Fachverband Quantenoptik und Photonik (Q)

Matthias Weidemüller
Physikalisches Institut
Universität Freiburg
Hermann-Herder-Str. 3
79104 Freiburg
m.weidemueller@physik.uni-freiburg.de

Übersicht der Fachsitzungen

(Hörsäle 5D, 5E, 5J, 5K, 5L, 5M und 6J; Poster C)

Fachsitzungen

Q 1.1–1.9	Mo	10:30–12:45	6J	**Quantengase (gemeinsam mit A)**
Q 2.1–2.8	Mo	10:30–12:30	5L	**Quanteninformation (Photonen und nichtklassisches Licht I)**
Q 3.1–3.8	Mo	10:30–12:30	5K	**Festkörperlaser I**
Q 4.1–4.8	Mo	10:30–12:30	5J	**Nichtlineare optische Effekte und Lichtquellen I**
Q 5.1–5.7	Mo	14:00–16:00	6J	**Quantengase (Bose-Einstein-Kondensation)**
Q 6.1–6.4	Mo	14:00–15:00	5L	**Quanteninformation (Photonen und nichtklassisches Licht II)**
Q 7.1–7.4	Mo	15:00–16:00	5L	**Quanteninformation (Ionen)**
Q 8.1–8.2	Mo	14:00–14:30	5K	**Festkörperlaser II**
Q 9.1–9.4	Mo	14:30–15:30	5K	**Halbleiterlaser**
Q 10.1–10.8	Mo	14:00–16:00	5J	**Nichtlineare optische Effekte und Lichtquellen II**
Q 11.1–11.7	Mo	14:00–16:00	5E	**Quanteneffekte (QED)**
Q 12.1–12.8	Mo	16:30–18:30	6J	**Quantengase (Unordnung)**
Q 13.1–13.7	Mo	16:30–18:30	5L	**Präzisionsmessungen I**
Q 14.1–14.8	Mo	16:30–18:30	5K	**Anwendung ultrakurzer Lichtimpulse I**
Q 15.1–15.6	Mo	16:30–18:00	5J	**Nichtlineare optische Effekte und Lichtquellen III**
Q 16.1–16.9	Mo	16:30–18:45	5E	**Quanteneffekte (Interferenz und Korrelationen)**
Q 17.1–17.8	Di	10:30–12:30	6J	**Quantengase (Bosonische Gitter I)**
Q 18.1–18.8	Di	10:30–12:45	5L	**Quanteninformation (Verschränkung und Dekohärenz I)**
Q 19.1–19.7	Di	10:30–12:15	5K	**Erzeugung ultrakurzer Lichtimpulse**
Q 20.1–20.9	Di	10:30–12:45	5J	**Laser in der Medizin und Umweltmesstechnik I**
Q 21.1–21.8	Di	10:30–12:30	5E	**Quanteneffekte (Offene und Wenigteilchensysteme)**
Q 22.1–22.5	Di	10:30–12:15	5M	**Ultrakalte Plasmen und Rydberg-Gase (gemeinsam mit A)**
Q 23.1–23.8	Di	10:30–12:45	6B	**Kalte Moleküle I (gemeinsam mit MO)**
Q 24.1–24.8	Di	14:00–16:00	6J	**Quantengase (Bosonische Gitter II)**
Q 25.1–25.9	Di	14:00–16:30	5L	**Quanteninformation (Verschränkung und Dekohärenz II)**
Q 26.1–26.8	Di	14:00–16:00	5K	**Anwendung ultrakurzer Lichtimpulse II**
Q 27.1–27.8	Di	14:00–16:15	6B	**Kalte Moleküle II (gemeinsam mit MO)**
Q 28.1–28.7	Di	16:30–18:30	Poster C	**Poster Festkörperlaser**
Q 29.1–29.11	Di	16:30–18:30	Poster C	**Poster Ultrakurze Lichtimpulse**
Q 30.1–30.11	Di	16:30–18:30	Poster C	**Poster Nichtlineare optische Effekte und Lichtquellen**
Q 31.1–31.9	Di	16:30–18:30	Poster C	**Poster Laserspektroskopie**
Q 32.1–32.4	Di	16:30–18:30	Poster C	**Poster Laser in Medizin und Umwelttechnik**
Q 33.1–33.10	Di	16:30–18:30	Poster C	**Poster Präzisionsmessungen**
Q 34.1–34.14	Di	16:30–18:30	Poster C	**Poster Quanteninformation**
Q 35.1–35.7	Di	16:30–18:30	Poster C	**Poster Quantenkommunikation**
Q 36.1–36.1	Mi	11:30–12:00	6J	**Robert-Wichard-Pohl Preisträgervortrag**
Q 37.1–37.3	Mi	12:00–13:00	6J	**Quantengase (Tunneln I)**
Q 38.1–38.4	Mi	12:00–13:00	5L	**Quanteninformation (Konzepte I)**
Q 39.1–39.4	Mi	12:00–13:00	5J	**Laser in der Medizin und Umweltmesstechnik II**
Q 40.1–40.7	Mi	14:00–15:45	6J	**Quantengase (Spinor-Gase)**
Q 41.1–41.8	Mi	14:00–16:00	5L	**Quanteninformation (Konzepte II)**
Q 42.1–42.7	Mi	14:00–15:45	5K	**Präzisionsmessungen II**

Q 43.1–43.8	Mi	14:00–16:00	5E	**Optische Messtechnik**
Q 44.1–44.8	Mi	14:00–16:00	5D	**Ultrakalte Atome (Manipulation und Detektion)**
Q 45.1–45.7	Mi	14:00–16:00	6G	**Attosekundenphysik (gemeinsam mit A)**
Q 46.1–46.9	Mi	16:30–18:45	6J	**Quantengase (Wechselwirkungseffekte)**
Q 47.1–47.9	Mi	16:30–18:45	5L	**Quanteninformation (Quantenkommunikation)**
Q 48.1–48.8	Mi	16:30–18:30	5J	**Photonik I**
Q 49.1–49.5	Mi	16:30–17:45	5E	**Informationsspeicherung und -verarbeitung**
Q 50.1–50.8	Mi	16:30–18:30	5D	**Ultrakalte Atome (Einzelne Teilchen und Ionenfallen)**
Q 51.1–51.1	Do	11:30–12:00	5L	**Hertha-Sponer Preisträgervortrag**
Q 52.1–52.4	Do	12:00–13:00	6J	**Quantengase (Tunneln II)**
Q 53.1–53.4	Do	12:00–13:00	5L	**Quanteninformation (Quantencomputer I)**
Q 54.1–54.4	Do	12:00–13:00	5K	**Teilchenoptik**
Q 55.1–55.4	Do	12:00–13:00	5E	**Quanteneffekte (Lichtstreuung I)**
Q 56.1–56.7	Do	14:00–15:45	6J	**Quantengase (Fermionen und Gemische)**
Q 57.1–57.8	Do	14:00–16:15	5L	**Quanteninformation (Quantencomputer II)**
Q 58.1–58.7	Do	14:00–15:45	5J	**Photonik II**
Q 59.1–59.8	Do	14:00–16:00	5E	**Quanteneffekte (Lichtstreuung II)**
Q 60.1–60.8	Do	14:00–16:00	5D	**Fallen und Kühlung (gemeinsam mit A)**
Q 61.1–61.14	Do	16:30–18:30	Poster C	**Poster Quanteneffekte**
Q 62.1–62.19	Do	16:30–18:30	Poster C	**Poster Ultrakalte Atome**
Q 63.1–63.8	Do	16:30–18:30	Poster C	**Poster Ultrakalte Moleküle**
Q 64.1–64.29	Do	16:30–18:30	Poster C	**Poster Quantengase**
Q 65.1–65.7	Do	16:30–18:30	Poster C	**Poster Photonik**
Q 66.1–66.2	Do	16:30–18:30	Poster C	**Poster Optische Messtechnik**
Q 67.1–67.3	Do	16:30–18:30	Poster C	**Poster Teilchenoptik**
Q 68.1–68.8	Fr	10:30–12:30	5K	**Laserspektroskopie I**
Q 69.1–69.4	Fr	10:30–11:30	5J	**Photonik III**
Q 70.1–70.7	Fr	10:30–12:30	6G	**Ultrakalte Atomstöße (gemeinsam mit A)**
Q 71.1–71.8	Fr	10:30–12:45	6B	**Ultrakalte Moleküle I (gemeinsam mit MO)**
Q 72.1–72.6	Fr	14:00–15:45	6J	**Ultrakalte Moleküle II (gemeinsam mit MO)**
Q 73.1–73.7	Fr	14:00–15:45	5K	**Laserspektroskopie II**

Mitgliederversammlung des Fachverbands Quantenoptik und Photonik

Mittwoch 13:00–13:30 6J

Vorläufige Tagesordnung:

- Bericht des Fachverbandsvorsitzenden
- Bericht der AG Photonik
- Verschiedenes

gez. Matthias Weidemüller

Q 1: Quantengase (gemeinsam mit A)

Zeit: Montag 10:30–12:45 Raum: 6J

Q 1.1 Mo 10:30 6J

Interference of one-dimensional quasi-condensates — •Sebastian Hofferberth[1], Igor Lesanovsky[2], Stephanie Manz[1], Thorsten Schumm[1], and Jörg Schmiedmayer[1] — [1]Atominstitut der Österreichischen Universitäten, TU-Wien, Stadionallee 2, A-1020 Vienna, Austria — [2]Universität Innsbruck, Institute for Quantum Optics and Quantum Information, A-6020 Innsbruck, Austria

Phase fluctuations play an important role in one-dimensional systems, preventing true long range phase order even at zero temperature. We study the thermal phase fluctuations in a one-dimensional Bose gas by coherently splitting a single quasi-condensate and observing interference between the two resulting matter wave packets.

Our interferometer scheme is based on radio-frequency induced adiabatic potentials implemented on an atom chip, which allows us to prepare two quasi-condensates with a defined macroscopic relative phase [1] . The phase fluctuations lead to an intrinsic dephasing over time, which can be extracted from the observed interference patterns [2].

We study the dependence of the dephasing time on the density in the quasi-condensates and the trap parameters. Additionally we investigate how a finite tunnel-coupling between the two systems affects the dynamics of the relative phase.

[1] S. Hofferberth, I. Lesanovsky, B. Fischer, J. Verdu and J. Schmiedmayer, Nature Phys. 2, 710 (2006) [2] V. Gritsev, E. Altman, E. Demler and A. Polkovnikov, Nature Phys. 2, 705 (2006)

Q 1.2 Mo 10:45 6J

Comparing Contact and Dipolar Interactions in a Bose-Einstein Condensate — •Axel Griesmaier, Jürgen Stuhler, Tobias Koch, Marco Fattori, Stefano Giovanazzi, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

We have measured the relative strength ε_{dd} of the magnetic dipole-dipole interaction compared with the contact interaction [1] in a dipolar chromium Bose-Einstein condensate [2]. We analyze the asymptotic velocities of expansion of the condensate with different orientations of the atomic magnetic moments. By comparing the experimental results with numerical solutions of the hydrodynamic equations for dipolar condensates, we obtain $\varepsilon_{dd} = 0.159 \pm 0.034$. We use this result to determine the s-wave scattering length $a = (5.08 \pm 1.06)\ 10^{-9}m=(96\pm20)\ a_0$ of ^{52}Cr. This is fully consistent with our previous measurements on the basis of Feshbach resonances [3] and therefore confirms the validity of the theoretical approach used to describe the dipolar Bose-Einstein condensate.

[1] A. Griesmaier *et al.*, Phys. Rev. Lett. in press (2006).
[2] A. Griesmaier *et al.*, Phys. Rev. Lett. **9**4, 160401 (2005).
[3] J. Werner *et al.*, Phys. Rev. Lett. **9**4, 183201 (2005).

Q 1.3 Mo 11:00 6J

Critical behavior of a trapped interacting Bose gas — •Tobias Donner, Stephan Ritter, Thomas Bourdel, Ferdinand Brennecke, Anton Öttl, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik, ETH Zürich, 8093 Zürich, Schweiz

In the vicinity of a phase transition minute variations in the controlling parameters can dramatically change the properties of a system. Using a trapped Bose gas we have entered the critical regime of Bose-Einstein condensation and gained access to its beyond mean-field physics. This regime is characterized by fluctuations extending far beyond the thermal de Broglie wavelength: The length scale over which the system behaves coherently diverges, which is directly reflected in the shape of the spatial first order correlation function.

Using matter-wave interference we measure the correlation length of these fluctuations as a function of temperature. We study the divergence of the correlation length of the order parameter as the temperature approaches the critical point and determine its critical exponent for a trapped, weakly interacting Bose gas to be $\nu = 0.67 \pm 0.13$.

Q 1.4 Mo 11:15 6J

Antibunching in einem atomaren Fermigas — •Tim Rom, Thorsten Best, Dries van Oosten, Ulrich Schneider, Simon Fölling, Belen Paredes und Immanuel Bloch — Insitut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

Entartete Quantengase in optischen Gittern könnten die Realisierung von Quantenphasen, wie zum Beispiel Antiferromagnet und Supersolid, erlauben. Zum Nachweis solcher Ordnungszustände könnten Dichtekorrelationen entscheidend beitragen. Wir berichten über die Messung von Korrelationen im Schrotrauschen eines Fermigases. Dabei konnten wir erstmals antibunching an neutralen Atomen beobachten. In unserem Experiment kühlen wir fermionische Kalium-Atome in einer optischen Falle zur Quantenentartung. Die Atome werden in ein dreidimensionales optisches Gitter geladen, wo sie bei entsprechender Wahl der Gitterparameter einen Bandisolator bilden. Die Absorptionsbilder der Atomwolke nach hinreichender Expansionszeit enthalten in ihrem Schrotrauschen die Information über den ursprünglichen Ordnungszustand, die wir durch Korrelationsanalyse sichtbar machen. Wir zeigen, wie sich daraus unter anderem die Temperatur des Fermigases rekonstruieren lässt.

Q 1.5 Mo 11:30 6J

Scissors Mode of a Strongly Interacting Fermi gas — •Stefan Riedl[1], Alexander Altmeyer[1], Christoph Kohstall[1], Matthew Wright[1], Johannes Hecker Denschlag[1], and Rudolf Grimm[1,2] — [1]Inst. of Experimental Physics and Center for Quantum Physics, Univ. Innsbruck, 6020 Innsbruck, Austria — [2]Inst. for Quantum Optics and Quantum Information, Acad. of Science, 6020 Innsbruck, Austria

A powerful method to investigate ultracold strongly interacting fermionic quantum gases is the study of collective excitation modes of the gas. Their behavior reveals the different regimes the gas can enter depending on the coupling between the Fermions. Here the scissors mode plays an important role since the qualitative behavior of the mode is different in a collisionless and hydrodynamic gas, respectively. Together with the low damping of the mode this allowed us to study the hydrodynamic to collisionless transition of the gas as a function of temperature. To distinguish between superfluid and collisional hydrodynamics we investigate the scissors mode in a slowly rotating trap, where the dynamic behavior of a superfluid is different compared to a normal gas.

Q 1.6 Mo 11:45 6J

Coherent Control of the Superfluid-to-Mott-Insulator Transition — •Andre Eckardt and Martin Holthaus — Institut für Physik, Carl von Ossietzky Universität, 26111 Oldenburg

We demonstrate that the transition from a superfluid to a Mott-insulator in the Bose-Hubbard-Modell can be controlled coherently by an oscillating force through an effective renormalization of the tunneling matrix element [1]. The mechanism involves adiabatic following of Floquet-states in combination with diabatic passing of tiny avoided crossings in the quasienergy spectrum that indicate interaction-induced resonant coupling to excited states. Deviations from this ideal dynamics result in a loss of coherence, i.e., heating of the system. We investigate conditions for a controlled time-evolution with respect to frequency, amplitude and switching time of the drive, and discuss a possible scenario for the limit of large lattices. The estimation of experimentally accessible parameters suggests that both the regime of coherent control and its limits can be observed with ultracold atoms in optical lattices.

[1] A. Eckardt, C. Weiss, and M. Holthaus, *Superluid-Insulator Transition in a Periodically Driven Optical Lattice*, Phys. Rev. Lett. 95, 260404 (2005)

Q 1.7 Mo 12:00 6J

Superradiant Rayleigh Scattering and Collective Atomic Recoil Lasing with ultracold atoms in a ring-cavity — •Sebastian Slama, Gordon Krenz, Simone Bux, Claus Zimmermann, and Philippe Courteille — Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

We present experiments with ultracold and Bose-Einstein condensed atoms in an optical high-finesse ring cavity. This represents the first realization of BEC inside an optical resonator.

We load ultracold ^{87}Rb atoms into a ring cavity and subsequently pump one of the cavity modes. Scattering of pump light from the atoms leads to the sudden build-up of a probe light field in the non-pumped mode. The characteristic feature is the emission of a sequence of light pulses, typical for Collective Atomic Recoil Lasing (CARL)[1]. By changing the finesse of the cavity we are able to reach a regime

in which Superradiant Rayleigh Scattering (SRyS) occurs[2]. This is the first observation of cavity-enhanced SRyS. We are able to observe SRyS for temperatures as high as several tens of μK. This demontrates clearly that SRyS does not rely on quantum statistical effects, but on the cooperative behaviour of the atoms.

[1] R. Bonifacio and L. De Salvo, Appl. Phys. B 60, S233 (1995).
[2] S.Inouye et al., Science 285, 571 (1999).

Q 1.8 Mo 12:15 6J

Spindomänen in F=2 87Rb Spinor-Kondensaten — •Jochen Kronjäger, Christoph Becker, Parvis Soltan-Panahi, Simon Stellmer, Kai Bongs und Klaus Sengstock — Institut für Laser-Physik, Luruper Chaussee 149 Geb. 69, 22761 Hamburg

Neue experimentelle und theoretische Untersuchungen von 87Rb Spinorkondensaten haben das grundlegende Verständnis der kohärenten Spindynamik in diesem System weit vorangebracht [1-3]. Dabei hat sich der Fokus von der semiklassischen Dynamik homogener Systeme hin zu räumlichen Effekten verschoben, die aufgrund verschiedener Mechanismen auftreten können und zu beobachtbarer Strukturbildung führen.

Spindomänen wurden bereits beobachtet in ferromagntischem F=1 87Rb [4], wo sie spontan aufgrund einer dynamischen Instabilität [5,6] auftreten. Dagegen handelt es sich bei F=2 87Rb um ein System mit antiferromagnetischem Grundzustand. Wir haben die Bildung von Spindomänen in nahezu isotroper und extrem elongierter Fallengeometrie untersucht und beobachten Strukturen auf verschiedenen charakteristischen räumlichen Skalen.

[1] M.-S. Chang et al., Nature Physics 8, 152 (2006)
[2] J. Kronjäger et al., Phys. Rev. A 72, 063619 (2005)
[3] J. Kronjäger et al., Phys. Rev. Lett. 97, 110404 (2006)
[4] L. E. Sadler at al., Nature 443, 312 (2006)
[5] W. Zhang et al., Phys. Rev. Lett. 95, 180403 (2005)
[6] J. Mur-Petit, Phys. Rev. A 73, 013629 (2006)

Q 1.9 Mo 12:30 6J

Coupling a Bose-Einstein condensate to a nanomechanical resonator — •Stephan Camerer[1], David Hunger[1], Daniel König[3], Jörg Kotthaus[3], Theodor Hänsch[1], Jakob Reichel[2], and Philipp Treutlein[1] — [1]MPQ und LMU München, Deutschland — [2]LKB, ENS Paris, France — [3]LMU München, Deutschland

The experimental fusion between quantum optics and solid-state physics is a rapidly developing and auspicious field of research. Due to the capability to control atom clouds near surfaces, atom chips are particularly well suited to provide an experimental interface between a quantum optical and a condensed matter system.

Our experiment aims at studying the interaction between small Bose-Einstein condensates (BECs) and a nanomechanical resonator on an atom chip. The coupling is mediated by a single domain magnetic island located on the resonator tip. The oscillation of the thermally driven resonator is transduced by the magnetic island into an oscillating magnetic field at the location of the BEC. On resonance, the field oscillations cause spin-flip transitions of the trapped atoms: the BEC serves as quantum probe for the mechanical motion of the resonator. For high mechanical quality factors, coherent interactions between the BEC and the resonator can be studied.

The core of our experiment is a chip which combines gold wires for a magnetic trap, free-standing nanomechanical structures and single-domain ferromagnets. It is fabricated using various lithographic, deposition and etching techniques. In the talk, the current status of the experiment is reported.

Q 2: Quanteninformation (Photonen und nichtklassisches Licht I)

Zeit: Montag 10:30–12:30 Raum: 5L

Q 2.1 Mo 10:30 5L

Polarization squeezing and its simulation — •Ruifang Dong[1], Joel Heersink[1], Joel Corney[2], Gerd Leuchs[1], Peter Drummond[2], and Ulrik Andersen[3] — [1]Institute for Optics, Information and Photonics,Max-Planck Researchgroup, University Erlangen-Nuernberg, Guenther-Scharowsky-Str. 1, 91058, Erlangen,Germany — [2]ARC Centre of Excellence for Quantum-Atom Optics, University of Queensland, Brisbane, QLD 4072, Australia — [3]Technical University of Denmark, DK-2800 Kongens Lyngby, Denmark

We report on the comparison between experimental and simulation results for the polarization squeezing, anti-squeezing as well as squeezing angle generated using a 13.35m fused silica fiber. Based on the nonlinear Kerr effect ($\chi(3)$) experienced by the ultra-short pulse in the fiber bright polarization squeezing was generated [1]. A first-principles simulation of the quantum time evolution in a many-body system for the polarization squeezing in optical fibers was also made by Joel F. Corney et al [2] which fits very well to the experiments. There they predicted that Raman effects will degrade the squeezing effect as the input energy surpasses the soliton energy. We investigate this prediction in experiment over a range of energies from 2 pJ to 170 pJ and achieve good agreement.

Q 2.2 Mo 10:45 5L

Verschränkung kontinuierlicher Variablen von Seitenbändern optischer Felder — •Aiko Samblowski, Boris Hage und Roman Schnabel — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Institut für Gravitationsphysik, Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover, Germany

In der Quanteninformation sind verschränkte Zustände von essentieller Bedeutung. Wir demonstrieren Verschränkung zwischen den korrespondierenden Seitenbändern eines gequetschten Dauerstrich-Lichtfeldes, welches mit einem optisch-parametrischen Verstärker (OPA) erzeugt wird. Durch räumliche Trennung dieser Seitenbänder erhält man ein Paar verschränkter Strahlen, wie im Experiment von E.H. Huntington et al. Phys.Rev.A, 71, 041802(R) (2005) gezeigt. Wir folgen jedoch dem Vorschlag von J. Zhang, Phys.Rev.A, 67, 054302 (2003), indem wir für die Detektion in den Homodyndetektoren frequenzverschobene Lokaloszillatoren benutzen.

Q 2.3 Mo 11:00 5L

Continuous-variable photonic interfaces using single atoms — •Giovanna Morigi[1], David Vitali[2], Priscilla Canizares[1,2], Stefano Mancini[2], and Jürgen Eschner[3] — [1]Dept. de Fisica, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Spain — [2]Dipt. di Fisica, Universitá di Camerino, I-62032 Camerino, Italy — [3]ICFO-The Institute of Photonic Sciences, E-08860 Castelldefels (Barcelona), Spain

Single atoms or ions are promising candidates for atom-photon interfaces due to the high degree of control one can achieve on these systems. Control can be gained both on the internal (electronic) as well as on the external (motional) degrees of freedom, which can both be interfaced with light by exchange of angular and linear momentum. We present our recent proposal of realizing an optical parametric amplifier based on a single cold trapped atom inside a high-finesse optical cavity, and we show that this system allows for the controlled, quantum-coherent generation of entangled light by exploiting the mechanical effects of atom-photon interaction [1,2]. Using a similar mechanism, the system also allows for the controlled creation, storage and release of pairs of entangled light pulses mediated by the single atom [1,3]. The efficiency of these schemes is investigated for parameter regimes of current experiments with cold atoms and cavities.

