebig geformte, periodische Potentiale für Atome mit Hilfe der Fouriersynthese zu erzeugen. Die Atome werden dabei in einem periodischen, durch Multiphotonen-Prozesse höherer Ordnung erzeugten Potential gefangen. Die Methode beruht auf der Tatsache, dass ein Multiphotonen-Prozess 2N-ter Ordnung eine räumliche Periodizität mit dem 2N-ten Bruchteil der optischen Wellenlänge zur Folge haben kann. Mit einer geeigneten Kombination von Laserfrequenzen können dabei ungewollte Stehwelleneffekte vermieden werden.

Zukünftige Anwendungen dieses Verfahrens können von geblazten Strahlteilern für Atome bis zu atomaren Quantenrutschen reichen.

Q 38.7 Di 12:45 HU 2002

**Collisions in a cloud of cold metastable neon atoms** — ●WOUTER VAN DRUNEN, NORBERT HERSCHBACH, PETER SPODEN, MARTIN ZINNER, WOLFGANG ERTMER, and GERHARD BIRKL — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany

We report on the experimental investigation of elastic and inelastic collisions of  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$  in the metastable  $3s[3/2]_2$ -state, which is of crucial importance for creating ensembles of high phase space densities. We investigate elastic collisions by observing the cross-dimensional relaxation of ensembles prepared in a non-equilibrium state. We present measured relaxation rates and an analysis for the extraction of the scattering length.

Inelastic collision rates of spin-polarized atoms in the magnetic trap are determined from atom loss and heating rates. These collisions predom-

inantly originate from Penning ionization (PI), as we could verify by detecting the produced ions on an MCP detector. Both neon isotopes show a suppression of PI due to spin-polarization. This effect, however, is less pronounced than predicted theoretically.

Due to a larger ratio of elastic to inelastic collisions,  $^{22}\text{Ne}$  is better suited for evaporative cooling than  $^{20}\text{Ne}$ . Experiments on the evaporation of  $^{22}\text{Ne}$  are in progress and an increase in phase space density has already been observed.