[1] G. Morigi, J. Eschner, S. Mancini, and D. Vitali, Phys. Rev. Lett. 96, 023601 (2006); Phys. Rev. A 73, 033822 (2006).
[2] D. Vitali, G. Morigi, J. Eschner, Phys. Rev. A 74, 053814 (2006).
[3] P. Canizares, D. Vitali, J. Eschner, and G. Morigi, in preparation.

Q 2.4 Mo 11:15 5L

Delayed Light Pulses Using Cesium Vapor — •David Hoeckel, Matthias Scholz, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, Hausvogteiplatz 5-7, 10117 Berlin

Many physical realizations are currently exploited as interfaces between single photons and atomic states, and the concept of electromagnetically induced transparency has been introduced as a promising candidate to slow down and store quantum information. We characterize absorption and pulse delays on the D1 transition in Cesium vapor with respect to future storage of narrow-band single photons generated from cavity down-conversion experiments. As a test setup, two

phase-locked lasers excite Cesium vapor in a *Lambda* configuration of which one will be replaced by a single-photon source in subsequent experiments. We achieve transparency windows in the MHz regime with pulse delays of a few 100 ns and discuss decoherence mechanisms between the atomic levels.

Q 2.5 Mo 11:30 5L

Towards Storage of Photonic Qubits in Atomic Vapor — •Matthias Scholz, David Höckel, Florian Wolfgramm, Nils Neubauer, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, Hausvogteiplatz 5-7, 10117 Berlin

Over the years of quantum information research, single photons have held the fort as the primary carriers of quantum bits over long distances. While in the early times polarization was the principal physical property to encode a qubit in a single photon, the which-way information of a photon in an interferometric setup has now become the main player, increasing the robustness against decoherence by dispersion in optical fiber links that are inevitable for the transmission of photons over more than a few kilometers.

Even though single photons have the capability to perform quantum computations on their own using linear optics, their chief application in quantum information science is seen as information carriers between processing nodes in larger quantum networks. These nodes may consist of atomic, ionic, or molecular systems where information is stored or delayed in order to modify it or to make it available at a later time when parallel computational threads have successfully been performed. In this talk, we report on our progress to prepare and store photonic qubits in atomic vapor and subsequently retrieve and decode them to form a relay for quantum information.

Q 2.6 Mo 11:45 5L

Quantum Imaging with Incoherent Photons — •Christoph Thiel[1], Enrique Solano[2], Thierry Bastin[3], John Martin[3], Joachim von Zanthier[1], and Girish S. Agarwal[4] — [1]Institut für Optik, Information und Photonik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Physics department, ASC, and CeNS, Ludwig-Maximilians-Universität, Munich, Germany — [3]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège au Sart Tilman, Liège, Belgium — [4]Department of Physics, Oklahoma State University, Stillwater, OK, USA

We propose a technique to obtain sub-wavelength resolution with 100% visibility using incoherent light. The method employs N photons spontaneously emitted from N atoms and subsequently detected by N detectors. We demonstrate that for certain detector positions $r_2, \ldots, r_N$ the N-th order correlation function as a function of r_1 takes the form $1 + \cos N\delta(r_1)$, resulting in a spatial modulation with a fringe spacing λ/N and a contrast of 100%.

The result corresponds to an N-fold increase in resolution compared to the classical interference pattern, obtained in, e.g., Young's double slit experiment. In our method the photons are created by spontaneous emission. The interference signal with a resolution of λ/N and 100% contrast is thus generated by incoherent light.

Q 2.7 Mo 12:00 5L

Polarization squeezing with photonic crystal fibers — •Josip Milanovic[1], Alexander Huck[1], Joel Heersink[1], Christoph Marquardt[1], Ulrik Andersen[1,2], and Gerd Leuchs[1] — [1]Institute of Optics, Information and Photonics, Max-Planck Research Group, University of Erlangen-Nuremberg, Guenther-Scharowsky-Straße 1, 91058, Erlangen, Germany — [2]Department of Physics, Technical University of Denmark, Fysikvej, 2800, Kgs. Lyngby, Denmark

Squeezing or quantum noise reduction of optical states in glass fibers has been chronically afflicted by the large phase noise from Guided Acoustic Wave Brillouin Scattering (GAWBS). Photonic Crystal Fibers (PCFs) represent a promising new approach to reduce this noise.

We report on the generation of polarization squeezed states employing intense, ultrashort light pulses by a single pass method in photonic crystal fibers. We investigated the squeezing behavior near the zero-dispersion wavelength and in the anomalous dispersion regime by using two distinct fibers. We observed a maximal squeezing at 810 nm of -3.3 ± 0.3 dB with an excess noise of $+16.8 \pm 0.3$ dB in the anomalous regime. Correcting for linear and interference losses between the polarization modes, this corresponds to -6 ± 1 dB of squeezing. The ratio of the squeezing to the excess noise indicates the creation of a much purer state in comparison to a standard fiber; this ratio indeed lies an order of magnitude below those of squeezing experiments exploiting traditional fibers.

Q 2.8 Mo 12:15 5L

Quantum reconstruction of the *Q*-function of an intense polarization squeezed state — •Christoph Marquardt[1], Joel Heersink[1], Ruifang Dong[1], Maria Chekhova[2], Andrei Klimov[3], Luis Sanchez-Soto[4], Ulrik Andersen[1], and Gerd Leuchs[1] — [1]Institute for Optics, Information and Photonics, Max-Planck Research Group, Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1 / Bau 24, 91058 Erlangen — [2]Department of Physics, M.V. Lomonosov Moscow State University, 119992 Moscow, Russia — [3]Departamento de Física, Universidad de Guadalajara, Revolución 1500, 44420 Guadalajara, Jalisco, Mexico — [4]Departamento de Optica, Facultad de Física, Universidad Complutense, 28040 Madrid, Spain

Quantum state reconstruction is an important tool to verify the properties of various quantum states [1]. We present an exact reconstruction formula of the polarization sector of the density matrix, starting from a complete set of Stokes parameters measurements. By using the *Q*-function as an appropriate quasidistribution and in the case of intense polarization states we show that the reconstruction reduces to an inverse Radon transform. We reconstructed the *Q*-function of an intense polarization squeezed state, generated by fs-pulses in an optical fiber exploiting the nonlinear Kerr effect [2].

[1] A.I.Lvovsky, M.G.Raymer, quant-ph/0511044
[2] J. Heersink et al., Opt. Lett. 30, 1192(2005)

Q 3: Festkörperlaser I

Zeit: Montag 10:30–12:30 Raum: 5K

Q 3.1 Mo 10:30 5K

Entwicklung eines kompakten und leistungsstarken Zündlasers für Verbrennungsmotoren — •Johannes Tauer, Heinrich Kofler, Georg Tartar und Ernst Wintner — Institut für Photonik, TU Wien, Österreich

Die seit mittlerweile über 100 Jahren verwendete Funkenzündung behindert die Optimierung der Verbrennungskraftmaschine zunehmend, da diese unter den geforderten Motorbedingungen (hohe Drücke - magere Kraftstoffgemische) nur noch erschwert funktioniert. Einen vielversprechenden Ausweg aus dieser Problematik stellt die Laserzündung dar. Eine hohe Zündfähigkeit magerer Gemische sowie die freie Wahl des Zündortes im Brennraum sprechen für deren Anwendung, wobei die benötigten Pulsenergien bei Pulsdauern unter 10 ns im Bereich von 5-10 mJ liegen. Konventionelle Lasersysteme, die diesen Anforderungen entsprechen, sind wegen ihrer Anschaffungskosten und Baugrößen nicht einsetzbar. Daher wurde die Entwicklung eines kompakten und leistungsstarken Lasersystems unternommen. Aufgrund der kompakten und robusten Ausführung wurde das Konzept eines longitudinal diodengepumpten und passiv gütegeschalteten Festkörperlasers verfolgt. Das Lasermedium (Nd:YAG) wurde mit einer 300W Diode gepumpt. Als sättigbarer Absorber kam Cr4+:YAG zum Einsatz. Der optimale Betriebspunkt des Lasersystems hängt im wesentlichem von der Reflektivität des Auskoppelspiegels und der Anfangstransmission des Absorbers ab. Bisweilen konnten Pulsenergien von über 10 mJ, Pulsdauern unter 1,5 ns und optische Wirkungsgrade von mehr als 9 % erreicht werden.

Q 3.2 Mo 10:45 5K

Charakterisierung eines Faserverstärkers bei 1014 nm — •Mathias Sinther, Albert Seifert und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Schlossgartenstr. 7, 64289 Darmstadt

Ytterbium-dotierte Faserverstärker und Faserlaser werden inzwischen für die unterschiedlichsten Anwendungen verwendet. In diesem Bei-

trag wird ein Yb-Faserverstärker vorgestellt, der bei 1014 nm betrieben wird, und dessen vierte Harmonische dann in einem Atomfallenexperiment eingesetzt werden soll. Bei der genannten Wellenlänge tritt im Yb-Spektrum noch eine Absorptionsbande auf, so dass die Fasern mit flüssigem Stickstoff gekühlt werden müssen. Auf diesen Aspekt soll im Besonderen eingegangen werden.

Q 3.3 Mo 11:00 5K

Spektroskopische Untersuchungen und erste Lasertätigkeit von Pr^{3+}:KY_3F_{10} — •Christina Braun, André Richter, Ernst Heumann und Günter Huber — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Wir berichten über spektroskopische Untersuchungen an Pr^{3+}:KY_3F_{10} und über die nach unserem Wissen erstmals demonstrierte Lasertätigkeit des Materials.

KY_3F_{10} ist mit seiner kubischen Kristallstruktur ein attraktives Wirtsmaterial für diodengepumpte Pr-basierte Lasersysteme. Absorptionsmessungen im blauen Spektralbereich ergaben einen maximalen Wirkungsquerschnitt von $2,4 \cdot 10^{-20}\,cm^2$ bei einer Wellenlänge von $446\,nm$. Demnach sind GaN-Laserdioden als Pumpquellen für den Grundzustandsübergang $^3H_4$ nach $^3P_2$ prinzipiell geeignet. Die intrinsische Lebensdauer des oberen Laserniveaus $^3P_0$ wurde aus den Fluoreszenzabklingkurven unterschiedlich stark dotierter Kristalle zu $46\,\mu s$ bestimmt und weist damit einen für Pr-dotierte Fluoride typischen Wert auf. Emissionswirkungsquerschnitte wurden sowohl nach Füchtbauer-Ladenburg als auch nach der Reziprozitätsmethode berechnet. Für den realisierten Laserübergang bei $645\,nm$ wurde ein Wirkungsquerschnitt von $9,1 \cdot 10^{-20}\,cm^2$ ermittelt.

Die ersten Laserexperimente wurden mit einem nahezu konzentrischen Resonator realisiert. Bisher konnten etwa $5\,mW$ rote Ausgangsleistung im Dauerstrich erreicht werden.

Q 3.4 Mo 11:15 5K

Synchronisiert gepulst gepumpter Yb-Faserverstärker zur effizienten Nachverstärkung eines $Cr^{4+}Nd^{3+}$:YAG Microchiplasers — •Christian Bohling[1], Konrad Hohmann[1], Wolfgang Schippers[1] und Wolfgang Schade[1,2] — [1]TU Clausthal, Institut für Physik und Physikalische Technologien (IPPT), Leibnizstr. 4, 38678 Clausthal-Zellerfeld — [2]TU Clausthal, LaserAnwendungsCentrum (LAC), Arnold-Sommerfeld-Str. 6, 38678 Clausthal-Zellerfeld

Ein passiv gütegeschalteter $Cr^{4+}Nd^{3+}$:YAG Microchiplaser (E_p = 100μJ, t_P = 1ns, λ = 1064 nm) wird in einer Ytterbium dotierten large mode area (LMA) double clad (DC) Faser (Fa. Nufern) mit einem Kerndurchmesser d_{core} = 45μm nachverstärkt. Die Verstärkungsfaser wird von einem fasergekoppelten gepulsten Diodenlaser (λ = 976nm, P_{pump} = 50W, t_p < 1ms) gepumpt. Durch Synchronisation der Seed- und Pumppulse wird bei Wiederholraten $f_{rep.}$ < 1kHz der Wirkungsgrad des Verstärkungssystems verbessert. Verstärkte spontane Emission (ASE) wird durch dieses Pumpverfahren nahezu vollständig unterdrückt. Es werden Pulsenergien bis E_p = 1,5mJ (Pulsspitzenleistung P = 1,5MW) erzielt. Wird der Laserstrahl auf eine Oberfläche abgebildet (Fokusdurchmesser d = 45 μm), so wird eine Intensität $I = 95\frac{\mathrm{GW}}{\mathrm{cm}^2}$ erreicht, mit der auf dieser Oberfläche ein spektroskopisch signifikantes Plasma erzeugt werden kann. Die Strahlquelle eignet sich daher zum Einsatz in einem fasergekoppelten LIBS-System.

Q 3.5 Mo 11:30 5K

Optische Steuerung der Emission eines Pr,Yb:ZBLAN Faserlasers — •Ortwin Hellmig, Oliver Back, Klaus Sengstock und Valeri Baev — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Pr,Yb:ZBLAN upconversion Faserlaser emittieren in mehreren Spektralbereichen zwischen 492 und 717 nm. Die Steuerung der Laserleistung und des Emissionsspektrums kann über die Pumplichtquelle und durch die Veränderung des Reflektionsgrades der Resonatorspiegel mit einem einstellbaren Luftspalt erfolgen, ist aber relativ langsam. Für eine schnelle Steuerung der Laserleistung haben wir ein neuartiges optisches Modulationsverfahren entwickelt. Dabei erfolgt eine verzögerungsfreie Inversionskontrolle durch ein zusätzlich in den Laser eingekoppeltes Steuerlicht mit einer Wellenlänge, die resonant zu einem anderen möglichen Laserübergang, z.B. 635 nm, gewählt wird. Bei dieser Steuerung wurde kontrollierter Superpulsbetrieb bei Frequenzen der Relaxationsschwingungen im Bereich von 10^4 - 10^6 Hz mit etwa 10-fach überhöhter Spitzenleistung erreicht. Die maximale Spitzenleistung von etwa 50 mW bei der Emissionswellenlänge von 493 nm und der Wiederholfrequenz von 300 kHz wurde bei einer eingekoppelten Pumpleistung von 100 mW demonstriert und ist durch einen Hystereseeffekt nur bei einer Reduzierung der Modulationsfrequenz erreichbar. Dieses Konzept funktioniert auch bei deutlich höheren Frequenzen; so besteht die Möglichkeit, allein durch eingekoppeltes Steuerlicht, ein „Mode Locking"-Betrieb mit einer Frequenz von 10^8 Hz ohne zusätzliche optische Elemente im Resonator einzustellen.

Q 3.6 Mo 11:45 5K

Nachverstärkung eines Er:Yb-Glas Microchiplasers in einem Er:Yb Faserverstärker — •Jörg Burgmeier[1,2], Christoph Bauer[2] und Wolfgang Schade[1,2] — [1]TU Clausthal, Institut für Physik und Physikalische Technologien (IPPT), Leibnizstraße 4, 38678 Clausthal-Zellerfeld — [2]TU Clausthal, LaserAnwendungsCentrum (LAC), Arnold-Sommerfeld-Straße 6, 38678 Clausthal-Zellerfeld

In diesem Beitrag werden verschiedene Faserverstärkersysteme diskutiert, welche im „eye-safe"-Bereich bei einer Wellenlänge von λ=1,5μm gepulste Laserstrahlung verstärken.

Ein passiv-gütegeschalteter Er:Yb-Glas Microchiplaser mit einer Pulsenergie von E_p=5μJ, einer Repetitionsrate von f_{Rep}=5kHz und einer Wellenlänge von λ_{Seed}=1535nm wird als Seedlaser eines Er:Yb Faserverstärkers eingesetzt. Als Verstärkerfasern werden eine single mode Erbium/Ytterbium-dotierte double clad Faser mit einem Kerndurchmesser von d_{Kern}=7μm, sowie eine polarisationserhaltende large mode area (LMA) Er:Yb-Faser mit einem Kerndurchmesser von d_{Kern}=25μm verwendet. Zurzeit werden beide Fasern in zwei unabhängigen Systemen getestet, ein Aufbau aus Vorverstärkerstufe und Hauptverstärkerstufe wird angestrebt. Mit der polarisationserhaltenden Faser wurde ein Verstärkungsfaktor von V=20 realisiert, was einer Pulsenergie von E_p=100μJ entspricht. Beim Durchlaufen der Verstärkerfaser verkürzt sich die Pulsdauer von t_{Seed}=3,7ns auf t_{Amp}=2,5ns.

Die Eigenschaften dieser Faserverstärkersysteme bieten die Möglichkeit zur Spektroskopie von Explosivstoffen.

Q 3.7 Mo 12:00 5K

Lasertätigkeit von Er^{3+}:Sc_2O_3 bei 1,58 μm Wellenlänge — •Matthias Fechner, Andreas Kahn, Hanno Scheife, Klaus Petermann und Günter Huber — Institut für Laser-Physik, Hamburg

Zum ersten Mal ist Lasertätigkeit auf dem Übergang $^4I_{13/2} \rightarrow {}^4I_{15/2}$ bei 1,58 μm Wellenlänge in Er^{3+}:Sc_2O_3 demonstriert worden. Frühere Versuche, diesen Laser zu realisieren, waren nicht erfolgreich [1], weil nur Laserkristalle mit zu hohen Erbiumkonzentrationen zur Verfügung standen. Sc_2O_3 eignet sich hervorragend als Wirtsmaterial. Es zeichnet sich durch eine hohe Wärmeleitfähigkeit, eine niedrige effektive Phononenenergie, große mechanische Stabilität und einen weiten Transparenzbereich (UV bis mittleres IR) aus. Sowohl bei einer Pumpwellenlänge von 980 nm als auch beim *In-Band-Pumping* bei Wellenlängen um 1535 nm werden in Er^{3+}:Sc_2O_3 Upconversionprozesse erwartet, die zu einer Inversionsabnahme führen können. Daher ist ein möglichst großer Abstand der aktiven Ionen im Wirtsgitter nötig. Bei einer Erbiumkonzentration von 0,2 Platz % und einer Kristalllänge von 5 mm konnte bei einer absorbierten Pumpleistung von 290 mW eine Ausgangsleistung von 23 mW bei 1,58 μm Wellenlänge erzielt werden. Als Pumpquelle diente ein Ti^{3+}:Al_2O_3-Laser bei einer Wellenlänge von 980 nm und einer optischen Leistung von 1,98 W. In Zukunft wird versucht, einen planaren Wellenleiterlaser gleichen Materials herzustellen, der in der integrierten Optik Anwendung finden kann.

[1] V. Peters. *Spektroskopie und Lasereigenschaften erbium- und praseodymdotierter hochschmelzender Oxide*. Diplomarbeit, Institut für Laser-Physik, Universität Hamburg (1998).

Q 3.8 Mo 12:15 5K

Untersuchungen zur schnellen Wellenlängenumschaltung eines Scheibenlasers — •Marco Franke, Wolfgang Paa und Wolfgang Triebel — IPHT-Jena e.V., Jena, Deutschland

Der alternierende Mehrwellenlängenbetrieb eines Yb:YAG-Scheibenlaseroszillators wird mit drei verschiedenen Konzepten der resonatorinternen Umschaltung realisiert. Die Umschaltfrequenzen betragen bis zu 1500 Hz und es werden Wellenlängensprünge von 93pm bis 1,1nm erreicht. Die Konzepte umfassen die Wellenlängenumschaltung mit polarisationsdrehenden Elementen, mit Doppelresonator und mit einem elektrisch durchstimmbaren Lyot-Filter. Ihre Erprobung wird vorgestellt und bewertet

Q 4: Nichtlineare optische Effekte und Lichtquellen I

Zeit: Montag 10:30–12:30 Raum: 5J

Q 4.1 Mo 10:30 5J

fs-Weißlichterzeugung in verschiedenen Festkörpermaterialien für spektroskopische Anwendungen — •Stefan Letzsch, Michael Seefeldt, Christian Spitz und Ralf Menzel — Institut für Physik/Photonik, Am Neuen Palais 10, 14469 Potsdam

Weißlicht findet in vielen Bereichen wie Spektroskopie, Mikroskopie, Interferometrie und Kurzpulserzeugung zunehmend Anwendung. Dabei ist ein breites kontinuierliches Spektrum mit hohen Leistungsdichten bei gleichzeitig sehr guter Strahlqualität erforderlich. Durch die Verwendung von Kurzpulslasersystemen ist eine effiziente Erzeugung von Weißlicht in optischen Fasern und Festkörpern möglich geworden.

Es werden die in verschiedenen Festkörpern wie Quarz, Bariumfluorid und Saphir generierten Weißlichtspektren präsentiert. Dazu wurden die spektrale Breite sowie die Leistungsdichte der erzeugten Spektren in Abhängigkeit von der Materialdicke und den Fokussierbedingungen des fs-Pumplichts untersucht. Die Ergebnisse werden hinsichtlich ihrer Eignung für spektroskopische Anwendungen ausgewertet und miteinander verglichen. An der Weißlichterzeugung in Festkörpern sind hauptsächlich die folgenden nichtlinear optischen Effekte beteiligt: Selbstfokussierung, Multiphotonenionisation, Selbstphasenmodulation und Wellenmischung. Der Zusammenhang zwischen den physikalischen Eigenschaften der verwendeten Materialien und den generierten Weißlichtspektren wird diskutiert.

Q 4.2 Mo 10:45 5J

Strongly Interacting Polaritons in Coupled Arrays of Cavities — •Michael Hartmann[1,2], Fernando Brandao[1,2], and Martin Plenio[1,2] — [1]Institute for Mathematical Sciences, Imperial College London, United Kingdom — [2]QOLS, Blackett Laboratory, Imperial College London, United Kingdom

The experimental observation of quantum phenomena in strongly correlated many particle systems is difficult because of the short length- and timescales involved. Obtaining at the same time detailed control of individual constituents appears even more challenging and thus to date inhibits employing such systems as quantum information processing devices.

Substantial progress to overcome these problems has been achieved with cold atoms in optical lattices, where a detailed control of collective properties is feasible. However it is very difficult to address and hence control or measure individual sites.

In this work, we demonstrate that polaritons, combined atom and photon excitations, in an array of cavities can form a strongly interacting many body system governed by a Bose-Hubbard Hamiltonian. In this system, individual particles can, by construction, be controlled and measured. It therefore allows to create inhomogeneous systems where different phases may coexists in adjacent spatial regions. Furthermore, the on-site potential can be attractive, where particles are much more delocalised than in superfluids and highly entangled W_N states can be generated. Finally not only an effective Bose-Hubbard Hamiltonian might be created but several different many body systems.

Q 4.3 Mo 11:00 5J

Charakterisierung des Amplitudenrauschens bei der resonatorinternen Frequenzverdopplung von optisch gepumpten Halbleiter-Scheibenlasern — •Kai Seger, René Hartke, Ernst Heumann und Günter Huber — Institut für Laser-Physik, Universität Hamburg, Luruperchaussee 149, 22761 Hamburg

Anwendungen in der Displaytechnologie erfordern kompakte, effiziente und stabile Laserquellen im grünen Spektralbereich. Ein vielversprechender Ansatz auf diesem Gebiet ist das Einsetzen von optisch gepumpten Halbleiter-Scheibenlasern. Bei der Verwendung von Halbleitern als Lasermedium muss zur Zeit noch auf Frequenzverdopplung (SHG) aus dem Infraroten zurückgegriffen werden. Dabei können starke Amplitudenschwankungen auftreten („Green-Problem“).

Zur Untersuchung dieser Amplitudenschwankungen wurde ein experimenteller Aufbau realisiert, mit dem es möglich ist, gleichzeitig Amplitudenrauschen und Modenstruktur zu untersuchen. Die Detektion der Moden erfolgte durch ein hochauflösendes Scanning Fabry-Perot Interferometer. Es konnte so ein direkter Zusammenhang zwischen Amplitudenrauschen der SHG und Modenverhalten des Lasers nachgewiesen werden.

Q 4.4 Mo 11:15 5J

Linear-circular dichroism in the high-order multiphoton ionization in dielectrics — •Vasily V. Temnov[1], Klaus Sokolowski-Tinten[2], Ping Zhou[2], Abdalla El-Khamhawy[2], and Dietrich von der Linde[2] — [1]Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — [2]Institut für Experimentelle Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

We apply the ultrafast time-resolved imaging interferometry [1] to follow the evolution of free carriers in fused silica and sapphire generated by single intense linearly or circularly polarized femtosecond laser pulses. The density $\rho(I)$ of laser-generated carriers just after laser excitation is investigated as a function of the intensity I and polarization state of the applied pump pulses. For both materials and both pump polarizations we found the scaling law to be $\rho(I) \sim I^6$ at intensities around 10 TW/cm^2, a clear evidence of six-photon ionization with the lowest order needed to cross the energy band gap. The rate of 6-photon ionization is found to be significantly higher for the linear polarization of the pump pulses [2], which represents the experimental verification of theoretical predictions for high-order multiphoton ionization already made in the early seventies [3].

[1] V.V. Temnov, K. Sokolowski-Tinten, P.Zhou, D. von der Linde, Appl. Phys. A 78, 483 (2004); J. Opt. Soc. Am B 23, 1954 (2006)

[2] V.V. Temnov, K. Sokolowski-Tinten, P. Zhou, A. El-Khamhawy and D. von der Linde, Phys. Rev. Lett 97, 237403 (2006)

[3] H.R. Reiss, Phys. Rev. Lett. 29, 1129 (1972)

Q 4.5 Mo 11:30 5J

Nonlinear Resonance Broadening and Shift due to Thermo-Optical Instability in Microsphere Resonators — •Carsten Schmidt[1], Arkadi Chipouline[1], Thomas Pertsch[1], Oleg Egorov[2], Falk Lederer[2], Andreas Tünnermann[3], and Lev Deych[4] — [1]ZIK Ultra optics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743, Jena, Germany — [2]Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743, Jena, Germany — [3]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Strasse 7, 07745 Jena, Germany — [4]Department of Physics of Queens College of the City University of New York, 65-30 Kissena Blvd, Flushing, NY 11367

During last several years, high-Q optical microresonators received significant attention [1]. Thresholds for nonlinear effects could be achieved at signal powers of the order of several milliwatts, which is stipulated by the unprecedented values of Q factors (up to 109) and the small occupied volume of whispering-gallery-modes [2]. In this work, the broadening of the resonance peaks and their shifting have been experimentally observed. The effects are caused by thermo-optical nonlinearity and could be described theoretically using a mean field approach.

[1] D. Braunstein, A. M. Khazanov, G. A. Koganov, and R. Shuker, "Lowering of threshold conditions for nonlinear effects in a microsphere", Phys. Rev. A 53, 3565-3572 (1996).

[2] A. E. Fomin, M. L. Gorodetsky, I. S. Grudinin, and V. S. Ilchenko, "Nonstationary nonlinear effects in optical microspheres", JOSA B 22, 459-465 (2005).

Q 4.6 Mo 11:45 5J

Mode statistics in random lasers — •Oleg Zaitsev — Fachbereich Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

Representing an ensemble of random lasers with an ensemble of random matrices, I compute average number of lasing modes and its fluctuations. The regimes of weak and strong coupling of the passive resonator to environment are considered. In the latter case, contrary to an earlier claim in the literature, I do not find a power-law dependence of the average mode number on the pump strength. For the relative fluctuations, however, a power law can be established. It is shown that, due to the mode competition, the distribution of the number of excited modes over an ensemble of lasers is not binomial.

Bibliography: O. Zaitsev, Phys. Rev. A **74**, 063803 (2006).

Q 4.7 Mo 12:00 5J

Optimization of high-order harmonics by spatial shaping before the filament — •Jan Lohbreier, Stefan Eyring, Robert

Spitzenpfeil, Dominik Walter, Matthias Weger, and Christian Spielmann — University of Würzburg, Department of Physics, Am Hubland, 97074 Würzburg, Germany

The generation of high-order harmonics provides ultrafast and coherent radiation in the EUV regime from a tabletop light source. For many experiments the best achievable control of the EUV photons in terms of brightness and spectrum is necessary.

We present a way of optimizing the output of the high-order harmonic generation process by means of spatial shaping. This phase shaping is performed with a PPM-SLM with a resolution of 768x768 pixels and employing a genetic algorithm. After spatially shaping the beam profile the laser is generating a filament in a gas-filled tube. The spectrally-broadened pulses are then compressed to about 12fs using a prism-compressor and used for harmonic generation in a gas-jet. Our results show that an optimization can be achieved regarding the overall photon flux. Further improvements (harmonic beam profile, selectivity of the spectrum) still need to be investigated.

Q 4.8 Mo 12:15 5J

Optimierung und Charakterisierung von Filamenten — •Stefan Eyring, Jan Lohbreier, Robert Spitzenpfeil, Dominik Walter, Matthias Weger und Christian Spielmann — Universität Würzburg, Physikalisches Institut, Am Hubland, 97074 Würzburg

Zur Erzeugung von ultrakurzen Laserpulsen benötigt ein Laser ein breites Spektrum von Frequenzen. Um die Pulse eines typischen Verstärkersystems weiter zu verkürzen, muss daher deren Spektrum verbreitert werden. Ein geeignetes Werkzeug hierfür ist die Selbstphasenmodulation während der Filamentation.

Hier zeigen wir, wie sich Inhomogenitäten des ursprünglichen Laserstrahls auf das Strahlprofil und die Pulseigenschaften nach dem Filament auswirken. Wir zeigen weiterhin, dass es mit Hilfe von zweidimensionaler Phasenformung vor dem Filament möglich ist, Einfluss auf das Strahlprofil und die Eigenschaften des spektral verbreiterten Pulses zu nehmen. Für die Phasenformung kommt ein PPM-SLM mit einer Auflösung von 768x768 Pixeln zum Einsatz, der von einem genetischen Algorithmus angesteuert wird.

Hierdurch ist es möglich viele unerwünschte Effekte der Filamentation zu eliminieren und kurze, intensive Laserpulse mit einem homogenen Strahlprofil zu erhalten.

Q 5: Quantengase (Bose-Einstein-Kondensation)

Zeit: Montag 14:00–16:00 Raum: 6J

Gruppenbericht Q 5.1 Mo 14:00 6J

Coherence in two dimensional Bose gases — •Peter Krüger, Zoran Hadzibabic, Marc Cheneau, Baptiste Battelier, Patrick Rath, and Jean Dalibard — Laboratoire Kastler Brossel, Ecole Normale Superieure, Paris, France

Dimensionality can drastically affect the properties of cold degenerate quantum gases. In three dimensions bosonic clouds can form Bose-Einstein condensates in which full phase coherence, i.e. true long range order, extends over the entire system. This is no longer true in reduced dimensions. Two dimensional systems are special as correlations in a quasi-ordered phase decay only algebraicly and not exponentially, so that order phenomena such as superfluidity can persist.

We implement a two dimensional bosonic system with Rb-87 atoms confined in a combined magnetic and optical potential and study coherence properties by a matter wave heterodyning technique. Interference experiments between two uncoupled flat clouds allow us to study phase correlations and the superfluid to normal phase crossover known as the Berizinskii Kosterlitz Thouless crossover.

Q 5.2 Mo 14:30 6J

On the detectability of quantum radiation in Bose-Einstein condensates — •Ralf Schuetzhold — Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany

Based on doubly detuned Raman transitions between (meta) stable atomic or molecular states and recently developed atom counting techniques, a detection scheme for sound waves in dilute Bose-Einstein condensates is proposed whose accuracy might reach down to the level of a few or even single phonons. This scheme could open up a new range of applications including the experimental observation of quantum radiation phenomena such as the Hawking effect in sonic black-hole analogues or the acoustic analogue of cosmological particle creation.

Q 5.3 Mo 14:45 6J

From Many-Body Interaction to Nonlinearity — •Niklas Teichmann[1], Christoph Weiss[2], and Martin Holthaus[1] — [1]Institut für Physik - Carl von Ossietzky Universität - D-2611 Oldenburg - Germany — [2]Laboratoire Kastler Brossel - École normale supérieure - 24 rue Lhomond - F-75231 Paris Cedex 05 - France

A model system is introduced, which allows one to study the N-particle dynamics of an externally forced Bose-Einstein condensate at zero temperature numerically for reasonably large N, and gives rise to mean-field dynamics which can be either regular or chaotic. The correspondence between the evolution of the N-particle system, governed by the linear many-body Schrödinger equation, and the mean-field dynamics described by the nonlinear Gross-Pitaevskii equation is illustrated by various examples. This correspondence is strongly sensitive to whether or not the mean-field dynamics are chaotic.

Q 5.4 Mo 15:00 6J

Noise-induced phase transitions — •María Eckholt[1], Juan José García-Ripoll[1,2], and Ignacio Cirac[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching (Germany) — [2]Dpto. de Física Teórica I, Facultad de CC. Físicas, Universidad Complutense, Ciudad Universitaria s/n, 28040 Madrid (Spain)

We study the quantum phase transition of ultracold bosonic atoms in the presence of a noisy environment. The study comprehends different analytical and numerical techniques to estimate the phases of the atoms.

Q 5.5 Mo 15:15 6J

Quantum vs. Classical Dynamics of an Ultracold Bose Gas — •Thomas Gasenzer[1] and Jürgen Berges[2] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]Institut für Kernphysik, Technische Universität Darmstadt, Schlossgartenstrasse 9, 64289 Darmstadt

Dynamics of an ultracold gas far from thermal equilibrium is studied with special focus on the quantum vs. the classical statistical aspects of the many-body time evolution. Knowledge about the differences between quantum and classical statistical dynamics is of particular interest for experimental and theoretical efforts to identify effects of quantum fluctuations. The employed functional-integral approach, which involves the two-particle irreducible (2PI) effective action, allows in a particularly transparent way to distinguish between the time evolution of correlation functions in the classical and quantum cases, respectively. It is shown that these cases only differ in the interaction vertices appearing in the phase factor in the generating functional. The differences in the dynamic equations beyond the purely classical Hartree-Fock-Bogoliubov mean-field theory are derived in next-to-leading order of the 2PI $1/\mathcal{N}$ approximation.

Q 5.6 Mo 15:30 6J

Transport of Bose-Einstein condensates beyond the Gross-Pitaevskii approach — •Thomas Ernst[1], Michael Hartung[1], Tobias Paul[2], and Peter Schlagheck[1] — [1]Institut für Theoretische Physik, Universität Regensburg — [2]Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris Sud, Orsay

We study the transport of Bose-Einstein condensates through scattering potentials in quasi one-dimensional waveguides. While our previous works used the Gross-Pitaevskii equation to calculate this process, we employ an approach which goes beyond this mean field theory and which is able to take into account excitations of the condensate as well as its depletion rate. This approach is based on a cumulant expansion [1], where we use a truncation scheme that is formally valid for weak interactions and a large number of atoms. We apply it to the scattering problem of a propagating BEC on a double barrier potential, where resonant transmission of the condensate takes place via the population of dynamically unstable scattering states. Our results confirm the

validity of previous calculations of these processes based on the Gross-Pitaevskii equation [2].
[1] T. Köhler and K. Burnett, Phys. Rev. A **65**, 033601 (2002)
[2] T. Paul, K. Richter and P. Schlagheck, Phys. Rev. Lett. **94**, 020404 (2005)

Q 5.7 Mo 15:45 6J

The many-particle mean-field correspondence for a BEC in quantum phase space — •Friederike Trimborn, Dirk Witthaut, and Hans Jürgen Korsch — FB Physik, TU Kaiserslautern, 67663 Kaiserslautern

In many cases the dynamics of a BEC is well described by a single macroscopic wave function following the Gross-Pitaevskii equation (GPE). However, the GPE takes into account only expectation values and neglects quantum fluctuations which are especially important for quantum phase transitions as the superfluid to Mott insulator transition which is therefore considered not to be explicable within mean-field theory. We will present a new approach representing many-particle quantum states by a classical phase space ensemble following a generalized GPE. This method provides an excellent tool to analyze the mean-field – many particle correspondence. Several examples will be given (e.g. the superfluid to Mott insulator transition).

Q 6: Quanteninformation (Photonen und nichtklassisches Licht II)

Zeit: Montag 14:00–15:00 Raum: 5L

Q 6.1 Mo 14:00 5L

A Single-Photon Server with Just One Atom — •Markus Hijlkema, Bernhard Weber, Holger Specht, Simon Webster, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans Kopfermann-Str. 1, 85748 Garching, Germany

In this contribution we present results on an experiment where just one single atom trapped in the mode of a high-finesse microcavity is used to generate single photons in a deterministic way. In our scheme, a single atom is trapped in a standing wave dipole potential, created by two counterpropagating laser beams. The focus of these laserbeams overlaps with the mode of our cavity. First, the atom is cooled down in the trap by applying a laser beam incident perpendicular to the cavity and under an angle of 45 degrees with respect to the trapping lasers. Second, a sequence of laserpulses is used to stimulate single-photon emission into the cavity, and subsequent recycling of the atom back into the initial state. The atom is cooled during the recycling phase if suitable parameters are chosen. It is thus possible to extend the lifetime of the atom in the trap up to several 10 seconds, while at the same time producing single-photons. The large number of photons generated in this way display a clear antibunching in the photon arrival times as can be determined from just a single run.

Q 6.2 Mo 14:15 5L

Experimental Demonstration of Continuous Variable Cloning with a priori Information — •Metin Sabuncu[1,2], Ulrik Andersen[2], and Gerd Leuchs[1] — [1]Institut für Optik Information und Photonik, Max Planck Forschungsgruppe, Universität Erlangen-Nürnberg — [2]Department of Physics, Technical University of Denmark

A state dependent cloning machine has the capability to produce clones, which have a higher average fidelity compared to the universal cloner. We experimentally realize a state dependent cloning machine consisting of only linear optical elements, homodyne detectors and feedforward electronics. Our machine generates clones of coherent states, which are chosen out of an apriori known alphabet, with an average fidelity which exceeds the universal coherent state cloning limit of 2/3.

Q 6.3 Mo 14:30 5L

A Narrow-Band Single-Photon Source — •Florian Wolfgramm, Matthias Scholz, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, Hausvogteiplatz 5-7, 10117 Berlin

Recently, there has been extensive progress on the storage of single photons. Most storage schemes rely on the matching of photons to the bandwidth of atomic resonances. This feature is not fulfilled by single-photon sources based on quantum dots, parametric down-conversion, molecules, or NV-centers in diamond.

While narrow bandwidths have been achieved using single stored atoms or ions, a more simple approach takes advantage of the narrow-band output of Optical Parametric Oscillators (OPO), where the down-conversion bandwidth is reduced to that of the cavity. Operating the OPO far below threshold, a heralded single-photon source can be realized with the idler photon as the trigger. The feasibility of such a scheme has been proven for a type-I OPO. Type-II down-conversion has the advantage of perpendicular polarization and has been implemented without active stabilization of the cavity. Our approach with type-II phase-matching avoids the problem of stabilizing the cavity for signal and idler. Instead, we are separating the idler by intracavity beamsplitters, stabilizing the cavity only for the signal. With this setup we were able to generate heralded single-photon states with a bandwidth of below 100 MHz at the D1-transition of cesium. Such a narrow-band single-photon source could find wide applications in the field of quantum information processing.

Q 6.4 Mo 14:45 5L

Remote Preparation of an Atomic Quantum Memory — •Wenjamin Rosenfeld[1], Jürgen Volz[1], Florian Henkel[1], Stefan Berner[1], Michael Krug[1], Fredrik Hocke[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Dept. für Physik der LMU, 80799 München — [2]Max-Planck Institut für Quantenoptik, 85748 Garching

Entanglement is a key element of quantum information and communication applications. Of special interest is entanglement between different quantum objects like photons and atoms. It allows to combine the advantages of long atomic coherence times with the ability of photons to transport quantum information over large distances. Therefore atom-photon entanglement forms the basic ingredient for future applications, as e.g. quantum repeater and quantum networks.

In our experiment we generate entanglement between the spin of a single optically trapped Rb87 atom and the polarization of a photon in a spontaneous decay process in a lambda-type transition[1]. Based on this entanglement we performed a first demonstration of a quantum communication protocol between an atomic qubit and a photonic communication channel[2]. In this so-called remote state preparation we utilize the idea of quantum teleportation to transfer an arbitrary quantum state of the single photon to the atomic qubit. Together with a high-fideliy read-out procedure of the atomic state, this is a major building block for the faithful distribution of quantum information.
[1] J. Volz et al., PRL 96, 030404 (2006)
[2] W. Rosenfeld et al., quant-ph/0608229 (2006)

Q 7: Quanteninformation (Ionen)

Zeit: Montag 15:00–16:00 Raum: 5L

Q 7.1 Mo 15:00 5L

Individuelle Adressierung und bedingte Dynamik von gespeicherten Ionen mit RF-Strahlung — •Michael Johanning[1], Alexander Braun[1], Vladimir Elman[1], Werner Neuhauser[2] und Christof Wunderlich[1] — [1]Universität Siegen, Institut für Physik, Walter-Flex-Straße 3, 57068 Siegen — [2]Universität Hamburg, Institut für Laserphysik, Luruper Chaussee 146, 22761 Hamburg

Ein beliebiger Quantenalgorithmus kann aus 1-Qubit Gattern und bedingter Quantendynamik mit wenigstens zwei Qubits (z. B. *CNOT*-Gatter) synthetisiert werden. Hierfür ist zum Einen eine individuelle Adressierung der Qubits und zum Andern deren Wechselwirkung untereinander erforderlich. Wir demonstrieren erstmalig i) die individuelle Adressierung von elektrodynamisch gespeicherten Ionen mit Radiofrequenzstrahlung im Frequenzraum, und ii) die Kopplung der internen Dynamik der Ionen an deren Bewegungszustände auch bei nahezu verschwindendem Lamb-Dicke-Parameter (d.h. vernachlässigbarem Photonenrückstoß). Damit werden wesentliche Voraussetzungen geschaffen für Quanten-Informationsverarbeitung mit Ionen-Spin-Molekülen. Den experimentellen Nachweis führen wir mit Hilfe eines RF-optischen Doppelresonanz-Experimentes mit $^{172}Yb^{+}$-Ionen gespeichert in einer linearen Paul-Falle.

Q 7.2 Mo 15:15 5L

Error-resistant Single Qubit Gates with Trapped Ions — •Nuala Timoney[1], Vladamir Elman[1], Cornelius Weiss[1], Michael Johanning[1], Werner Neuhauser[2], and Christoph Wunderlich[1] — [1]Fachbereich Physik, Universität Siegen, 57068 Siegen — [2]Institut für Laser-Physik, Universität Hamburg

Coherent operations constitutive for the implementation of single and multi-qubit quantum gates with trapped ions are demonstrated that are robust against variations in experimental parameters and intrinsically indeterministic system parameters. In particular, single qubit gates developed using optimal control theory [1] are demonstrated for the first time with trapped ions. Their performance as a function of error parameters is systematically investigated and compared to composite pulses [2].

The two level quantum mechanical system is realized on the $S_{1/2}(F=0) \leftrightarrow S_{1/2}(F=1, m_F=0)$ transition in $^{171}Yb^{+}$ confined in a Paul trap, driven by microwave radiation close to 12.6 GHz. Shaped pulses and composite pulses have been realized that are specifically designed to tackle off-resonance errors, timing errors, or power variations of the driving field.

Good agreement is seen between simulated results and the measured ones. Higher experimental fidelities are obtained with the aforementioned shaped and composite pulses over an extended parameter regime than with a simple pulse. [1] T.E. Skinner, T.O. Reiss, B. Luy, N. Khaneja and S. Glaser, J. Mag. Res. **163**, 8 (2003). [2] H. Cummins, G. Llewellyn, and J. Jones, Phys. Rev. A **67**, 042308 (2003)

Q 7.3 Mo 15:30 5L

Generation of Dicke States in Distant Qubits Using Linear Optics — •Christoph Thiel[1], Joachim von Zanthier[1], Thierry Bastin[2], Enrique Solano[3], and Girish S. Agarwal[4] — [1]Institut für Optik, Information und Photonik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège au Sart Tilman, Liège, Belgium — [3]Physics Department, ASC, and CeNS, Ludwig-Maximilians-Universität, Munich, Germany — [4]Department of Physics, Oklahoma State University, Stillwater, OK, USA

We propose a method for generating symmetric Dicke states (like e.g. W states) of distant particles. Unlike former proposals, ours is capable of producing Dicke states of an arbitrary number of particles based on linear optics and photodetection.

In particular, we consider a chain of stored ions in a Paul trap or, equivalently, a chain of neutral trapped atoms, where each of them is driven in a Λ-configuration. All atoms are initially excited into the upper state and the spontaneously emitted photons are recorded by single photodetectors. In front of each detector a polarization analyzer determines the polarization state of the registered photon. We show that for generating a particular Dicke state there exists, at least, one suitably designed geometry of non-local detection events that will enforce that particular outcome in the long-lived atomic state.

The proposed probabilistic scheme does not require auxiliary systems like the use of collective motional degrees of freedom, or single cavity modes, and is feasible with current technology.

Q 7.4 Mo 15:45 5L

Trapped ion chain as a neural network: Error resistant quantum computation — Marisa Pons[1], Veronica Ahufinger[2,3], Christof Wunderlich[4], Anna Sanpera[2,5], •Sibylle Braungardt[6], Aditi SenDe[6], Ujjwal Sen[6], and Maciej Lewenstein[2,6] — [1]Departamento de Física Aplicada I, Universidad del País Vasco, 20600 Eibar, Spain. — [2]ICREA - Institució Catalana de Recerca i Estudis Avançats, Passeig Lluis Companys 23, E-08010 Barcelona, Spain*. — [3]Grup d*Optica, Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain. — [4]Fachbereich Physik, Universität Siegen, 57068 Siegen, Germany. *Fachbereich Physik, Universität Siegen, 57068 Siegen, Germany. — [5]Grup de Física Teòrica, Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain. — [6]ICFO-Institut de Ciències Fotòniques, 08860 Castelldefels (Barcelona), Spain.

We consider experimentally feasible chains of trapped ions with pseudo-spin half, and *nd models that can potentially be used to implement error resistant quantum computation. We consider protocols for implementing a universal set of quantum logic gates in the system, by adiabatic passage of a few low-lying energy levels of the whole system. We show that the *delity of the computation remains virtually unchanged when introducing noise to the system, if the noise is not too strong. The noise resistance of the system is achieved by encoding the qubits distributed over the whole system, and is similar in spirit to that of classical neural networks.

Q 8: Festkörperlaser II

Zeit: Montag 14:00–14:30 Raum: 5K

Q 8.1 Mo 14:00 5K

Spektroskopische Charakterisierung von Er^{3+}- und Er^{3+}, Yb^{3+}-dotierten Sesquioxidschichten für Laseranwendungen — •Andreas Kahn, Matthias Fechner, Nils-Owe Hansen, Henning Kühn, Yury Kuzminykh, Hanno Scheife und Günter Huber — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg

Mittels Pulsed Laser Deposition (PLD) wurden auf Saphirsubstraten hochtexturierte Er^{3+}- und Er^{3+}, Yb^{3+}-dotierte Y_2O_3- und Sc_2O_3-Schichten hergestellt. Spektroskopische Untersuchungen dieser Schichten ergaben Emissionswirkungsquerschnitte, die in der Größenordnung mit denen von entsprechenden Volumeneinkristallen übereinstimmen. Insbesondere wurden bei den für Telekommunikationsanwendungen interessanten Laserwellenlängen um 1.55 μm Emissionswirkungsquerschnitte von $10^{-20}\,cm^2$ erreicht. Da auch die Fluoreszenzlebensdauer des entscheidenden $^4I_{13/2}$-Niveaus bis zu 8 ms betrug, die Oberflächenrauigkeit (RMS) typischerweise unter 3 nm lag und sich das Materialsystem aufgrund des Brechungsindexunterschieds zur Wellenleitung eignet, ist die Realisierung eines planaren Wellenleiterlasers geplant. Desweiteren steht mit der PLD aufgrund der guten Übereinstimmung der Schichtspektren mit denen von Volumeneinkristallen eine effiziente Methode zur Herstellung von Materialproben für spektroskopische Messungen (z.B. an Konzentrationsreihen) zur Verfügung.

Q 8.2 Mo 14:15 5K

Erhöhung der Strahldichte im Laseroszillator und Verstärker durch den Einsatz von kerndotierten Nd:YAG Keramikstäben — •Alexander Strässer und Martin Ostermeyer — Universität Potsdam, Am neuen Palais 10, 14469 Potsdam

Das transversale Pumpen von Laserstäben ist eine geeignete einfache und robuste Pumpgeometrie für die Erzeugung von Nanosekundenpulsen mit Energien im Joulebereich. Aufgrund der geringeren Intensität der Außenbereiche des Gaußprofils ist es allerdings schwierig die gespeicherte Energie an den Rändern des Stabes effizient zu extrahieren. Ein größerer Strahldurchmesser erlaubt eine bessere Extraktion führt aber zu einer stärkeren Beugung an der Apertur des Stabes. In diesem Beitrag wird untersucht inwiefern mit kerndotierten Nd:YAG Keramik Stäben, dieses Problem umgangen werden kann. Ein durch einen kerndotierten Stab propagierender Strahl mit gaußförmigen Intensitätsprofil kann somit die Inversion effizienter nutzen ohne an der Apertur des Stabes Beugung zu erfahren. Ein herkömmlicher Kristall wurde mit zwei kerndotierten Keramikstäben verglichen. Die Stäbe wurden in Hinblick auf ihre thermische Linse, thermisch induzierte Doppelbrechung, Verluste und Effizienz hin untersucht. Außerdem kam bei den Verstärkungsexperimenten ein phasenkonjugierender Spiegel zum Einsatz um den Phasensprung, der durch den unterschiedlichen Brechungsindex von dotierten und undotierten Material entsteht, zu kompensieren. Beim Einsatz der kerndotierten Keramikstäbe in einem Laseroszillator und einem Verstärker konnte die Strahldichte jeweils um einen Faktor 2 verbessert werden.

Q 9: Halbleiterlaser

Zeit: Montag 14:30–15:30 Raum: 5K

Q 9.1 Mo 14:30 5K

Passively mode-locked semiconductor disk laser with graded and step indices — •Florian Saas[1], Günter Steinmeyer[1], Uwe Griebner[1], Martin Zorn[2], and Markus Weyers[2] — [1]Max-Born-Institut, Max-Born-Strasse 2a, D-12489 Berlin, Germany — [2]Ferdinand-Braun-Institut, Gustav-Kirchhoff-Str.4, D-12489 Berlin, Germany

We report generation of sub-picosecond pulses with an optically-pumped semiconductor disk laser (SCDL), passively mode-locked by a semiconductor saturable absorber (SAM). For this purpose, we investigate different InGaAs-QW-gain structures, both, based on step index (STIN) and graded index (GRIN) [1] designs. Pulses with durations as short as 590 fs and 2.9 ps were achieved, respectively. The mode-locked SCDLs were diode-pumped at 800 nm and delivered about 30 mW of output power. The emission was centered at a wavelength of 1040 nm, and the repetition rate amounted to 3 GHz for both laser oscillators. The dispersion characteristics of the utilized semiconductor structures were calculated and measured, and their influence on the pulse generation is discussed. Furthermore, we quantitatively characterized spectral tuning of the exciton resonance of the InGaAs-QW SAM, exploiting the AC-Stark-effect for quasi-instantaneous pulse shaping.
[1] F. Saas et al., Appl. Phys. Lett. **89**, 151120 (2006).

Q 9.2 Mo 14:45 5K

Ultraschnelle Ladungsträgerdynamik in Hochleistungs-Halbleiterverstärkern — •Thorsten Ulm, Harry Fuchs, Johannes L'huillier und Richard Wallenstein — Technische Universität Kaiserslautern, Fachbereich Physik, Erwin-Schrödinger-Straße 46, 67663 Kaiserslautern

Hochleistungs-Halbleiterverstärker stellen eine Schlüsselkomponente beim Aufbau rein halbleiter-basierter fs-Strahlquellen dar. Sie sind aufgrund ihrer großen spektralen Bandbreite, Effizienz und Kompaktheit eine Alternative zu fs-Lasersystemen auf Titan-Saphir-Basis. Im Gegensatz zu Festkörperverstärkern wirken sich nichtlineare Effekte in Halbleiterverstärkern allerdings deutlich stärker auf die zeitlich-spektrale Pulsform aus. Im Hinblick darauf wurden Pulse von 2 ps und 130 fs Dauer in Halbleiterverstärkern mit Trapezgeometrie verstärkt und die zeitlichen und spektralen Eigenschaften der emittierten Pulse untersucht. Als Strahlquelle mit definierten zeitlichen und spektralen Eigenschaften wurde ein Titan-Saphir-Laser eingesetzt. Die elektrisch gepumpten Verstärker aus InGaAs wurden für eine Zentralwellenlänge von 920 nm gefertigt. Sie besitzen eine 750 μm lange *ridge-waveguide*-Sektion und eine 2 mm lange Trapez-Sektion mit 200 μm breiter Austrittsfacette, die eine gute räumliche Strahlqualität gewährleistet. Es wurden Untersuchungen zur *Chirped Pulse Amplification* mit Halbleiterverstärkern durchgeführt. 130 fs lange Pulse wurden auf 14 ps gestreckt und unter Beibehaltung eines gaußförmigen Spektrums verstärkt. Das Zeit-Bandbreite-Produkt der komprimierten Pulse liegt nur 10% über dem theoretischen Limit.

Q 9.3 Mo 15:00 5K

Untersuchungen zum zeitlichen Emissionsverhalten einer Breitstreifen Laserdiode im externen Resonator — •Danilo Skoczowsky, Axel Heuer und Ralf Menzel — Universität Potsdam, Institut für Physik, Lehrstuhl Photonik, Am Neuen Palais 10, 14469 Potsdam

Es werden Untersuchungen zum zeitlichen und spektralen Emissionsverhaltens einer Breitstreifen Laserdiode präsentiert. Die Laserdiode wird im externen Resonator betrieben, mit dem auf das spektrale und transversale Emissionsverhalten Einfluß genommen wird. Mittlere Ausgangsleistungen über 300 mW bei sehr guter Strahlqualität mit M2 $< 1{,}5$ wurden erreicht. Der Laser zeigt bei Erhöhung des Pumpstromes einen Übergang von longitudinalem Monomodebetrieb kurz über Schwelle zu Multimodebetrieb bei höherem Pumpstrom. Dies korrespondiert mit einer Veränderung des zeitlichen Emissionsverhaltens von cw zu gepulster Emission.

Aufbauend auf ersten Untersuchungen dieses Effekts mit Hilfe einer Streakkamera werden systematische Untersuchungen präsentiert, die mit einem Autokorrelator durchgeführt wurden. Der Pumpstrom wurde bei fester Resonatorlänge variiert, ebenso wie die Resonatorlänge bei konstantem Pumpstrom. Weiterhin wurde das Emissionsverhalten des Lasers bei verschiedenen Resonatorkonfigurationen untersucht.

Bisher konnten Pulse mit 25 ps Dauer und einer Wiederholrate von 2,6 GHz erzeugt werden. Bei einer mittleren Leistung von 311 mW ergibt sich eine Pulsenergie von 170 pJ und eine Pulsspitzenleistung von 4,7 W.

Q 9.4 Mo 15:15 5K

Kompakte durchstimmbare blaue Laserstrahlquellen bei 488 nm auf der Basis von frequenzverdoppelten Breitstreifenlaserdioden — •Andreas Jechow, Danilo Skoczowsky und Ralf Menzel — Universität Potsdam, Institut für Physik, Lehrstuhl für Photonik, Am Neuen Palais 10, 14469 Potsdam

Die Entwicklung von periodisch gepolten Kristallen wie Lithiumniobat (PPLN) ermöglicht effiziente single-pass Frequenzverdopplung (SHG) bei mittleren Leistungsdichten.

Breitstreifenlaserdioden (BAL) sind aufgrund ihrer geringen Brillanz für SHG nicht geeignet; durch die Verwendung von V-förmigen externen Resonatoren ist es jedoch möglich ihre Emissionseigenschaften deutlich zu verbessern.

Eine im externen Resonator betriebene infrarote BAL liefert beugungsbegrenztes, schmalbandiges und durchstimmbares Licht mit bis zu 1 Watt cw-Leistung, welches mithilfe von PPLN Kristallen in den sichtbaren Spektralbereich frequenzverdoppelt wird.

Bei einer Zentralwellenlänge von 488 nm konnten Leistungen von bis zu 30 mW bei exzellenter Strahlqualität und schmalbandiger Emission erzielt werden. Im Gegensatz zu den frequenzverdoppelten Festkörperlasern ist das Laserlicht im sichtbaren Wellenlängenbereich durchstimmbar.

Q 10: Nichtlineare optische Effekte und Lichtquellen II

Zeit: Montag 14:00–16:00 Raum: 5J

Q 10.1 Mo 14:00 5J

Aktive Stabilisierung eines Femtosekunden OPO mit 1GHz Repetitionsrate über die Signal- und Idler-Frequenzkämme — •Raphael Gebs[1], Thomas Dekorsy[1] und Albrecht Bartels[2] — [1]Fachbereich Physik und Center for Applied Photonics, Universität Konstanz, 78457 Konstanz — [2]Gigaoptics GmbH, 78462 Konstanz

Untersucht wird ein synchron gepumpter optisch parametrischer Oszillator (OPO) basierend auf periodisch gepoltem Lithiumniobat (PPLN). Als Pumpquelle dient ein Kerr-Linsen modengekoppelter Ti:Saphir Laser mit einer Repetitionsrate von 1 GHz, Pulslänge ca. 25fs und Zentral-Wellenlänge von 800nm. Die Signal Lichtpulse haben eine Pulslänge von ca. 100 fs und eine Zentral-Wellenlänge bei 1550nm. Der OPO wird nahe am Entartungspunkt betrieben, so dass die Frequenzkämme des Signals und Idlers überlappen. Zur aktiven Stabilisierung des OPO wird erstmals die Schwebungsfrequenz zwischen den Signal- und Idler- Frequenzkämmen bei ca. 1600 nm detektiert und an eine externe Radiofrequenz phasengekoppelt. Dadurch ist die relative Lage von Signal und Idler festgelegt und der OPO stabilisiert. Verbleibende Schwankungen der Signal Zentral-Wellenlänge liegen unterhalb der Auflösung des verwendeten Spektrometers (0.5 nm).

Q 10.2 Mo 14:15 5J

Möglichkeiten der Wellenlängenvariation in einem Doppelkristall-Optisch-Parametrischen Oszillator* — •Rosita Sowade, Ingo Breunig und Karsten Buse — Universität Bonn, Wegelerstr. 8, 53115 Bonn

Eine Möglichkeit, durchstimmbare Lichtpulse im Terahertzbereich (0.1-10 THz) zu erzeugen, ist ein sog. Doppelkristall-Optisch-Parametrischer-Oszillator (D-OPO), in dem zwei Signal-/Idlerwellen-Paare generiert werden und für eine Differenzfrequenzerzeugung zur Verfügung stehen [1]. Im Gegensatz zur Arbeit von Taniuchi et al. verwenden wir einen Dauerstrich-D-OPO. Es gibt verschiedene Varianten, den Frequenzunterschied der beiden Signal- oder Idlerwellen zu verändern: Einerseits kann dies durch zwei Kristalle mit gleicher Polungsperiode aber einem variablen Temperaturunterschied realisiert werden. In diesem Fall beobachten wir eine untere Grenze des Signalfrequenzabstandes von etwa 1 THz. Dessen Stabilität liegt bei 0.05 THz über einen Zeitraum von bis zu 40 s. Weiterhin ist es möglich, unterschiedliche Polungsstrukturen innerhalb eines Kristalls zu erzeugen. Bei einem solchen Kristall ist die Temperaturstabilisierung wesentlich einfacher. Wir untersuchen auch diese Variante auf Durchstimmbarkeit und Wellenlängenstabilität und vergleichen sie mit der ersten.

[1] T. Taniuchi, J. Shikata und H. Ito, Electron. Lett., 36, 1414-1416 (2000)

*Wir danken der Deutsche Forschungsgemeinschaft (FOR 557) und der Deutsche Telekom AG für die finanzielle Unterstützung.

Q 10.3 Mo 14:30 5J

Grenzen der Durchstimmbarkeit im Doppelkristall-Optisch-Parametrischen Oszillator — •Ingo Breunig, Rosita Sowade und Karsten Buse — Universität Bonn, Wegelerstr. 8, 53115 Bonn

Durchstimmbare Quellen für monochromatisches Licht im Terahertzbereich (0.1-10 THz) sind von großem wissenschaftlichen und technischen Interesse. Dafür werden verschiedene Ansätze verfolgt. Durch Photomischung oder die elektronische Frequenzvervielfachung ist es möglich, Frequenzen bis etwa 4 THz zu erzeugen. Um in den Bereich größer als 4 THz vorzudringen, bietet sich die optische Differenzfrequenzerzeugung an.

Wir verwenden einen Dauerstrich-Optisch-Parametrischen Oszillator, in dem zwei magnesiumdotierte periodisch gepolte Lithiumniobatkristalle mit nahezu gleicher Polungsperiode jeweils ein Signal-/Idlerwellen-Paar generieren. Das bietet die Möglichkeit, die Differenzfrequenz entweder der Signal- oder der Idlerwellen in einem dritten nichtlinearen Kristall zu erzeugen. Der Frequenzabstand der beiden Signalwellen kann durch Variation des Temperaturunterschieds der beiden Kristalle verändert werden. Dabei zeigt sich in unserem Aufbau eine untere Grenze der möglichen Differenzfrequenz von etwa 1 THz. Ein Modell, das die Kopplung der Verstärkungsprofile der einzelnen Kristalle beinhaltet, kann dieses Verhalten quantitativ beschreiben.

*Wir danken der Deutsche Forschungsgemeinschaft (FOR 557) und der Deutsche Telekom AG für die finanzielle Unterstützung.

Q 10.4 Mo 14:45 5J

Noncollinear optical parametric amplification of vacuum fluctuations, cw light, and continua — •Christian Homann, Markus Breuer, Stefan Lochbrunner, and Eberhard Riedle — LS für BioMolekulare Optik, LMU München

We have investigated a blue pumped two-stage noncollinear optical parametric amplifier that was operated in three different modes. In all cases we obtain μJ visible output at 1 kHz repetition rate. With seeding by a supercontinuum generated in a sapphire plate, broadband pulses with fluctuations in the 1% rms range are obtained. The spectrum is nearly structureless and highly reproducible from shot to shot. A single longitudinal mode cw laser (532 nm) renders as seed extremely clean 88 fs pulses, close to the Fourier limit given by the 6 nm bandwidth and the 170 fs pump pulse. The output does, however, fluctuate by about 30% due to the less than 500 seed photons per pulse. When neither the cw seed nor the continuum is used, the second amplifier stage is seeded by the parametric super-fluorescence generated in the first stage. This is the typical OPG/OPA configuration. The single shot spectral analysis shows that the spectrum is highly structured and varies from shot to shot dramatically and needs about 500 shots averaging to converge to a stable and smooth distribution. The width of each individual spectral structure is identical to the one found in cw seeding and the height varies largely. We conclude that we amplify individual photons out of the vacuum fluctuations and each amplification process starts at a different depth in the first amplifier crystal.

Q 10.5 Mo 15:00 5J

Erzeugung von sub 10 fs Pulsen mit einem MHz-NOPA — •Andy Steinmann, Anne Harth und Uwe Morgner — Institut für Quantenoptik, Leibniz Universität Hannover

Wir präsentieren einen nicht-kollinearen optischen parametrischen Verstärker (NOPA) mit einer Repetitionsrate von 1 MHz, der direkt mit einem Yb:KYW Laseroszillator mit Cavity-Dumping gepumpt wird. Der NOPA emittiert Pulse um 800 nm Zentralwellenlänge mit einer Energie von 45 nJ bei einer Pulsdauer unter 10 fs.

Das Potential zur Leistungsskalierung macht den MHz-NOPA zu einer interessanten Alternative zu herkömmlichen auf Titan:Saphir-Verstärkern basierenden Systemen, und viele Anwendungen wie die nichtlineare Mikroskopie oder Laserspektroskopie werden von dieser Technologie profitieren.

Q 10.6 Mo 15:15 5J

Second-Order Nonlinear Effects in Lithium Niobate Directional Couplers — •Anna Heidt[1], Roland Schiek[2], Thomas Pertsch[1], Arkadi Chipouline[1], Wolfgang Sohler[3], and Andreas Tünnermann[4] — [1]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743, Jena, Germany — [2]University of Applied Sciences Regensburg, Prüfeninger Str. 58, 93049 Regensburg, Germany — [3]Applied Physics, Universität Paderborn, 33095 Paderborn, Germany — [4]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Strasse 7, 07745 Jena, Germany

All-optical switching in coupled nonlinear optical waveguides [1, 2] has been investigated experimentally and theoretically. The experiments have been performed in a Ti-diffused Periodically Poled Lithium Niobate (PPLN) Z-cut crystal waveguides exhibiting high second order nonlinearity. All-optical switching up to 10 MHz for the C telecom band has been experimentally tested. Numerical code has been developed in order to evaluate the switching performance theoretically. A feasibility of the extrapolation on higher frequencies up to 10 GHz has been checked theoretically (experiments are ongoing). [1] R.Schiek, Y.Baek, G. Krijnen, G.I. Stegeman, I. Baumann, and W. Sohler, "All-optical switching in lithium niobate directional couplers with cascaded nonlinearity", Optics Lett., 21, July 1 (1996). [2] R. Schiek, R. Iwanow, G.I. Stegeman, T. Pertsch, F. Lederer Y. Hong Min, and W. Sohler, "Low-power, multiport, ultrafast, parametric switching in cascaded waveguide couplers", Appl. Phys. Lett., 87, 011109 (2005).

Q 10.7 Mo 15:30 5J

Nonlinear Effects in PPLN Waveguide Resonators — •Reinhard Geiss[1], Roland Schiek[2], Thomas Pertsch[1], Arkadi

Chipouline[1], Wolfgang Sohler[3], and Andreas Tünnermann[4] — [1]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743, Jena, Germany — [2]University of Applied Sciences Regensburg, Prüfeninger Str. 58, 93049 Regensburg, Germany — [3]Applied Physics, Universität Paderborn, 33095 Paderborn, Germany — [4]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Strasse 7, 07745 Jena, Germany

The dissipative nature of the optical resonators requires loss compensation through some pump process. The nonlinear response of the resonator in combination with the feedback causes a bunch of new effects, including multistability and pattern formation [1, 2]. In this work the nonlinear effects have been investigated in resonators formed in Periodically Poled Lithium Niobate (PPLN) exhibiting strong second order nonlinearity. The final goal of the tests is to demonstrate fast memory operations in optical waveguide resonators based on PPLN samples. A theoretical model has been developed in order to estimate the influence of different parameters on the system performance. Theoretical predictions have been compared with the experimental results.

[1] U. Peschel, D. Michaelis, and C. O.Weiss, "Spatial solitons in optical cavities", IEEE J. Quantum Electron., 39, 51-64 (2003).

[2] C. Etrich, U. Peschel, and F.Lederer, "Solitary waves in quadratically nonlinear resonators", Phys. Rev. Let., 29, 2454-2457 (1997).

Q 10.8 Mo 15:45 5J

Spektroskopie an Rubidiumzellen bei 400 bar Puffergasdruck: auf dem Weg zum thermischen Gleichgewicht von gekoppelten Atom-Licht-Zuständen? — •Ulrich Vogl und Martin Weitz — Institut für Angewandte Physik, Wegelerstraße 8, 53115 Bonn

Bei üblichen Experimenten der Atomphysik liegt die beobachtete Fluoreszenzlinienbreite um viele Größenordnungen unterhalb der Raumtemperatur, so dass das Anregungsprofil weitgehend unbeeinflusst von der statistischen Verteilungsfunktion ist. Wir berichten über Experimente, bei denen durch 400 bar Puffergasdruck in einer Hochdruckzelle eine Linienbreite von einigen Nanometern für die Rubidium D-Linien erreicht wird. Bei hoher Lichtleistung des anregenden Laserlichts werden die Resonanzlinien durch zusätzliche Leistungsverbreiterung bis auf Werte oberhalb von kT verbreitert. In diesem Parameterbereich beobachten wir eine starke Asymmetrie der Fluoreszenzlinien, wobei die blaue Flanke der Linien stark überhöht ist. Wir interpretieren die Messdaten als Hinweis darauf, dass die gekoppelten Atom-Licht-Zustände ("dressed states") zunehmend ins thermische Gleichgewicht gelangen, wobei die Thermalisierung durch Atom-Puffergas-Stöße erfolgt. Wir erwarten an diesem neuartigen Hochdrucksystem längerfristig vielfältige Untersuchungen zur kollektiven Dynamik hybrider Atom-Licht-Quasiteilchen (Polaritonen) durchführen zu können.

Q 11: Quanteneffekte (QED)

Zeit: Montag 14:00–16:00 Raum: 5E

Gruppenbericht Q 11.1 Mo 14:00 5E

Observing the quantum jumps of light: birth and death of a photon in a cavity — •Stefan Kuhr[1,2], Sébastien Gleyzes[2], Christine Guerlin[2], Julien Bernu[2], Ulrich Hoff[2], Michel Brune[2], Jean-Michel Raimond[2], and Serge Haroche[2,3] — [1]Institut für Physik, Johannes Gutenberg Universität, Staudingerweg 7, D-55128 Mainz — [2]LKB, Ecole Normale Supérieure, 24 rue Lhomond, F-75231 Paris Cedex 05 — [3]Collège de France, 11 place Marcelin Berthelot, F-75231 Paris Cedex 05

A microscopic system under continuous observation exhibits at random times sudden jumps between its states. Quantum jumps of trapped massive particles (electrons, ions or molecules) have already been observed, which is not the case of the jumps of light quanta. Here we report on the first observation of photon number quantum jumps [1]. Microwave photons are stored in a superconducting cavity for times in the second range [2]. They are repeatedly probed by a stream of non-absorbing atoms. An atom interferometer measures the atomic dipole phase shift induced by the non-resonant cavity field, so that the final atom state reveals directly the presence of a single photon in the cavity. Sequences of hundreds of atoms highly correlated in the same state, are interrupted by sudden state-switchings. These telegraphic signals record, for the first time, the birth, life and death of individual photons.

[1] S. Gleyzes *et al.*, Nature (to be published), quant-ph/0612031.

[2] S. Kuhr *et al.*, quant-ph/0612138.

Q 11.2 Mo 14:30 5E

An analogy to Cavity QED in scattering-induced modal coupling in a microsphere resonator — •Andrea Mazzei[1], Leonardo Menezes[2], Stephan Götzinger[3], Vahid Sandoghdar[3], and Oliver Benson[1] — [1]Humboldt Universität zu Berlin - AG Nanooptik, Hausvogteiplatz 5-7, 10117 Berlin — [2]Departamento de Fìsica, Universidade Federal de Pernambuco, Brazil — [3]Laboratory of Physical Chemistry, ETH Zürich - Switzerland

The basic system to study in Cavity QED is a single dipole emitter interacting with a single mode of an optical cavity. In a coupled system with damping, two main regimes can be distinguished: in the *strong coupling regime* the dynamics between, e.g. an atom and a cavity, is reversible: Rabi oscillations and mode splitting are observed. In the *weak coupling regime* the interaction with a continuum of states results in an irreversible decay of the dipole. In this paper we introduce an analogy between CQED effects (atom and cavity) and the modal coupling of high-Q modes in an optical microresonator induced by a Rayleigh scatterer. In our experiments a scanning probe is used as a controllable Rayleigh scatterer, which can be positioned with nanometer precision in the whispering-gallery modes of a microsphere resonator. By moving the scanning probe into the mode, the modal coupling constant can be controlled and the transition from weak to strong coupling was observed: the resonance splits into a doublet, with a frequency splitting proportional to the coupling rate. The developed theoretical analogy gives also an explanation for the surprisingly large modal splitting previously reported by other groups.

Q 11.3 Mo 14:45 5E

Signatures of the Unruh effect from electrons accelerated by ultra-strong laser fields — •Ralf Schuetzhold[1], Gernot Schaller[1], and Dietrich Habs[2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Department für Physik der Ludwig-Maximilians-Universität München und Maier-Leibnitz-Laboratorium, Am Coulombwall 1, 85748 Garching, Germany

We calculate the radiation resulting from the Unruh effect for strongly accelerated electrons and show that the photons are created in pairs whose polarizations are perfectly correlated. Apart from the photon statistics, this quantum radiation can further be discriminated from the classical (Larmor) radiation via the different spectral and angular distributions. The signatures of the Unruh effect become significant if the external electromagnetic field accelerating the electrons is not too far below the Schwinger limit and might be observable with future facilities. Finally, the corrections due to the birefringent nature of the QED vacuum at such ultra-high fields are discussed.

Q 11.4 Mo 15:00 5E

Body-assisted van der Waals interaction between two atoms — •Hassan Safari[1], Stefan Yoshi Buhmann[1], Dirk-Gunnar Welsch[1], and Ho Trung Dung[2] — [1]Theoretisch-Physicalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien Platz 1, 07743 Jena, Germany — [2]Institute of Physics, Academy of Sciences and Technology, 1 Mac Dinh Chi Street, District 1, Ho Chi Minh City, Vietnam

It is well known that the vacuum fluctuations of the electromagnetic field can cause an interaction between electrically neutral, but polarizable particles, commonly referred to as the van der Waals (vdW) interaction. When the two atoms are not in free space, but placed within a nontrivial magnetoelectric environment, then the vdW interaction can be substantially modified.

Using fourth-order perturbation theory, a general formula for the vdW interaction potential between two neutral, electrically polarizable, ground-state atoms in the presence of an arbitrary arrangement of magnetoelectric bodies is derived. The theory is applied to two atoms in the presence of a planar multilayer system (with special emphasis on the perfectly reflecting plate and half space) and in the presence of a sphere. It is shown that in the nonretarded limit, the modification of the vdW interaction due to the presence of a perfectly reflecting plate

can be understood by using the method of image charges.

Q 11.5 Mo 15:15 5E

Light-by-light diffraction — •Antonino Di Piazza, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The influence of a strong optical standing wave into the propagation of an x-ray probe is calculated in the framework of nonlinear quantum electrodynamics. It is shown that the procedure usually followed, to assign to vacuum a refractive index different from unit due to vacuum polarization effects, is a too crude approximation because of the tight focusing of the strong field. After the interaction a linearly polarized x-ray probe becomes elliptically polarized with the main axis of the ellipse rotated with respect to the initial polarization direction. The obtained ellipticity and the polarization rotation angle are shown to be in principle measurable [1].

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. **97**, 083603 (2006). See also hep-ph/0602039.

Q 11.6 Mo 15:30 5E

Temperature dependence of the Casimir-vdWaals potential — •Lodewijk Arntzen — arntzen@physi.uni-heidelberg.de

The temperature dependence of the Casimir-vdWaals potential will be discussed. For the system He-Si, the Casimir-vdWaals potential is explicitly calculated using a model for the polarizability of the helium atom, and a model for the dielectric function of silicon. Experimental access is obtained with the Atomic Beam Spin Echo (ABSE) spectrometer by quantum reflecting cold ^{3}He atoms from a Si(111) surface. The temperature of the surface is varied between 300K and 1200K. It is found that the quantum reflectivity drops approximately with a factor 3 in this temperature range. It is shown that a potential term proportional to T and r^{-3} is needed to describe the data, and its value is compared with the zero frequency term from the Lifshitz theory.

Q 11.7 Mo 15:45 5E

Dynamical theory of Casimir-Polder forces — •Stefan Yoshi Buhmann and Dirk-Gunnar Welsch — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

The Casimir-Polder force experienced by a single atom in the presence of magnetoelectric bodies is a well-known consequence of QED. In contrast to the common static approaches often used to study forces on ground-state atoms, we employ a genuinely time-dependent approach in order to account for the nontrivial dynamics arising for initially excited atoms. Starting from the operator-valued Lorentz force, a general formula for the dynamical Casimir-Polder force is presented, which can be further evaluated by solving the coupled atom-field dynamics.

For weak coupling the Markov approximation can be used to show that the Casimir-Polder force on an initially excited atom can be written as a linear combination of components whose dynamics follows that of the associated atomic density-matrix elements. Strong atom-field coupling may arise if an atom near-resonantly interacts with a narrow quasimode of the body-assisted electromagnetic field, leading to a reversible exchange of excitation between the atom and the field mode. Assuming that the atom-mode system initially shares a single excitation, it is found that the resulting Casimir-Polder force undergoes damped Rabi oscillations, where both amplitude and mean value of the oscillations depend on the initial state.

Q 12: Quantengase (Unordnung)

Zeit: Montag 16:30–18:30 Raum: 6J

Q 12.1 Mo 16:30 6J

Disorder Induced Shift of Condensation Temperature for Dilute Trapped Bose Gases — •Matthias Timmer, Axel Pelster, and Robert Graham — Fachbereich Physik, Universität Duisburg-Essen. Lotharstraße 1, 47048 Duisburg, Germany

We determine the leading shift of the Bose-Einstein condensation temperature for an ultracold dilute atomic gas in a harmonic trap due to weak disorder by treating both a Gaussian and a Lorentzian spatial correlation for the quenched disorder potential. Increasing the correlation length from values much smaller than the geometric mean of the trap scale and the mean particle distance to much larger values leads first to an increase of the positive shift to a maximum at this critical length scale and then to a decrease.

Q 12.2 Mo 16:45 6J

Mean-Field Phase Diagram of Disordered Bosons in a Lattice at Non-Zero Temperature — Konstantin Krutitsky, •Axel Pelster, and Robert Graham — Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

Bosons in a periodic lattice with on-site disorder at low but non-zero temperature are considered within a mean-field theory [1]. The criteria used for the definition of the superfluid, Mott insulator and Bose glass are analysed. Since the compressibility does never vanish at non-zero temperature, it cannot be used as a general criterion. We show that the phases are unambiguously distinguished by the superfluid density and the density of states of the low-energy exitations. The phase diagram of the system is calculated. It is shown that even a tiny temperature leads to a significant shift of the boundary between the Bose glass and superfluid.

[1] K.V. Krutitsky, A.Pelster, and R.Graham, New J.Phys. **8**, 187 (2006)

Q 12.3 Mo 17:00 6J

Thermodynamics of a Bose-Einstein Condensate with Weak Disorder — •Giovanni Falco, Axel Pelster, and Robert Graham — Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We determine the thermodynamic properties of a homogeneous superfluid dilute Bose gas in presence of weak quenched disorder. To this end we extend the Bogoliubov theory of Huang and Meng [1] to finite temperatures by applying both the Popov and the many-body T-Matrix approach. Within a high-temperature approximation we derive self-consistent equations for the temperature dependence of both the condensate density and the s-wave scattering length which generalize the theory of Ref. [2]. Their solution allows to calculate how the temperatures T_c and T_s, which characterize the onset of Bose-Einstein condensation and superfluidity, respectively, depend on the strengths of disorder and contact interaction.

[1] K. Huang and H.F. Meng, Phys. Rev. Lett. **69**, 644 (1992)

[2] A.V. Lopatin and V.M. Vinokur, Phys. Rev. Lett. **88**, 235503 (2002)

Q 12.4 Mo 17:15 6J

Bogoliubov excitations in 2D disordered Bose-Einstein condensates — •Christopher Gaul and Cord Müller — Universität Bayreuth

We consider a 2D–Bose–Einstein–Condensate in a disordered potential. In a first step we calculate the condensate density for different types of disorder using the Gross–Pitaevskii equation. In a second step we determine the disorder–broadened dispersion relation for elementary excitations using diagrammatic perturbation theory and calculate relevant transport coefficients.

Q 12.5 Mo 17:30 6J

Bose-Einstein Condensates in Disordered Lattice Potentials — •Sascha Drenkelforth, Thomas Schulte, Georg Kleine Büning, Wolfgang Ertmer, and Jan Arlt — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

Optical lattices are excellent tools to probe the nature of quantum degenerate Bose gases and serve as an ideal testing ground for theories originating in condensed matter physics. The addition of small pseudorandom potentials can disturb ideal lattice configurations and allows for the introduction of disorder in the experimental system. Depending on the experimental parameters this disorder is predicted to lead to the formation of new phases in the strongly interacting and the weakly interacting case. In the weakly interacting regime an observation of non-trivial localization effects and a full analysis including

the interplay of interactions and localization in the system is still outstanding.

We will report on the realization of a disordered lattice and discuss the effect of the nonlinear interactions and the shape of the disorder potential in detail. The investigation of transport phenomena is of particular relevance for the understanding of disordered potentials in the solid state case. We have therefore addressed the use of Bloch oscillations as a probe of the disorder in our system. We will present our theoretical results on these Bloch oscillations in disordered optical lattice potentials

Q 12.6 Mo 17:45 6J

Transport of Bose-Einstein condensates through two-dimensional disorder potentials — •Michael Hartung, Klaus Richter, and Peter Schlagheck — Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

The rapid progress in the experimental techniques for Bose-Einstein condensates permits detailed studies of mesoscopic transport dynamics of interacting matter waves with rather high accuracy and high flexibility in the control of parameters. We particularly focus on the transport of a Bose-Einstein condensate through a two-dimensional disorder potential. To this end we developed, in analogy with our previous study on one-dimensional condensate transport [1], a two-dimensional numerical method to simulate the time-dependent propagation process within the mean-field approximation of the condensate. We discuss the influence of the repulsive atom-atom interaction on the transport process of the condensate, and focus here in particular on the phenomena of coherent backscattering and weak localization.

[1] T. Paul, P. Leboeuf, N. Pavloff, K. Richter, and P. Schlagheck Phys. Rev. A **72**, 063621 (2005)

Q 12.7 Mo 18:00 6J

From superfluidity to Anderson-localization in quasi 1d Bose-Einstein condensates. — •Tobias Paul, Patricio Leboeuf, and Nicolas Pavloff — Laboratoire de Physique Théorique et Modèles Statistiques, Universite Paris Sud, Batiment 100, F-91405 Orsay Cedex

The interplay between particle-particle interactions and disorder-induced interference effects is a challenging aspect of condensed matter physics, which is due to the advent of coherent atom manipulation nowadays revisited in guided Bose-Einstein condensates [1,2]. In this contribution we present a new, global analysis of the coherent condensate flow through a disordered region. We show that a variation of the condensate velocity v with respect to the disordered potential induces different regimes of quantum transport. We demonstrate the existence of three different regimes: At velocities v small compared to the sound velocity c the flow shows superfluid behaviour, whereas a domain of time dependent flow is reached when v becomes comparable to c. For velocities considerably larger then the sound velocity again a stationary regime is found. In this domain, depending of the extent of the disordered region, the system enters an Anderson localized phase.

[1] D. Clement *et al.* Phys. Rev. Lett. **95**, 170409 (2005)
[2] T. Schulte *et al.* Phys. Rev. Lett. **95**, 170411 (2005)

Q 12.8 Mo 18:15 6J

Anderson localization in guided beams of Bose condensed atoms — •Tobias Paul[1], Patricio Leboeuf[1], Peter Schlagheck[2], and Nicolas Pavloff[1] — [1]Laboratoire de Physique Théorique et Modèles Statistiques, Universite Paris Sud, Batiment 100, F-91405 Orsay Cedex — [2]Institut für Theoretische Physik, Universität Regensburg, D–93040 Regensburg

Recently the influence of atom-atom interactions on the phenomenon of Anderson localization has been investigated by a series of experimental [1] and theoretical studies [2,3] on BEC systems. Following up these works, the objective of this contribution is to demonstrate that the scenario of Anderson localization is preserved in a quasi 1D coherent beam of weakly interacting Bose condensed atoms. For that purpose we study the coherent flow of a condensate through a disordered potential formed by a series of uncorrelated delta scatterers. This particular disorder model allows an analytical treatment within which we recover the well known picture of Anderson localization, with a rescaled localization length in the presence of a weak atom-atom interaction. Complementary numerical computations indicate that this behaviour is generic and does not depend on the specific structure of the disordered potential.

[1] D. Clement *et al.* Phys. Rev. Lett. **95**, 170409 (2005)
[2] B. Damski *et al.* Phys. Rev. Lett. **91**, 080403 (2003)
[3] T.Paul, *et al.* Phys. Rev. A **72**, 063621 (2005)

Q 13: Präzisionsmessungen I

Zeit: Montag 16:30–18:30 Raum: 5L

Gruppenbericht Q 13.1 Mo 16:30 5L

Atomic microwave clocks at accuracy of 10^{-16} — •P. Rosenbusch[1], S. Bize[1], F. Chapelet[1], C. Lacroute[1], Ph. Laurent[1], J. Reichel[2], F. Reinhard[1,2], D. Rovera[1], G. Santarelli[1], and A. Clairon[1] — [1]SYRTE, Observatoire de Paris, 61 Av. de l'Observatoire, 75014 Paris, France — [2]LKB, Ecole Normale Supérieure, 24 rue Lhomond, 75005 Paris, France

Today's best microwave clocks are atomic fountains. About 10^9 atoms are laser cooled to 1μK and launched up vertically, where they pass through a microwave cavity. This Ramsey interrogation leads to a 1 Hz FWHM of the central fringe [S. Bize *et al.*, J. Phys. B vol. 38, S449 (2005)]. Since 2006 the SYRTE disposes of three fountain clocks operating quasi-continuously, among other thanks to a new interference-filter stabilised laser system [X. Baillard *et al.*, Opt. Comm., vol. 266, 609 (2006)]. Two fountains exhibit a relative stability of $2 \cdot 10^{-14}$ at 1 s and an accuracy in the low 10^{-16}. A comparison between the fountains gave a statistical frequency resolution of a few 10^{-17} and an offset within the systematic uncertainties. Smaller microwave clocks may not reach the same performances but may well be the solution where transportability is required. The new project TACC (Trapped Atom Clock on a Chip) building on the demonstration experiment [P. Treutlein *et al.*, Phys. Rev. Lett., vol. 92, 203005 (2004)] aims at a stability of a few 10^{-13} at 1 s while being of breadboard size. TACC will be able to operate with magnetically trapped thermal atoms or a Bose-Einstein condensate, thereby being one of the first experiments to use condensates in a metrological apparatus.

Q 13.2 Mo 17:00 5L

Michelson-Interferometer mit diffraktivem Strahlteiler — •Daniel Friedrich, Alexander Bunkowski, Oliver Burmeister, Michael Britzger, Karsten Danzmann und Roman Schnabel — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Institut für Gravitationsphysik, Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover

Rein-reflektive Interferometertopologien ermöglichen die Vermeidung von thermooptischen Effekten in transmitierten Optiken und die Reduzierung von thermischem Rauschen. Für die Empfindlichkeitssteigerung hochpräziser Laserinterferometer wird daher der Einsatz von dielektrischen Reflexionsgittern erforscht.

Die Ersetzung des zentralen 50/50-Strahlteilers in einem Michelson-Interferometer durch ein speziell angefertigtes dielektrisches Reflexionsgitter wurde untersucht und experimentell umgesetzt. Über die Leistungsüberhöhung durch einen zusätzlichen Spiegel vor dem Interferometer („Power-Recycling“) konnten die optischen Gesamtverluste des Gitterstrahlteilers zu $\approx 0,1\%$ bestimmt werden. Die Konzepte und experimentelle Realisierung werden in diesem Beitrag vorgestellt.

Q 13.3 Mo 17:15 5L

A new Apparatus for a Precision Test of the Isotropy of the Speed of Light using ULE Optical Resonators — •Ch. Eisele[1], A. Yu. Nevsky[1], M. Okhapkin[1,2], and S. Schiller[1] — [1]Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf — [2]Institute for Laser Physics, Novosibirsk, Russia

Over the past years several Michelson-Morley-type experiments have been performed [1-4], utilising either optical or microwave resonators, which lead to strong constraints on possible violations of Local Lorentz Invariance (LLI) for electromagnetic waves.

We will report on the development of a new apparatus for an improved test of LLI. Our experimental approach is based on orthogonal high-finesse optical resonators, embedded in a rectangular ULE (ultra-

low expansion glass) block. The use of the monolithic construction, which possesses a certain value of common-mode rejection, reduces the sensitivity of the setup to external perturbations (temperature instability, mechanical vibrations, etc.). A monolithic Nd:YAG-laser is frequency stabilized to the cavities. The complete setup can be continuously rotated. The frequency of the beat signal between the two cavities is analysed as a function of orientation in space. A detailed characterisation of the systematic effects of the setup (tilt,laser power, etc.) and first experimental results will be presented.

[1]P.Antonini et al., Phys.Rev.A 71, 050202 (2005); S.Schiller et al., arXiv:physics/0510169 [2]P.L.Stanwix et al., Phys.Rev.Lett. 95, 040404 (2005) [3]S.Herrmann et al., Phys.Rev.Lett. 95, 150401 (2005) [4]P.L.Stanwix et al., Phys.Rev.D 74 (2006), 081101 (R)

Q 13.4 Mo 17:30 5L

A Test of Lorentz Invariance Using Rotating Optical High-Finesse Resonators — •Katharina Möhle, Sven Herrmann, Alexander Senger, Roberto Vannucchi, Evgeny Kovalchuk, and Achim Peters — Humboldt-Universität zu Berlin, Institut für Physik, AG Quantenoptik und Metrologie, Hausvogteiplatz 5-7, 10117 Berlin

We present an improved setup of a modern Michelson-Morley experiment testing Lorentz invariance in electrodynamics. Within a long-term measurement the experiment aims to investigate a hypothetical anisotropy of the speed of light at the level of 10^{-17}. The experiment compares the resonance frequencies of two crossed optical high-finesse resonators, implemented in a single block of fused silica and continuously rotating on a high-performance airbearing turntable. Besides common-mode rejection of cavity length fluctuations, the new setup further benefits from the use of an active vibration isolation, and a low level of systematic effects due to accurate control of rotation axis tilt. We report on the current status of the experiment and discuss the performance limiting role of thermal noise for cavities made from different materials.

Q 13.5 Mo 17:45 5L

Rauscharmer fs-Faserlaser mit 250 MHz Repetitionsrate für Frequenzkammanwendungen — •Tobias Wilken[1], Theodor W. Hänsch[1], Ronald Holzwarth[1,2], Peter Adel[2] und Michael Mai[2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Menlo Systems GmbH, Am Klopferspitz 19, 82152 Martinsried

Er^{3+}-dotierte Faserlaser eignen sich sehr gut zur effizienten Erzeugung von Frequenzkämmen für die Messung optischer Frequenzen. Gegenüber den mit Ti:Sa-Lasern erzeugten Frequenzkämmen hatten sie jedoch bisher zwei entscheidende Nachteile. Zum Einen erschwerte die relativ niedrige Repetitionsrate von 100 MHz oder weniger die Unterscheidung der einzelnen Kammmoden mit einem einfachen Wavemeter. Zum Anderen haben Faserfrequenzkämme ein relativ hohes Phasenrauschen der Carrier Envelope Offset (CEO) Frequenz.
Wir haben die Repetitionsrate durch einen sehr kompakten Aufbau und durch Nutzung hoch dotierter Er-Faser auf 250 MHz steigern können. Bei gleicher Pulsenergie steht damit im Vergleich zu früheren Systemen eine 2,5 fach höhere Leistung pro Mode zur Verfügung. Gleichzeitig können die einzelnen Kammmoden nun bequem mit einem Wavemeter unterschieden werden.
Das CEO-Phasenrauschen konnte von uns auf unter 500 mrad reduziert werden. Dazu haben wir eine Phasenstabilisierung mit einer Regelbandreite von über 100 kHz verwendet und zusätzlich das Regelsignal hochpassgefiltert um dem durch die Lebensdauer des oberen Laserniveaus bedingten Tiefpassverhalten des Systems entgegenzuwirken.

Q 13.6 Mo 18:00 5L

Präzisionsvergleiche optischer Frequenzstandards über einen 850 km langen Glasfaserlink — •Katharina Predehl[1], Ronald Holzwarth[1], Theodor Hänsch[1], Harald Schnatz[2], Gesine Grosche[2] und Burkhard Lipphardt[2] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Physikalisch Technische Bundesanstalt, Braunschweig

Mit Hilfe optischer Uhren lassen sich wesentlich kleinere Unsicherheiten und höhere Kurzzeitstabilitäten erreichen als mit Mikrowellennormalen. Um dieses Potenzial voll auszuschöpfen, ist es erforderlich, optische Uhren mit unterschiedlichen Frequenzen und an entfernten Standorten direkt miteinander vergleichen zu können. Die Physikalisch Technische Bundesanstalt (PTB) in Braunschweig und das Max-Planck-Institut für Quantenoptik (MPQ) in Garching untersuchen daher eine neue Methode zur Übertragung optischer Normale über weite Strecken. Im Gegensatz zu bisherigen Verfahren mittels Modulationstechniken soll die Frequenzinformation über einen 850 km langen Glasfaserlink direkt in Form eines trägerfrequenten cw Signals bei 195 THz (1,55 μm) übertragen werden. Um Genauigkeiten von besser als 10^{-15} zu erreichen, müssen z.B. Dämpfung, stimulierte Brillouinstreuung, Polarisationsmodendispersion, Verstärkerrauschen sowie akustische und thermische Einflüsse berücksichtigt werden. Diese Einflüsse werden zunächst in Laborexperimenten simuliert und die gewonnenen Erkenntnisse an einem ca. 50 km langen Glasfaserring um Braunschweig überprüft. Die Gesamtverbindung wird schrittweise aufgebaut und charakterisiert. Wir berichten über den Stand des Projektes.

Q 13.7 Mo 18:15 5L

Precision spectroscopy of singly ionized helium — •Valentin Batteiger, Maximilian Herrmann, Sebastian Knünz, Thomas Udem, and Theodor W. Hänsch — Max-Planck-Institut für Quantenoptik, Hans-Kopfermannstr. 1, 85748 Garching

The development of XUV frequency combs provides the opportunity for high resolution spectroscopy in the XUV regime. The 1s-2s two photon transition of hydrogen-like helium at 60 nm is an interesting candidate for precision tests of bound state QED. We discuss a spectroscopy scheme for singly ionized helium sympathetically cooled by co-stored magnesium ions in a segmented linear Paul trap. Our trap setup and the experimental progress is presented.

Q 14: Anwendung ultrakurzer Lichtimpulse I

Zeit: Montag 16:30–18:30 Raum: 5K

Q 14.1 Mo 16:30 5K

Oktavbreiter optischer Wellenform-Synthesizer — •Stefan Rausch, Thomas Binhammer, Emilia Schulz, Claudia Hoffmann und Uwe Morgner — Institut für Quantenoptik, Leibiz Universität Hannover, Deutschland

Die gezielte Manipulation der spektralen Phase eines ultrakurzen Laserpulses erlaubt die Formung seines zeitlichen Pulsprofils auf Femtosekunden-Zeitskalen. Dadurch eröffnen sich zahlreiche Anwendungen im Bereich der "kohärenten Quantenkontrolle".

Wir präsentieren ein Pulsformer-System bestehend aus einem ultra-breitbandigen Titan:Saphir-Laseroszillator, SPIDER und LCD-Pulsformer. Der Laseroszillator kommt ohne Prismen zur Dispersionskompensation aus. Das oktav-breite Spektrum unterstützt eine Fourier-limitierte Pulsdauer von etwa 4 fs und macht den Laser damit zur idealen Lichtquelle für Pulsformungsvorhaben. Es ist damit einerseits möglich, Fourier-limitierte Pulse zu erzeugen, andererseits können in Grenzen komplexere Pulssequenzen generiert werden, die z.B. im Bereich der Molekülspektroskopie Anwendung finden. So wurden z.B. zweifarbige Doppelpulse als Anrege- und Abfragepulse bei "Pump-Dump" Experimenten erfolgreich eingesetzt.

Die Erweiterung des Systems um einen Amplitudenformer erlaubt zusätzlich, die spektrale Amplitude selektiv zu beeinflussen, und ermöglicht zusammen mit der Phasenformung die Kontrolle über sämtliche Freiheitsgrade des Pulses. Somit ist ein echter "Wellenform-Synthesizer" realisiert, mit dem es möglich ist, beliebige Pulsformen und Sequenzen zu formen.

Q 14.2 Mo 16:45 5K

Evaneszente Kopplung in Systemen von Femtosekunden-Laser geschiebenen Wellenleitern — •Matthias Heinrich[1], Felix Dreisow[1], Alexander Szameit[1], Thomas Pertsch[1], Stefan Nolte[1] und Andreas Tünnermann[1,2] — [1]Friedrich-Schiller-Universität Jena, Institut für Angewandte Physik, Albert-Einstein-Str.15, 07745 Jena — [2]Fraunhofer Institut für Optik und Feinmechanik, Albert-Einstein-Str. 7, 07745 Jena

Die direkte Einschreibung von Wellenleitern in transparente Materialien eröffnet neue Wege im Design dreidimensionaler integriert optischer Bauelemente. Bedingt durch den Herstellungsprozess haben sol-

che Wellenleiterstrukturen meist kein radialsymmetrisches Profil und damit keine radialsymmetrische Mode. In Systemen von Wellenleitern resultiert daraus eine anisotrope Kopplung. Diese wird mit Hilfe einer neuen Messmethode quantifiziert. Insbesondere wird die Winkelabhängigkeit und die Dispersion der Koppelkonstanten aufgeführt. Weitergehend soll gezeigt werden, wie man die Anisotropie der Beugung in zweidimensionalen Wellenleiterarrays verändern kann.

Q 14.3 Mo 17:00 5K

New polarization pulse shaping techniques — •Stefan Martin Weber, Fabian Weise, Mateusz Plewicki, and Albrecht Lindinger — Institut f. Experimentalphysik, FU Berlin, Arnimallee 14, 14195 Berlin

The manipulation of the polarization state of femtosecond laser pulses is an emerging topic in the expanding field of coherent control. Such pulses are optimally suited for the interaction with real-world, three-dimensional quantum objects found on the molecular scale [1]. We present two major improvements to the original shaper setup, one by adding the amplitude [2], and another that employs two paths that interferometrically, fully controls the three-dimensional electrical field [3].

The capabilities and stability of the two setups are demonstrated, and a feedback-loop application that optimizes the ionization of the NaK dimer in a molecular beam is presented. We compare results from free and parametric optimizations, using a temporal sub-pulse encoding of the parameters: distance, intensity, zero order spectral phase, and polarization state [4].

[1] T. Brixner et al., PRL 92, 208301 (2004)

[2] M. Plewicki et al., Independent control over the amplitude, phase, and polarization of femtosecond pulses, Appl. Phys. B (in press), DOI: 10.1007/s00340-006-2464-y

[3] M. Plewicki et al., Appl. Opt. 45, 8354 (2006)

[4] S. M. Weber et al., Parametric phase, amplitude, and polarization shaping on molecules, submitted to Phys. Rev. A. (2006)

Q 14.4 Mo 17:15 5K

Materialbearbeitung von Lichtleitfasern mittels ultrakurzer Laserpulse — •A. Lemke[1], D. Ashkenasi[2], T. Trebst[3] und H.-J. Eichler[1] — [1]TU Berlin, Str. des 17. Juni 135, 10623 Berlin — [2]LMTB GmbH, Schwarzschildstr. 8, 12489 Berlin — [3]CeramOptec GmbH, Siemensstr. 44, 53121 Bonn

Wachsende Erfahrung in der Materialbearbeitung mittels ultrakurz gepulster Laser hat in den letzten Jahren zu einem zunehmenden Interesse am Einsatz von Femtosekundenlasern auch für die Mikromaterialbearbeitung geführt. Gute Strahlqualität und hohe Pulsspitzenleistungen bei gleichzeitig niedrigen Einzelpulsenergien ermöglichen eine exakte Platzierung der Photonenenergie nicht nur auf der Oberfläche sondern auch im Inneren des zu bearbeitenden Materials.

In der vorgestellten Anwendung soll eine normale Quarz-Quarz-Lichtleitfaser lokal modifiziert werden, bevorzugt am Kern-Mantel-Übergang und ohne eine Entfernung des Nylonbuffers. Gleichzeitig soll die Faser mechanisch möglichst wenig belastet werden. Die induzierte lokale Modifikation führte zu einer gezielten Störung der Wellenleitereigenschaften der Faser. Als Ergebnis einer Vielzahl solcher Störstellen wurde eine Lichtauskopplung entlang der bearbeiteten Strecke beobachtet. Ziel ist eine möglichst gleichmäßige und effiziente, radiale Auskopplung des Lichtes über eine definierte Strecke.

Der Einfluss der Einzelpulsenergien, der Lage des Fokuspunktes innerhalb der Faser und die Dichte der verursachten Modifikation wurden untersucht. Die physikalische Natur der induzierten Störung wird vorgestellt und diskutiert.

Q 14.5 Mo 17:30 5K

Superkontinuumsentstehung in hoch nichtlinearen Glasfasern — •Alexander Sell, Florian Adler und Alfred Leitenstorfer — Fachbereich Physik, Universität Konstanz, 78464 Konstanz, Deutschland

Anhand von Simulationsrechungen wird die Entstehung oktavenüberspannender Superkontinua in hoch nichtlinearen Glasfasern untersucht. Aus 80 fs-Impulsen bei der Zentralwellenlänge 1,55 μm entstehen dabei Kontinua, die den Wellenlängenbereich von 1,0 μm bis 2,4 μm umfassen. Über FROG (frequency resolved optical gating) gemessene Eingangsimpulsformen erlauben eine präzise Simulation der experimentell beobachteten Ausgangsspektren, wobei kein freier Parameter eingeht. Dazu wird die Dispersion der Faser mit Hilfe eines neuartigen, faserbasierten Weißlichtinterferometers mit thermischer Lichtquelle gemessen. Um die Experimente exakt zu beschreiben, berücksichtigt das Modell auch retardierte nichtlineare Effekte. Als Resultat sind erstmals fundierte Aussagen über den genauen Ablauf der Superkontinuumsentstehung und die zu Grunde liegenden Prozesse in hoch nichtlinearen Fasern bei Telekom-Wellenlängen möglich. Darüber hinaus können mittels der Rechnungen Kriterien für die Optimierung der Ausgangsspektren abgeleitet werden.

Q 14.6 Mo 17:45 5K

Berechnung der freien Elektronendichte bei der Bestrahlung von Dielektrika mit ultrakurzen Laserpulsen — •Bärbel Rethfeld — Gesellschaft für Schwerionenforschung, Planckstrasse 1, 64291 Darmstadt

Bei der Bestrahlung von Isolatoren mit Laserpulsen nahe der Durchbruchsschwelle sind nichtlineare Absorptionsprozesse bestimmend. Im betrachteten Intensitätsbereich führen sowohl Multiphotonionisation also auch Elektron–Elektron Stoßionisation zum Anwachsen der freien Elektronendichte im Leitungsband des Isolators und damit zur verstärkten Absorption der Laserenergie.

Für die Beschreibung der transienten Elektronendichte gibt es mehrere Modelle, deren Gültigkeitsbereiche in diesem Vortrag verglichen werden. Anwendungsbeispiele zeigen, wie experimentelle Ergebnisse mit Hilfe neuer Beschreibungsmöglichkeiten interpretiert werden können; insbesondere können unterschiedliche Bearbeitungsergebnisse, die mit asymmetrischen Pulsformen erzielt werden, erklärt werden [1]. Eine Möglichkeit zur phänomenologischen Implementierung schneller Rekombinationsprozesse wird aufgezeigt.

[1] L. Englert, B. Rethfeld, L. Haag, C. Sarpe-Tudoran, M. Wollenhaupt und T. Baumert „Control of ionization processes in high band gap materials via tailored femtosecond laser pulses“, Poster im Fachverband Kurzzeitphysik, DPG Tagung 2007 Düsseldorf.

Q 14.7 Mo 18:00 5K

High harmonic generation on aligned molecules — •Markus Gühr[1,2], Brian McFarland[1,2], Joseph Farrell[1,2], and Philip Bucksbaum[1,2] — [1]Stanford PULSE Center, SLAC, Menlo Park CA 94025, USA — [2]Physics Department, Stanford University, Stanford CA 94305,USA

We prepare an aligned distribution of N_2 molecules by the interaction with an intense nonresonant fs laser pulse (pump pulse). The distribution is probed by high harmonic generation (HHG) using a time delayed second pulse. The high harmonics show an enhancement if the molecules are aligned with the probe pulse polarization and a suppression if the molecules are aligned orthogonal to the polarization. We observe a first alignment 300 fs after the pump pulse. For longer time delays, we observe fractional and full revivals (the later at about 8 ps) of the rotational wave packet. The alignment contrast is different among the high harmonics. We model the recombination process of the free electron wave packet in the single electron approximation and discuss the underlying physics in the context of the two center model [1,2].

[1] M. Lein et al, Phys. Rev. A, 66, 023805 (2002)

[2] T. Kanai et al, Nature, 435, 470 (2005)

Q 14.8 Mo 18:15 5K

Femtosecond Excitation of Ultracold Molecules and Collision Pairs — •Terence Mullins[1], Wenzel Salzmann[1], Judith Eng[1], Magnus Albert[1], Roland Wester[1], Matthias Weidemüller[1], Andrea Merli[2], Steffan Weber[2], Franziska Sauer[2], Mateusz Plewicki[2], Fabian Weise[2], Ludger Wöste[2], and Albrecht Lindinger[2] — [1]Universität Freiburg, Hermann Herder Str.3, D-79104 Freiburg i. Br., Germany — [2]Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

We investigate the interaction of femtosecond pulses with free collision pairs and ultracold molecules in a high density dark magneto-optical trap [1]. In a pump-probe experiment, these complexes are excited and ionized by a double-pulse sequence consisting of a shaped pump pulse and an ionization probe pulse, adjusted to detect excited state molecules. The molecular ion signals show wavepacket dynamics in electronically excited potentials, a crucial requirement for further coherent manipulation of molecule formation [2] and de-excitation [3]. Our results show, in addition to earlier experiments [4], that pump pulse spectra and energies have to be carefully controlled in order to avoid multi-photon excitation effects. These observations are discussed in view of the goal of forming deeply bound ultracold molecules in the electronic ground state.

[1] C.G. Townsend *et al.*, Phys. Rev. A, **53**, 1702, 1996.

[2] U. Poschinger *et al.*, J. Phys. B, **39**, 1001 2006.
[3] C.P. Koch *et al.*, Phys. Rev. A, **73**, 043409, 2006.
[4] W. Salzmann *et al.*, Phys. Rev. A, **73**, 023414, 2006.

Q 15: Nichtlineare optische Effekte und Lichtquellen III

Zeit: Montag 16:30–18:00 Raum: 5J

Q 15.1 Mo 16:30 5J

Effiziente resonatorinterne Erzeugung derzweiten und dritten harmonischen eines gütegeschaltetenNd:YVO_4 Lasers — •Florian Lenhardt[1], Thorsten Bauer[2], Martin Nittmann[2], Jürgen Bartschke[2] und Johannes L'huillier[1] — [1]TechnischeUniversität Kaiserslautern, Fachbereich Physik,Erwin-Schrödinger-Strasse 46, 67663 Kaiserslautern — [2]Xiton Photonics GmbH, Opelstrasse 10, D-67661Kaiserslautern

Resonatorinterne Frequenzkonversion von gütegeschalteten Festkörperlasern ist eine attraktive Methode zur Erzeugung von Wellenlängen im sichtbaren (532 nm) und ultravioletten (355 nm) Spektralbereich. Auf Basis eines gütegeschalteten Diodenlaser gepumpten Nd:YVO_4-Lasers mit einer Impulsrepetitonsrate von 15 kHz, einer Impulsdauer von $<$ 10 ns und einer mittleren Leistung von 5 W wurde resonatorintern die zweite (SHG) und dritte (THG) Harmonische in Lithiumtriborat (LBO) durch Typ I bzw. Typ II Phasenanpassung erzeugt. Experimentell wurde eine mittlere Ausgangsleistung von 4.3 W bei 532 nm erreicht. Die Konversionseffizienz betrug 86 % und die Impulsdauer war <12 ns. Die Strahlung der zweiten Harmonischen war nahezu beugungsbegrenzt ($M_x^2 < 1.4$ bzw. $M_y^2 < 1.2$) und die Schwankung der Ausgangsleistung betrug $\leq 0.5\%$ in 30 Min. Bei 355 nm wurde eine mittlere Ausgangsleistung von 456 mW bei einer Impulsdauer von $<$ 8 ns mit Leistungsschwankungen $\sigma < 1\%$ über 30 Min. erzielt. Die THG-Strahlung war beugungsbegrenzt ($M_x^2 < 1.1$ und $M_y^2 < 1.2$). Das realisierte Konzept ermöglicht damit die effiziente Erzeugung von leistungsstarker Strahlung im Sichtbaren und Ultravioletten.

Q 15.2 Mo 16:45 5J

Phase-dependent light propagation in atomic vapors — •Sarah Kajari-Schröder[1], Giovanna Morigi[2], Sonja Franke-Arnold[3], and Gian-Luca Oppo[4] — [1]Institut für Quantenphysik, University of Ulm, D-89069 Ulm, Germany — [2]Grup d'Optica, Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain — [3]Department of Physics, University of Glasgow, G12 8QQ Glasgow, Scotland, U.K. — [4]Department of Physics, University of Strathclyde, G14 0NG Glasgow, Scotland, U.K.

We analyse the propagation of light in an atomic medium whose coupled energy levels form a $\diamondsuit$-configuration. This atomic configuration is characterised by a closed cycle of radiation-induced transitions, hence its dynamics and steady-state depend critically on the relative phase between the driving lasers [1]. In fact, depending on the phase at the input, the response of the medium can vary from opaque to semi-transparent, as coherences form due to interference in the atomic excitations [2]. Alkali-earth atoms with zero nuclear spin are ideal candidates for observing these phenomena which could offer new perspectives in control techniques in quantum electronics.

[1] G. Morigi et al., Phys. Rev. A 66, 053409 (2002)
[2] S. Kajari-Schröder et al., physics/0605176

Q 15.3 Mo 17:00 5J

Gradient induced position trapping and guiding of solitary structures in an LCLV single feedback experiment — •Carsten Cleff, Björn Gütlich, and Cornelia Denz — Institut für Angewandte Physik und Center for Nonlinear Science - Westfälische Wilhelms-Universität Münster - Corrensstraße 2, 48149 Münster, Germany

Solitary structures are localised spots, which are interesting for optical data processing because of their binary features. For potential applications, control of the solitary structures is required, because of mutual interaction and spontaneous dynamics. We use an incoherent external amplitude control in an LCLV single feedback experiment to control the static and dynamic positions of the solitary structures. The interaction of stationary and drifting solitary structures with different spatial intensity distributions (e.g. conus, hexagonal latices, obstacles, linestructures etc) is studied. The control method allows to arrange stationary solitary structures in arbitrary geometries whereas the possibility of traping depends on the wavelength of the trapgeometrie. Trapping can also be induced with a conus intensity distribution. We show that the induced velocity depends linearly on the conus gradient while the solitary structure is attracted to the conus. Also, the interaction of drifting solitary structures with line structures is investigated. The guiding of drifting solitary structures by these lines is demonstrated. External amplitude control also enables to control the velocity of drifting solitary structures and to create a position selector.

Q 15.4 Mo 17:15 5J

Experimental synchronization of spatiotemporal disorder — •Katharina Havermann, Björn Gütlich, and Cornelia Denz — Institut für Angewandte Physik, Westfälische Wilhelms-Universität, Corrensstr. 2, 48149 Münster, Germany

In the last years, the experimental investigation of synchronization of temporal chaotic systems has received increased attention. In this field synchronization of chaos in space and time is a rather new and hardly explored topic with great potential for new phenomena. An interesting model system showing various types of spatiotemporal dynamic is the liquid crystal light valve (LCLV) single feedback system. Subsequently to first successful experiments of synchronization of unidirectional coupled systems the role of spatial inhomogeneities is analyzed in detail. The degree of synchronization is measured for different coupling strengths. The whole range of spontaneous structures of the nonlinear optical system with focus on spatiotemporal disordered states is considered. For analysis cross-correlation functions and mutual information are used.

Q 15.5 Mo 17:30 5J

Control of self-organized patterns in a photorefractive single feedback system by seeding — •Nicoletta Brauckmann, Philip Jander, and Cornelia Denz — Institut für Angewandte Physik and Center for Nonlinear Science, Westfälische Wilhelms-Universität, Corrensstraße 2, 48149 Münster, Germany

The photorefractive single feedback system is known to show a rich variety of transverse patterns (hexagonal patterns, squeezed hexagons, rectangles and rhombohedrons). Different temporal and spatial control approaches, such as pattern manipulation by frequency detuning or pattern selection by Fourier control, turned out to be powerful techniques of pattern control. In this contribution, we consider direct control of pattern formation by seeding the pump beam with patterns of selectable contrast, orientation, scale and symmetry via a liquid crystal amplitude light modulator. In addition to generating new system solutions, the addressing of states which are already stable or unstable fix points is of special interest. In these cases, we can realize an adaptive control scheme, where the control signal is diminished as the system approaches the desired state. The remaining control signal level is only needed to counter noise-induced fluctuations, and thus can be used as a measure of the impact of noise on the stability of different patterned states. Beyond seeding the system with a single pattern, we prestructure the pump beam with domains of different symmetries and scale in order to observe induced competition between the addressed patterns.

Q 15.6 Mo 17:45 5J

Weak localisation of light in disordered nonlinear media — •Thomas Wellens[1] and Benoit Gremaud[2] — [1]Institut für Theoretische Physik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen — [2]Laboratoire Kastler Brossel, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cedex 05

In general, transport of waves in disordered media cannot fully be described as a simple diffusion process, since interference effects lead to a reduction or even complete suppression of the diffusion constant (weak or strong localisation) and the appearance of a coherent backscattering peak.

On the present poster, we examine the impact of nonlinearities on the interferential corrections to the diffusive transport. Using diagrammatic methods in combination with a dilute medium approximation,

we derive equations describing the coherent transport of the average wave intensity in the nonlinear medium. In the case where the wave intensity is conserved, we predict an effective dephasing mechanism induced by the nonlinearity, which reduces the height of the coherent backscattering peak. The opposite occurs for amplifying media, where coherent backscattering factors larger than the linear barrier two can be observed.

Q 16: Quanteneffekte (Interferenz und Korrelationen)

Zeit: Montag 16:30–18:45 Raum: 5E

Q 16.1 Mo 16:30 5E

Quantum correlations between photons scattered by strongly pumped regular structures — •Mihai Macovei, Jörg Evers, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg.

Interference light phenomena as well as photon correlations attract considerable attention due to their enormous potential applications [1].

As, at strong driving, the scattered light separates into distinct spectral bands, it is naturally to consider interference effects resulting from individual spectral lines. Here spectral photon correlations and cross-correlations of light scattered by a regular structure of strongly driven atoms are investigated [2]. In particular, we focus on spatial second-order intensity-intensity correlation functions in two- and multi-atom systems. We show that the cross-correlations between photons emitted in the spectral sidebands violate Cauchy-Schwartz inequalities, and that their emission ordering cannot be predicted, thus suggesting quantum entanglement between the photons.

[1] Roy J. Glauber, Rev. Mod. Phys. 78, 1267 (2006).

[2] M. Macovei, J. Evers, G.-x. Li, and C. H. Keitel, submitted; quant-ph/0606151.

Q 16.2 Mo 16:45 5E

Photon antibunching from a single qantum dot-microcavity system in the strong coupling regime — •Stephan Götzinger[1], David Press[1], Yoshihisa Yamamoto[1], Stephan Reitzenstein[2], Carolin Hofmann[2], Andreas Löffler[2], Martin Kamp[2], and Alfred Forchel[2] — [1]E. L. Ginzton Laboratory, Stanford University, Stanford California 94305, USA — [2]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Strong coupling in solid state systems is of great interest for a variety of quantum information applications. Although it has been demonstrated in several quantum dot-microcavity configurations, it was not verified that the system had one and only one emitter.

In our experiment, we observe antibunching in the photons emitted from a strongly-coupled single quantum dot and pillar microcavity on resonance. When the quantum dot was spectrally detuned from the cavity mode, the cavity emission remained antibunched, and also anticorrelated from the quantum dot emission [1]. Resonant pumping of the selected quantum dot via an excited state enabled these observations by eliminating the background emitters that are usually coupled to the cavity. This device demonstrates an on-demand single-photon source operating in the strong coupling regime, with a Purcell factor of 61 and a quantum efficiency of 97%.

[1] D. Press et al., quant-ph/0609193.

Q 16.3 Mo 17:00 5E

Two-Photon Optics — •Daniel Schlenk[1] and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, Schellingstraße 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

The properties of imaging systems can be described by the point-spread function, which is determined by diffraction. A shorter wavelength results in a smaller diffraction pattern and therefore allows (in principle) a better resolution. It has been shown [1,2,3] that entangled n-photon states offer diffraction effects of the wavelength divided by n, if a n-photon detection is performed.

Here we use this feature to enhance the resolution of an imaging system. An image of the biphotons (signal and idler) created in a type I collinear down conversion is formed by a lens, and recorded by scanning a single mode fiber through the image plane and detecting pairs of photons (coincidences) behind a beam splitter with avalanche photodiodes. The point-spread function of the biphotons was by a factor of 1.7 smaller than the one of single photons.

[1] Ph. Walther et al., Nature 429, 158 (2004)

[2] M. W. Mitchell et al., Nature 429, 161 (2004)

[3] M. C. Teich and B. A. E. Saleh, Cesk. Cas. Fyz 47, 3-8 (1997)

Q 16.4 Mo 17:15 5E

Decoherence measurements and visualisation of the quantum-classical border using an electron interferometer — •Peter Sonnentag and Franz Hasselbach — Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen

The incompatibility of the quantum mechanical superposition principle with our everyday experience of a 'classical' world has been a longstanding problem, nowadays being solved by the theory of decoherence. To investigate decoherence experimentally, we used free electrons interacting by Coulomb force with a truly macroscopic and theoretically nontrivial environment, the electron and phonon gas inside a semiconducting plate. The electron beam in a biprism interferometer is split into two parts which travel over the plate at the same, small height, but laterally separated. The induced currents inside the plate encounter ohmic resistance, leading to Joule heating which quantum-mechanically means a disturbance of the electron and phonon gas [1]. As this disturbance is different for the two paths of the beam electron, entanglement between beam electron and plate is formed, leading to a decrease in fringe visibility. The experiment also allows for an intuitive explanation in terms of which-path information.

Our results are quantitatively compared with different theoretical calculations. Furthermore, our modification of the original proposal [1] enabled us to directly visualize the quantum-classical border in single interferograms.

[1] J. R. Anglin, W. H. Zurek, Phys. Rev. **A** 55 (1997) 4041.

Q 16.5 Mo 17:30 5E

Photon statistics in the cooperative spontaneous emission — •Vasily V. Temnov and Ulrike Woggon — Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany

The statistics of photons emitted by an incoherently pumped ensemble of N two-level systems coupled to a single damped cavity mode is investigated numerically by Monte-Carlo simulations [1]. Below the lasing threshold the second-order photon correlation function $g_2(\tau)$ shows a giant photon bunching with $g_2(0) >> 1$, strongly exceeding the bunching factor $g_2(0) \sim 2$ for thermal radiation. The dependence of bunching behavior on the homogeneous, inhomogeneous broadening and the number of emitters N in the atomic ensemble is investigated. The maximum bunching factor is found for N=2 and is explained by the cooperative evolution through the superradiant (Dicke) states [2] resulting in the emission of photon pairs.

[1] V.V. Temnov and U. Woggon, Phys. Rev. Lett. 95, 243602 (2005)

[2] R.H. Dicke, Phys. Rev. 93, 99 (1954)

Q 16.6 Mo 17:45 5E

Riemann-Zetafunktion als Autokorrelationsmessung eines Quantenzustands — •Rüdiger Mack und Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm

Die Faktorisierung von Zahlen mit Hilfe eines Quantencomputers, die Quantenkryptographie oder die Ähnlichkeit zwischen den statistischen Verteilungen der Energieniveaus eines Billards und den Nullstellen der Riemann-Zetafunktion weisen auf eine enge Verbindung zwischen Quantenmechanik und Zahlentheorie.

Die Entwicklung von ultrakurzen Laserpulsen und die Fortschritte der Ionenfallentechnologie haben die Möglichkeit eröffnet, die Zeitentwicklung von Wellenpaketen auch tatsächlich zu beobachten. Die Bewegung von Rydberg-Elektronen, die Schwerpunktsbewegung von Ionen in Paul-Fallen oder Atome in stehenden Wellen sind nur einige wenige Beispiele in denen Wellenpakete heute praktisch routinemäßig erzeugt und modifiziert werden. Zentraler Punkt all dieser Experimente

ist die Messung der Autokorrelationsfunktion, die den zeitabhängigen Überlapp zwischen dem entwickelten Zustand und dem Anfangszustand des Quantensystems darstellt.

Durch die semiklassische Rydberg-Klein-Rees Inversionsmethode ist es möglich, ein Potential zu finden, dessen Energieeigenwerte logarithmisch verteilt sind. Die Autokorrelationsfunktion der Bewegung eines speziell präpariertes Wellenpacket in solch einem Potential ist die Riemann-Zetafunktion.

Q 16.7 Mo 18:00 5E

Electromagnetically Induced Transparency in an optical dipole trap — •Harald Kübler[1], Bernd Kaltenhäuser[1], Andreas Chromik[1], Jürgen Stuhler[2], Atac Imamoglu[3], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Toptica Photonics AG, Lochhamer Schlag 19, 82166 Graefelfing, Germany — [3]Institut für Quantenelektronik, ETH Höggerberg, Wolfgang-Pauli-Str. 16, CH-8093 Zürich, Switzerland

Inhomogeneous magnetic fields are limiting the applications of electromagnetically induced transparency like slow light, quantum memory and quantum repeaters. As an optical dipole trap works independent of magnetic fields, we are able to apply a homogeneous field, which enables us to overcome these limitations. We use Rubidium atoms in a CO2-laser dipole trap, which is directly loaded from a magneto-optical trap.

We present EIT measurements with co propagating Raman laser beams showing absorptive and dispersive features with a width less than 10kHz.

Q 16.8 Mo 18:15 5E

Photon second order correlations vs. interference for a single atom in a half cavity — •Daniel Rotter[1], Francois Dubin[1], Manas Mukherhjee[1], Carlos Russo[1], Juergen Eschner[3], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]"Osterreichische Akademie der Wissenschaften, Austria — [3]Institute for Photonic Sciences (ICFO), Spain

We present experiments with a single Ba^+ ion in a Paul trap, continuously laser-excited at Doppler cooling conditions. A part of the resonance fluorescence emitted by the ion is retro-reflected, thus leading to single-photon interference fringes of high contrast [1]. We investigate the second order photon correlations, varying the relative distance between the ion and the retro-reflecting mirror. We demonstrate that the measured correlations can be tuned smoothly from an antibunching minimum to a bunching-like maximum. Our analysis concerns the non-Markovian regime, i.e. the detection of photon pairs separated by large time intervals is modulated by single-photon interference. The field establishment in a half-cavity interferometer is revealed.

[1] J. Eschner et al., Nature **413**, 495 (2001).

Q 16.9 Mo 18:30 5E

Non-destructive measurements on the Cs clock transition: towards atomic spin squeezing — •Patrick Windpassinger, Daniel Oblak, Niels Kjaergaard, and Eugene Polzik — Niels Bohr Institute, Blegdamsvej 17, Copenhagen, Denmark

We use a nondestructive interferometric measurement of the clock states populations of an ensemble of laser-cooled and trapped Cs atoms to study the state evolution when the sample is subjected to light and microwave pulses.

The nondestructive character of the measurement allows us to follow online the quantum state of the system while it is being engineered. Here we show measurements of Rabi-oscillations on the clock transition which allow us to produce states on a generalized Bloch sphere. Ultimately, the dispersive character of the measurement leads to squeezing of the population number difference of the clock states and the sensitivity of the setup should allow us to observe squeezing as sub-projection noise.

Q 17: Quantengase (Bosonische Gitter I)

Zeit: Dienstag 10:30–12:30 Raum: 6J

Q 17.1 Di 10:30 6J

Sweeping from the Superfluid to the Mott Phase in the Bose-Hubbard Model — •Michael Uhlmann[1], Ralf Schützhold[1], Yan Xu[1], and Uwe Fischer[2] — [1]Institut für Theoretische Physik, TU Dresden — [2]Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen

We study the sweep through the quantum phase transition from the superfluid to the Mott state for the Bose-Hubbard model with a time-dependent tunneling rate $J(t)$. In the experimentally relevant case of exponential decay $J(t) \propto e^{-\gamma t}$, an adapted mean-field expansion for large fillings n yields a scaling solution for the fluctuations. This enables us to analytically calculate the evolution of the number and phase variations (on-site) and correlations (off-site) for slow ($\gamma \ll \mu$), intermediate, and fast (non-adiabatic $\gamma \gg \mu$) sweeps, where μ is the chemical potential. Finally, we derive the dynamic decay of the off-diagonal long-range order as well as the temporal shrinkage of the superfluid fraction in a persistent ring-current setup.

Q 17.2 Di 10:45 6J

Phase-dependent Landau-Zener effect in asymmetric optical lattices — •Tobias Salger[1,2], Gunnar Ritt[1,2], Carsten Geckeler[1,2], Sebastian Kling[1,2], and Martin Weitz[1,2] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

We report experimental results on transport properties of Bose-Einstein condensates in periodic optical potentials of variable asymmetry. By studying the Landau-Zener effect and Bloch oscillations, we have explored the band structure of both ratchet-type asymmetric and symmetric optical potentials. In earlier work, quantum transport in "conventional" sinusoidal lattices has proven to be a powerful technique for characterisation of the band structure. To realize lattice potentials of variable asymmetry, we superimpose the conventional lattice potential of $\lambda/2$ spatial periodicity with a fourth-order optical potential of $\lambda/4$ spatial periodicity. The high periodicity lattice is realized using dispersive properties of multiphoton Raman transitions[1]. To study quantum transport in such Fourier-synthesized lattice potentials the periodic potential is accelerated. We find that the Landau-Zener tunneling rate between the first and the second excited Bloch band critically depends on the relative phase between the two spatial lattice harmonics. Our experimental results are in agreement with theoretical calculations.

[1] G. Ritt et al., PRA (in press).

Q 17.3 Di 11:00 6J

Semiclassical quantization of an N-particle Bose-Hubbard model — •Eva-Maria Graefe and Hans-Jürgen Korsch — Fachbereich Physik Technische Universität Kaiserslautern

We study an N-particle two-mode Bose-Hubbard system, modelling a Bose-Einstein condensate in a double-well potential. We investigate the correspondence of a full many particle description and a mean-field-approximation, which is often called 'classical'. Furthermore we introduce a semiclassical approximation based on the classical mean-field Gross-Pitaevskii equation, which is expected to be valid for large N. By using a WKB-type quantization condition we reconstruct the quantum properties of the N-particle system approximately from the mean-field dynamics. The resulting eigenvalues are found to be in very good agreement with the exact ones, even for small values of N.

Q 17.4 Di 11:15 6J

Kicked Bose-Hubbard systems and kicked tops – destruction and stimulation of tunneling — •Martin P. Strzys, Eva-Maria Graefe, and Hans-Jürgen Korsch — Fachbereich Physik, Technische Universität Kaiserslautern

In the two-mode approximation Bose-Einstein condensates (BEC) in a

[1]1
[1][

double-well potential can be described by a many particle Hamiltonian of Bose-Hubbard type. We focus on such a BEC whose interatomic interaction strength is modulated periodically with δ-kicks. This system in fact represents a model of a kicked top. The mean-field dynamics provide a rich mixed phase space with regular and chaotic regions. By increasing the kick-strength a bifurcation leads to the appearance of self-trapping states localized in regular islands. This self-trapping is also found for the many particle system, however in general suppressed by tunneling oscillations. We show that the tunneling time can be calculated from the quasi-energy splitting of the corresponding Floquet states. By varying the kick-strength these quasi-energy levels undergo both avoided and even real crossings. Using this fact stimulation or actually complete destruction of tunneling can be achieved for this many particle system.

Q 17.5 Di 11:30 6J

Bloch-Oscillations Instability of a Bose-Einstein Condensate in an Optical Lattice — Andrey Kolovsky[1,2], •Ming-Chiang Chung[1], and Andreas Buchleitner[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden — [2]Kirensky Institute of Physics, Ru-660036 Krasnoyarsk

We consider ultracold atoms prepared in the superfluid state, loaded into a 3D optical lattice, and exposed to a linear force, e.g., gravitation. If the linear force is large enough, it localizes the condensate in a 2D plane transverse to the gravitational field, what reduces the microscopic 3-D problem to a 1-D mean field problem. We derive the phase diagram for the quantum dynamics under these conditions, which exhibits a transition from stable to unstable Bloch oscillations. In the unstable regime, the Bloch oscillations decay irreversibly, while they persist in the stable regime.

Q 17.6 Di 11:45 6J

Quenching, relaxation, and a central limit theorem for quantum lattice systems — Christopher Dawson[1,2], Tobias Osborne[3], Jens Eisert[1,2], and •Marcus Cramer[4] — [1]QOLS, Blacket Laboratory, Imperial College London, Exhibition Road, London, SW7 2BW, UK — [2]Institute for Mathematical Sciences, Imperial College London, Exhibition Road, London, SW7 2BW, UK — [3]Department of Mathematics, Royal Holloway University of London, Egham, Surrey TW20 0EX, United Kingdom — [4]Institut für Physik, Universität Potsdam, Am Neuen Palais 10, D-14469 Potsdam, Germany

A folk conjecture in the study of interacting quantum systems says that, independent of initial state, the system will tend to equilibrate. In this work we study a setting where relaxation to a steady state is exact, namely for the Bose-Hubbard model where the system is quenched from a Mott phase to the strong superfluid regime. We find that the evolving state locally relaxes to a steady state with maximum entropy constrained by the initial local energy. Remarkably, this relaxation is true for all large times, and no time average is necessary to obtain relaxation. Our argument makes use of a non-commutative central limit theorem for harmonic systems. Additionally, we show that for large finite blocks the system will also relax, but not to the thermal state of the new Hamiltonian. We outline generalisations to spin systems, sketch implications for the foundations of quantum statistical mechanics, and discuss signatures of relaxation in the experimental context of cold atoms in optical lattices.

Q 17.7 Di 12:00 6J

Cold atom dynamics in a quantum optical lattice potential — •Christoph Maschler and Helmut Ritsch — Universität Innsbruck, Institut für theoretische Physik, Technikerstraße 25, 6020 Innsbruck

We study a generalized cold atom Bose Hubbard model, where the periodic optical potential is formed by a cavity field with quantum properties. On the one hand the common coupling of all atoms to the same mode introduces cavity mediated long range atom-atom interactions and on the other hand atomic backaction on the field introduces atom-field entanglement. This modifies the properties of the associated quantum phase transitions and allows for new correlated atom-field states including superposition of different atomic quantum phases. After deriving an approximative Hamiltonian including the new long range interaction terms we exhibit central physical phenomena at generic configurations of few atoms in few wells. We find strong modifications of population fluctuations and next-nearest neighbor correlations near the phase transition point.

Q 17.8 Di 12:15 6J

Visibility of Atomic Cloud Released from Optical Lattice — •Alexander Hoffmann[1], Konstantin Krutitsky[2], and Axel Pelster[2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We present an analytical calculation for the interference pattern of an atomic cloud which expands from an optical lattice. To this end we work out a variational approach which considers quantum fluctuations beyond the mean-field level for finite temperatures. The resulting visibility of the interference pattern indicates both short-range and long-range coherence in the Mott insulator and the superfluid regime, respectively. Furthermore, we account for inhomogeneity effects, which arise from an overall harmonic trap.

Q 18: Quanteninformation (Verschränkung und Dekohärenz I)

Zeit: Dienstag 10:30–12:45 Raum: 5L

Gruppenbericht Q 18.1 Di 10:30 5L

An observable entanglement measure — •Florian Mintert[1], Leandro Aolita[2,3], Rafal Demkowicz Dobrzanski[4], Stephen Walborn[2], Paulo Souto Ribeiro[2], Luiz Davidovich[2], Marek Kus[4], and Andreas Buchleitner[3] — [1]Department of Physics, Harvard University — [2]Universidade Federal do Rio de Janeiro — [3]Max Planck Institut fuer Physik Komplexer Systeme, Dresden — [4]Centrum Fizyki Teoretycznej Polskiej Akademii Nauk, Warszawa

Although entanglement constitutes one of the most remarkable differences between classical and quantum mechanics, and it does have directly observable consequences, it is not an observable like for example momentum or energy. Unlike a regular observable that has an associated hermitean operator, an entanglement measure is rather a non-linear functional of a large set of such observables. Therefore, one typically needs to perform many different measurements, in order to determine the degree of entanglement of a given quantum state. We show, how the entanglement measure concurrence is given in terms of collective observables of two identically prepared quantum states. This allows for a direct experimental estimate of the concurrence of arbitrary finite dimensional quantum states as it is demonstrated in a laboratory experiments with pure twin photon states.

Q 18.2 Di 11:00 5L

Experimental detection of SLOCC invariants — •Andreas Osterloh[1] and Jens Siewert[2] — [1]Institut für Theoretische Physik, Universität Hannover, D-30167 Hannover, Germany — [2]Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

Characterization and quantification of multipartite entanglement is a crucial task for state-of-the-art experiments in quantum information processing, and also in modern condensed-matter physics. According to theory, this is established by entanglement monotones, that is, functions that do not increase under stochastic local operations and classical communication (SLOCC). However, typically such functions are expressed in terms of expectation values of antilinear operators, and therefore are not directly accessible in an experiment. Here we show how such monotones can be re-written in terms of expectation values of (linear) hermitian operators. That is, the amount of entanglement – of specific SLOCC classes – in a given state can be extracted from the measurement of correlation functions of local operators.

Q 18.3 Di 11:15 5L

Photon-photon entanglement in the 2E1 decay of atomic hydrogen — •Thomas Radtke[1], Stephan Fritzsche[1], and Andrey Surzhykov[2] — [1]Institut für Physik, Universität Kassel, D-34132 Kassel, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

The theory of the two-photon decay of (metastable) hydrogen was developed already in the early days of quantum mechanics. However, only several decades later, it was demonstrated experimentally that the correlation in the polarization states of the two photons indeed violates Bell's inquality so that the photons are entangled [1].

More recently, within the context of quantum information processing, new interest arose in controllable sources of entanglement. Therefore, in this contribution, we have investigated in more detail the photon-photon entanglement in the 2E1 decay of atomic hydrogen. In particular, we study the entanglement as a function of the emission angles of the two photons and (for the case of excited states) the atom's initial spin state. It is found that the two-photon decay of hydrogen may lead to pairs of photons with controllable degree of entanglement as it is used in various quantum information protocols.

[1] Perrie et al., Phys. Rev. Lett. 54, 1790 (1985)

Q 18.4 Di 11:30 5L

Covariance matrices and the separability problem — Otfried Gühne[1], Philipp Hyllus[2,3], •Oleg Gittsovich[4,1], and Jens Eisert[3] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Österreich — [2]Institut für Theoretische Physik, Universität Hannover, Appelstrasse 2, 30167 Hannover, Deutschland — [3]QOLS, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2BW, UK and Institute for Mathematical Sciences, Imperial College London, Prince's Gate, London SW7 2PE, UK — [4]Institut für Theoretische Physik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Österreich

The separability problem deals with a question to decide whether a given state is entangled or separable, which is very important from the point of view of applicability of the quantum information theory. This task belongs to the one of the still unsolved theoretical problems, which has received a significant amount of attention in recent years. In this talk I will present a new unifying approach to the separability problem for finite dimensional systems. Our method uses a representation of a quantum state by a covariance matrix of suitable observables. On the one hand, our approach leads to entanglement criteria that detect all entangled states of two qubits, as well as indeed many bound entangled states and, on the other hand, provides a framework to link and understand several existing criteria like cross-norm (or realignment) criterion, a recent criterion using Bloch representation or the local uncertainty relations.

Q 18.5 Di 11:45 5L

Do NPT bound entangled states exist? — •Elisabeth Rieper and Reinhard Werner — Institut für Mathematische Physik, TU Braunschweig, www.imaph.tu-bs.de

The existence of NPT bound entangled states is equivalent to the existence of NPT Bound Werner states. A current conjecture is that 1-copy undistillable Werner states remain undistillable even for many copies. This would provide a large set of NPT bound entangled states. We investigate the distillation properties of these states with a new distillation protocol. We check for the maximal achievable fidelity of the output state by solving a generalized eigenvalue problem. By exploiting the symmetries of Werner states we find a new contraction scheme avoiding high dimensional matrices. This scheme enables us to test distillability of up to four copies. The numerical results for 1 to 4 copies support the above conjecture that undistillable Werner states are already 1-copy undistillable.

Q 18.6 Di 12:00 5L

talk "statistic dependence of the entanglement entropy" moved to 12:30 — •xxx xxx — xxx

xxx

Q 18.7 Di 12:15 5L

Full experimental characterization of Gaussian entangled states — •James DiGuglielmo, Boris Hage, Alexander Franzen und Roman Schnabel — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut),Institut für Gravitationsphysik, Leibniz Universität Hannover,Callinstr. 38, 30167 Hannover

A quantitative characterization of quantum information communication channels by means of quantities such as the von Neumann entropy and quantum capacity require the full knowledge of the entangled EPR state being used to establish the channel. For Gaussian states, this can be achieved by measuring the covariance matrix. To this end we present an experimental procedure for the measurement of the entire covariance matrix using as few measurements as possible. We apply this method to the characterization of three different types of EPR states and then use the reconstructed matrices to obtain the lower bound to the quantum channel capacity as well as other information theoretic quantities such as the partial information. The purity and logarithmic negativity are calculated as well.

Q 18.8 Di 12:30 5L

Statistics dependence of the entanglement entropy — •Marcus Cramer[1], Jens Eisert[2,3], and Martin Plenio[2,3] — [1]Institut für Physik, Universität Potsdam, Am Neuen Palais 10, D-14469 Potsdam, Germany — [2]QOLS, Blacket Laboratory, Imperial College London, Exhibition Road, London, SW7 2BW, UK — [3]Institute for Mathematical Sciences, Imperial College London, Exhibition Road, London, SW7 2BW, UK

The entanglement entropy of a distinguished region of a quantum many-body problem reflects the entanglement present in its pure ground state. In this work, we establish scaling laws for the entanglement entropy for critical quasi-free fermionic and bosonic lattice systems, without resorting to numerical means. We consider the geometrical setting of D-dimensional half-spaces. Intriguingly, we find a difference in the scaling properties depending on whether the system is bosonic—where an area-law is first proven to hold—or fermionic, extending previous findings for cubic regions. For bosonic systems with nearest neighbor interaction we prove the conjectured area-law by computing the logarithmic negativity analytically. For fermions we determine the multiplicative logarithmic correction to the area-law, which depends on the topology of the Fermi surface. We find that Lifshitz quantum phase transitions are accompanied with a non-analyticity in the prefactor of the leading order term.

Q 19: Erzeugung ultrakurzer Lichtimpulse

Zeit: Dienstag 10:30–12:15 Raum: 5K

Q 19.1 Di 10:30 5K

Fourier limited tunable pulses in the visible and NIR by cw seeding of fs and ps NOPAs — •Markus Breuer[1], Christian Homann[1], Eberhard Riedle[1], and Frank Setzpfandt[2] — [1]LS für BioMolekulare Optik, LMU München — [2]Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena

Optical parametric amplifiers (OPAs) seeded by a continuum or a parametric generator are the prime source of tunable ultrafast radiation. They do, however, not render pulses with a clean Gaussian spectrum and a pulse length given by the Fourier limit. In the nanosecond regime superior pulses are generated by amplification of monomode cw seed light in dye amplifiers and optical parametric oscillators. For the ultrafast regime the principle has so far not been exploited, due to the small number of seed photons contained within the temporal amplification interval. Yet, the ever increasing availability of low cost diode sources would make it an attractive method. We have succeeded to operate cw seeded 2-stage noncollinear OPAs (NOPAs) with a 150 fs Ti:sapphire pump source and a 10 ps Nd:VAN system. A few hundred μJs of pump energy at 1 or 5 kHz led to a few μJs of output with single mWs of seed power. The fs NOPA rendered 88 fs pulses at 532 nm with a bandwidth of 6 nm (time bandwidth product of 0.55) from about 500 seed photons. For ps operation the lower damage threshold of the BBO amplifier crystals for ps pulses had to be overcome by long crystal lengths. The resulting ps NOPA was tunable over a wide range in the NIR by tuning the fiber coupled seed and had a spectral bandwidth of only 0.86 nm (at 1.53 um) with a clean Gaussian distribution.

Q 19.2 Di 10:45 5K

Circular phase mask for control and enhancement of femtosecond optical filamentation — •Thomas Pfeifer[1,2], Lukas

Gallmann[1,2], Mark J. Abel[1,2], Phillip M. Nagel[1,2], Daniel M. Neumark[1,2], and Stephen R. Leone[1,2] — [1]Departments of Chemistry and Physics, University of California, Berkeley, CA 94720, USA — [2]Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Optical filamentation is an interesting alternative to gas-filled hollow-core fibers for applications in supercontinuum generation and pulse compression to the few-cycle limit. The output characteristics of the optical filamentation process are critically dependent on the stability of the laser system and spatial quality of the laser beam. Imprinting circular phase masks onto the beam prior to filamentation can be used to improve crucial characteristics of the optical filaments: spectral bandwidth and beam pointing stability [1]. A simulation was developed which indicates that the imprinted phase mask could result in a better pointing stability after the filament than the pointing of the laser beam that produced it.

Ref.: [1] T. Pfeifer et al., Opt. Lett. **31**, 2326 (2006).

Q 19.3 Di 11:00 5K

Amplification of Shaped Supercontinuum from a Photonic Crystal Fiber — •Jens Möhring, Tiago Buckup, Bernhard von Vacano, and Marcus Motzkus — Physikalische Chemie, Philipps Universität Marburg, D-35032 Marburg, Germany

Ultrafast spectroscopy applications require the generation of intense and broadband ultrashort pulses. To achieve the respective optical bandwidth, supercontinuum (SC) can be generated in photonic crystal fibers (PCF) with great flexibility. When pumped by an amplified femtosecond laser system, a PCF generated supercontinuum can be used for seeding in parametric amplification. In this work, we present the amplification of a phase modulated supercontinuum from a PCF in a single stage noncollinear parametric amplifier (nc-OPA). A pulse shaper is used for complete phase management of the SC pulse before the amplifier stage. This approach allows the generation of intense Fourier-limited pulses after the amplification stage, without the need of any additional compressor behind the parametric amplifier. Besides that, complex phase modulation of the amplified pulse can also be easily obtained by phase control of the SC seed pulse. We show compression, complex phase modulation and amplification of a 14 fs supercontinuum pulse at 700 nm.

Q 19.4 Di 11:15 5K

Flexible Dispersion Control for Ultrashort Laserpulses — •Georg Gademann, Konstantin Simeonidis und Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The compression of ultrashort laser pulses by filamentation in a noble gas is an easy and efficient method to approach the one cycle limit for laser pulses. These afterwards can be used to produce single attosecond light pulses through high harmonic generation. Used in pump probe experiments these atto second light pulses yield a higher time resolution. The presented setup for filamentation is based on previous works [1].

On such short time scales it is of particular importance to have good means of compensating dispersion which is introduced by air and optical material. In our case the remaining dispersion is compensated for by a multi level setup. This setup consists of a chirped mirror pair, prism compressor and deformable mirror. Using the combination of those different parts we are able to flexibly react on changing configurations and variation of experimental parameters while ensuring optimal compression. Furthermore active pulse shaping is also possible.

Particularly innovative is the use of the deformable mirror, wherein the spectral phase information measured by ZAP-SPIDER method can be directly used for compensation. Especially residual higher order chirp can efficiently be adjusted.

[1] C.P.Hauri and J.Biegert and U.Keller Generation of intense view-cycle laser pulses through filamentation - parameter dependence Optics Express **19** 7541-7547 (2005)

Q 19.5 Di 11:30 5K

Tunable ultrashort laser pulses generated through filamentation in gases — •A. Becker[1], F. Theberge[2], N. Akozbek[3], W. Liu[2], and S.L. Chin[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden — [2]COPL, Université Laval, Québec G1K 7P4, Canada — [3]Time Domain Corporation, Huntsville, Alabama 35806, USA

Tunable ans stable ultrashort laser pulses in the visible spectrum are generated with high efficiency by four-wave-mixing process during filamentation of near-infrared and infrared laser pulses in gases. It is shown [1] that these tunable ultrashort pulses have a very low energy fluctuation and an excellent mode quality due to the processes of intensity clamping and self-filtering in the filament.

[1] F.Théberge et al., Phys. Rev. Lett. **97**, 023904 (2006).

Q 19.6 Di 11:45 5K

Short-pulse optical parametric chirped-pulse amplification (OPCPA) for the generation of high-power few-cycle pulses — •Andreas Henig[1,2], József Fülöp[1,2], Zsuzsanna Major[1], Sebastian Kruber[1], Jens Osterhoff[1], Rainer Hörlein[1,2], Ferenc Krausz[1,2], and Stefan Karsch[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [2]Department für Physik, Ludwig-Maximilians-Universität München, Am Coulombwall 1, D-85748 Garching, Germany

In order to combine ultrashort pulse durations in the few-cycle regime with high pulse energies, we propose to pump an OPCPA chain with TW-scale short pulses (100 fs – 1 ps) delivered by a conventional CPA laser system. This approach inherently improves the conditions for generating high-power ultrashort pulses using OPCPA in the following ways. The short pump-pulse duration firstly reduces the necessary stretching factor for the seed pulse, thereby increasing stretching and compression fidelity. Secondly, it allows for a much higher contrast. In addition, the significantly increased pump power makes the use of thinner OPCPA crystals possible, which implies an even broader amplification bandwidth, thereby allowing for even shorter pulses.

We present experimental results of the first stage of a multi-stage OPCPA setup pumped by the frequency doubled output of our ATLAS TW-scale Ti:Sapphire laser located at MPQ. The final system is expected to deliver high-energy ($\sim$ 100 mJ) few-cycle ($\sim$ 5 fs) pulses, which together with the inherently optically synchronized pump laser will be ideally suited for future pump-probe experiments.

Q 19.7 Di 12:00 5K

Tunable pulses from below 300 to 950 nm with durations down to 12 fs from a 2 MHz Yb-doped fiber system — Christian Schriever, Patrizia Krok, •Stefan Lochbrunner, and Eberhard Riedle — Lehrstuhl für BioMolekulare Optik, LMU München

For many applications in spectroscopy, imaging, and machining, ultrafast low energy pulses at a high repetition rate are required. Fiber based femtosecond lasers are promising sources, however, they are not tunable which limits their application areas. We developed a noncollinearly phase matched optical parametric amplifier (NOPA) [1] for high repetition rates that not only provides the necessary tunability but also shortens the pulses by more than a factor of 10. A commercial 2 MHz Yb-doped fiber oscillator / fiber-amplifier system (IMPULSE; Clark-MXR, Inc.) delivering 10 μJ pulses at 1035 nm is used as pump. Its output is first frequency doubled, then the green is split off for pumping the NOPA stage while the remainder is used for continuum generation. The NOPA provides a tuning range of 600 - 950 nm with pulse energies up to 850 nJ. Due to the noncollinearity, the bandwidth can reach as much as 175 nm with a Fourier limit of 11 fs. With a fused silica prism sequence pulses at 865 nm were compressed to 11.9 fs and at 720 nm to 17.7 fs. Frequency doubling the NOPA output allows to access the spectral region of 300 - 475 nm and subsequent sum frequency mixing with NIR pump light reaches 233 - 326 nm. Applying these schemes, pulses at 427 nm were generated with an internal efficiency of 15% and pulses at 303 nm with 18% for the second step.

[1] T. Wilhelm, J. Piel, and E. Riedle, Opt. Lett. **22** 1494, (1997).

Q 20: Laser in der Medizin und Umweltmesstechnik I

Zeit: Dienstag 10:30–12:45 Raum: 5J

Q 20.1 Di 10:30 5J

OCT-kontrollierte Mikrochirurgie an den Stimmlippen — •Henning Wisweh[1], Ulrich Merkel[1], Kathrin Lüerssen[1] und Holger Lubatschowski[2] — [1]Medizinische Hochschule Hannover, Carl-Neuberg-Str. 1, 30625 Hannover — [2]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

Die chirurgische Behandlung gutartiger Stimmlippenveränderungen führt zu einer dauerhaften Heiserkeit des Patienten, wenn die Schichtgrenzen der Stimmlippen beim Operieren nicht berücksichtigt werden. Durch die präzise und schonende Gewebebearbeitung des fs-Lasers können zusammen mit einer gleichzeitigen bildgebenden Darstellung des Schichtaufbaus gezielte Resektionen mit Rücksicht auf die Schichtgrenzen vorgenommen werden.

In früheren Arbeiten konnte gezeigt werden, dass die optische Kohärenztomographie (OCT) für den Einsatz an den Stimmlippen sehr gut geeignet ist. So kann deren Schichtstruktur innerhalb der für chirurgische Eingriffe relevanten Tiefe von bis zu 1 mm mit einer Auflösung im Bereich von 10-20 μm dargestellt werden.

In einer Studie an extrahierten Schweinestimmlippen wurde das Abtragverhalten des fs-Lasers unter OCT-Kontrolle in situ untersucht. Bei richtiger Wahl der Laserparameter haben die thermischen Effekte geringe Schädigungen des Gewebes hervorgerufen. Die Ausdehnung der Nekrosezone lag im erwarteten Bereich unterhalb 10 μm.

Es konnte also gezeigt werden, dass ein OCT-kontrolliertes Schneiden mit dem fs-Laser im μm-Bereich mit minimaler Gewebeschädigung möglich ist.

Q 20.2 Di 10:45 5J

Faserbasiertes Fourier-Domain-OCT für die Mikrochirurgie — •Ole Massow[1], Fabian Will[2] und Holger Lubatschowski[1,2] — [1]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover — [2]Rowiak GmbH, Garbsener Landstr. 10, 30419 Hannover

Die Femtosekunden-Technologie stellt aufgrund der nichtlinearen Wechselwirkung mit optisch transparenten Medien ein sehr interessantes Werkzeug für die Bearbeitung von biologischen Proben dar, womit innerhalb von Geweben mit hoher Präzision Mikrochirurgie betrieben werden kann. Zugleich eignen sich die ultrakurzen Pulse durch ihre große spektrale Breite als ideale Lichtquelle für bildgebende Verfahren wie die optische Kohärenztomographie (OCT), mit deren Hilfe Strukturen innerhalb von biologischen Proben nicht invasiv beobachtet werden können.

Die Kombination dieser beiden Technologien stellt aufgrund der Präzision von wenigen Mikrometern und hohen Flexibilität in der Schnittführung, die damit erreicht werden könnte, ein außerordentlich interessantes Werkzeug für die Mikrochirurgie dar. Dieses würde in vielen Fällen neue Operationsmöglichkeiten bzw. Präparationstechniken von biologischem Gewebe eröffnen.

Um diese beiden Technologien miteinander vereinen zu können, wurde ein faserbasiertes Fourier-Domain-OCT aufgebaut, welches in den Strahlengang eines fs-Lasers integriert wird. In einem ersten Schritt wird es alternierend mit der fs-Strahlquelle betrieben werden, um so eine Kontrolle des Operationsgebietes in situ zu ermöglichen.

Q 20.3 Di 11:00 5J

Fourier Domain Mode Locking (FDML): Neue Laser für die Optische Kohärenztomographie (OCT) — •Robert Huber[1,2], Desmond Adler[2], Vivek Srinivasan[2] und James Fujimoto[2] — [1]Lehrstuhl für BioMolekulare Optik, Ludwig-Maximilians-Universität München — [2]Massachusetts Institute of Technology, Cambridge, USA

Die optische Kohärenztomographie (OCT) [1] stellt ein vergleichsweise junges, optisches Bildgebungs-Verfahren dar, welches mit einer räumlichen Auflösung von wenigen Mikrometern die dreidimensionale Darstellung von Gewebekontrast erlaubt. Seit langem zielt die technologische Entwicklung neuer OCT-Systeme auf eine Erhöhung der Abbildungs-Geschwindigkeit ab, um Bewegungs-Artefakte zu vermeiden sowie dicht gerasterte, dreidimensionale Datensätze aufzunehmen. Derzeitige kommerzielle OCT-Systeme erreichen Abbildungs-Geschwindigkeiten im Bereich einiger tausend Linien pro Sekunde (axiale Abtastungen, A-Scans), was etwa 1-10 Bildern pro Sekunde entspricht. Durch einen neuen Operationsmodus von Lasers, der so genannten Fourier Domänen Moden Kopplung (FDML) [2], wird eine 100 bis 1000-fache Erhöhung der OCT-Abbildungsgeschwindigkeit möglich. Anwendungen verschiedener FDML basierter OCT-Systeme im Bereich der Entwicklungsbiologie, der Ophthalmologie und zur intravaskulären Bildgebung werden diskutiert.

1. Huang D et al. Science 254:1178-1181 (1991).
2. Huber R et al. Optics Express 14:3225-3237 (2006).

Q 20.4 Di 11:15 5J

Laserosteotomie mit gepulsten CO_2-Lasern — •Martin Werner[1,2], Mikhail Ivanenko[1], Manfred Klasing[1], Daniela Harbecke[1,2], Hendrik Steigerwald[1,3] und Peter Hering[1,2] — [1]Forschungszentrum caesar, Bonn — [2]Institut für Lasermedizin, Universität Düsseldorf — [3]Physikalisches Institut, Universität Bonn

Laserosteotomie - das Schneiden von Knochen mit Lasern - bietet Vorteile in vielen Feldern der operativen Medizin. Jedoch verhinderte bisher thermische Schädigung des angrenzenden Gewebes den Einsatz dieser Technik. Kurzgepulste CO_2-Laser in Kombination mit einem Wasserspray und einer in unserer Gruppe entwickelten Multi-Pass-Scann-Technik stellen eine effiziente und thermisch minimal belastende Möglichkeit dar Hartgewebe für medizinische Anwendungen zu bearbeiten. Um effizienten Abtrag mit minimalen Randeffekten zu erzielen sind ein tieferes Verständnis des Ablationsprozesses sowie spezielle Bestrahlungstechniken notwendig. Der Ablationsprozess basiert auf der schnellen Erhitzung des im Knochen eingeschlossenen Wassers, durch den resultierenden internen Druckanstieg wird der Knochen abgetragen. Resthitze wird zusammen mit ablatiertem Gewebe abtransportiert und eine thermische Schädigung des umliegenden Gewebes wird unterbunden. Histologische Untersuchungen belegen eine minimale thermische Schädigung in einer Zone von ca. 10 μm entlang der Laserschnittkante. Die Möglichkeit den Laserstrahl mit Hilfe eines Laserstrahlscanners frei über die Knochenoberfläche zu bewegen, erlaubt beliebige Schnittgeometrien und eine exzellente Basis für die Integration in medizinische Operationsplanungs- und Navigationssysteme.

Q 20.5 Di 11:30 5J

Spectral analysis of the acoustic signal during ablation of biological tissue with pulsed CO_2-lasers — •Hendrik Steigerwald[1,2], Martin Werner[1,3], Mikhail Ivanenko[1], Manfred Klasing[1], and Peter Hering[1,3] — [1]Center of advanced European studies and research (caesar), Bonn, Germany — [2]Rheinische Friedrich-Wilhellms-Universität, Bonn, Germany — [3]Institut für Lasermedizin, Heinrich-Heine-Ubiversität, Düsseldorf, Germany

Today osteotomy, the transection of bone, is still performed with drills, oscillating saws and chisels. The advantages of laser osteotomy are free cut geometry and minimal thermal damage. Due to the lack of haptic feedback there is need for an alternate feedback method for accurate laser osteotomy. Based on the frequency analysis of the acoustic signal, generated by the ablation process, we are developing a feedback system to obtain in situ information of the ablation process and for differentiation between different biological tissue. We used a pulsed slab CO_2-laser and piezoelectric sensors for sound detection. We studied the correlation of the acoustic ablation signal of different kinds of tissue in the frequency domain. Furthermore the time shift between the laser pulse and the optical signal generated by the ablation process is analyzed.

Q 20.6 Di 11:45 5J

Bohrungen im biologischen Hartgewebe mit kurzgepulsten CO_2-Lasern — •Daniela Harbecke[1,2], Martin Werner[1,2], Manfred Klasing[1], Mikhail Ivanenko[1], Hendrik Steigerwald[1], Christian Wagner[1] und Peter Hering[1,2] — [1]Lasertechnologie Gruppe, Forschungszentrum caesar, Bonn — [2]Institut für Lasermedizin, Universität Düsseldorf

Laserosteotomie - also das Abtragen von Knochengewebe - mittels kurzgepulster CO_2-Laserstrahlung bietet aufgrund geringer thermischer Schäden eine gute Möglichkeit, Bohrungen selbst von geringem Durchmesser ($\leq$ 1 mm) durchzuführen. Motivation war es, Bohrungen beliebiger Geometrie, Größe und Tiefe herstellen zu können, um z.B. darin Implantate einzusetzen. Solche Bohrungen sind in der Implantologie von großem Vorteil. Ein aktuelles Beispiel für die mögliche Anwendung dieser Laserbohrtechnik ist die Einsetzung eines Cochlea-Implantates. Die günstigsten Parameter für eine solche Anwendung mit einem kurzgepulsten CO_2-Laser wurden ermittelt.

Bei der Lasermaterialbearbeitung nimmt die Abtragseffizienz der Bohrungen bei zunehmender Tiefe ab. Zusätzlich werden runde Bohrungen elliptisch. Gewünscht sind Bohrungen, die auch in der Tiefe zylindrisch und formtreu bleiben. Mithilfe einer Fokusverschiebung des Laserstrahls relativ zur Knochenoberfläche sowie einer Änderung des Kontur-/Füllmusterverhältnisses der Bohrung wurden Konizität und Elliptizität des Bohrloches stark vermindert.

Q 20.7 Di 12:00 5J

Untersuchungen zur Presbyopiebehandlung mittels fs-Laser — •Heike Theuer[1], Silvia Schumacher[1], Uwe Oberheide[2], Michael Schäfer[1], Michael Fromm[1], Tammo Ripken[1], Georg Gerten[2] und Holger Lubatschowski[1] — [1]Laser Zentrum Hannover e. V., Hollerithallee 8, 30419 Hannover — [2]Laserforum e. V., Schildergasse 107-109, 50667 Köln

Die als Presbyopie (Alterweitsichtigkeit) bezeichnete Einschränkung der Akkommodationsfähigkeit beruht auf dem natürlichen Alterungsprozess der Augenlinse von Geburt an. Die zum Fokussieren erforderliche Brechkraftzunahme wird erzielt, indem die Linse auf Grund ihrer elastischen Kräfte ihre kugelförmige Ruhelage anstrebt. Dieser Vorgang, Akkommodation genannt, wird durch die zunehmende Sklerosierung des Linsenkerns, verbunden mit einem Elastizitätsverlust der Linsenkapsel mit zunehmendem Alter beeinträchtigt und macht sich im Alter von etwa 45 Jahren bemerkbar. Momentan erfolgt die Korrektur der Presbyopie üblicherweise in Form einer Brille für die Nähe. Als Alternative bietet sich eine Laserbehandlung an, um der natürlichen Verhärtung der Linse und dem damit einhergehenden Verlust der Akkommodationsfähigkeit entgegen zu wirken. Hierbei werden mit Hilfe von fs-Laserpulsen Mikroschnitte in die Augenlinse eingebracht. Durch entsprechende Schnittgeometrien ergeben sich Gleitebenen, die eine Flexibilitätsrückgewinnung der Linse bewirken. Aktuelle Ergebnisse über die Auswirkungen der Behandlung auf die Geometrie der Augenlinse werden erläutert.

Q 20.8 Di 12:15 5J

Schwellwertbestimmungen zum Schneiden im biologischen Gewebe in Abhängigkeit der Repetitionsrate — •Sarah Schmidt, Silvia Schuhmacher, Tammo Ripken, Alexander Heisterkamp, Wolfgang Ertmer und Holger Lubatschowski — Laser Zentrum Hannover e. V., Hannover, Deutschland

Zunehmend werden fs-Laser zur Bearbeitung biologischer Materialien eingesetzt. Anwendungen finden sie beispielsweise bei der Fehlsichtigkeitkorrektur und in der Nanochirurgie an einzelnen Zellen. Obwohl das Schneiden mit fs-Laserpulsen sowohl im kHz- als auch im MHz-Repititionsratenbereich bereits erfolgreich angewendet wird, gibt es noch keine genauen Kenntnisse über die Zusammenhänge der Pulsenergie, Pulsanzahl und Repetitionsrate, die das effektivste Schneiden ermöglichen und somit eine optimale und schonende Behandlung garantieren. Um die Varianz des biologischen Gewebes bei den grundlegenden Versuchen zur Optimierung des Schneidens ausschließen zu können, wurden zunächst entsprechende Untersuchungen in Glas durchgeführt. Die Schwelle des optischen Durchbruchs wurde in Abhängigkeit der Repetitionsrate bei unterschiedlichen Numerischen Aperturen untersucht. Dabei wurde jeweils die Pulsanzahl variiert und somit eine Abhängigkeit zwischen der Anzahl der Pulse und der Leistung, bzw. der Repetitionsrate und der Pulsanzahl geschaffen. Anschließend wurden die gleichen Untersuchungen in Polyacrylamidgel, eine gewebeähnliche Substanz, bei der der Wassergehalt entsprechend des Gewebes variiert werden kann, durchgeführt. Die Ergebnisse und die unterschiedlichen, beobachteten Effekte werden präsentiert.

Q 20.9 Di 12:30 5J

Volldigitale holographische Gesichtsvermessung mit einem kurzgepulsten Laser — •Sven Hirsch[1,2,4], Stephanie Heintz[1,3], Andrea Thelen[1], Nicola Gisbert[1] und Peter Hering[1,4] — [1]Stiftung caesar, Ludwig-Erhard-Allee 2, 53175 Bonn — [2]Hightech Research Center of Cranio-Maxillofacial Surgery, University Hospital Basel, Schanzenstrasse 46, CH-4031 Basel — [3]Hochschule Furtwangen University, Robert-Gerwig-Platz 1, 78120 Furtwangen — [4]Institut für Lasermedizin, Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

Mit gepulster Holographie wird die Oberfläche eines lebenden Objektes dargestellt. Eine Referenzwelle wird mit der vom Objekt rückgestreuten Welle off-axis auf einem CCD-Sensor überlagert. Das Objekt wird mit einem einzigen Laserpuls (Nd:YAG) von 20 ns Länge holographisch erfasst. Mit Kenntnis der Aufnahmeparameter wird das ursprüngliche Wellenfeld schichtweise aus dem Interferenzmuster numerisch rekonstruiert. Die so berechneten Schnitte setzt man zu einem Bilderstapel zusammen.

Die räumliche Auflösung des reelen Bildes ist vom Objektabstand und der Sensorgröße abhängig und unterscheidet sich stark in lateraler (ca. 30 μm) und axialer (ca. 1 mm) Richtung. Im reelen Bild sind scharfe und unscharfe Bereiche überlagert. Durch Filterungen und Beleuchtungsoptimierung werden Artefakte im Bild unterdrückt. Ein numerisches Verfahren identifiziert scharfe Bildbereiche und setzt aus diesen eine Höhenkarte zusammen, gleichzeitig wird die Textur des Objektes pixelgenau extrahiert.

Q 21: Quanteneffekte (Offene und Wenigteilchensysteme)

Zeit: Dienstag 10:30–12:30 Raum: 5E

Q 21.1 Di 10:30 5E

Monitoring approach to open quantum dynamics — •Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München

A general method will be discussed to obtain Markovian master equations which describe the interaction with the environment in a non-perturbative and microscopic fashion [1,2]. It is based on combining time-dependent scattering theory with the concept of continuous quantum measurements. As two nontrivial applications, I will outline how this yields the master equation for the internal dynamics of a trapped molecule in a gaseous environment, and the exact quantum linear Boltzmann equation for a Brownian point particle.

[1] K. Hornberger, Phys. Rev. Lett. 97, 060601 (2006).
[2] K. Hornberger, quant-ph/0612078

Q 21.2 Di 10:45 5E

Casimir force between planar mirrors in the real world — •Francesco Intravaia and Carsten Henkel — Universitaet Potsdam, Institut fuer Physik, Am Neuen Palais 10, 14469 Potsdam, Germany

In the field of nanotechnology, there is a considerable interest in manipulating the Casimir force (both in magnitude and sign) playing with geometry and material structure. The benefit one can possibly achieve under realistic experimental conditions depends on properties like microscopic surface roughness, finite conductivity, material temperature, as shown by the comparison of accurate measurements with theory [1]. Regarding the sign of the force, we have recently identified a parameter range for Casimir repulsion within a certain class of artificial (or meta-) materials [2]. Our current activities aim at improving the understanding of dispersion forces between non-local or dissipative media that pose intriguing theoretical challenges on their own. Both aspects play a role for the finite-temperature correction to the Casimir force, for example, on which a consensus is currently lacking. We investigate a particular non-local model that allows us to perform calculations from first principles and to assess the limits and scope of the widely used Lifshitz formula.

[1]S. K. Lamoreaux. The casimir force: background, experiments, and applications. Reports on Progress in Physics 68, 201-236, 2005.
[2]C. Henkel and K. Joulain. Casimir force between designed materials: What is possible and what not. Europhys. Lett.72, 929-935, 2005.

Q 21.3 Di 11:00 5E

Application of the quantum jump approach to a spin-boson model — •Jens Timo Neumann[1], Gerhard C. Hegerfeldt[1], and Lawrence S. Schulman[2] — [1]Institut für Theoretische Physik, Univ. Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Physics Department, Clarkson University, Potsdam, NY 13699-5820, USA

The quantum jump approach has proved itself as a useful tool for the

investigation of many quantum optical issues as, e.g., photon statistics, cooperative effects of atoms in a trap, or quantum optical models for arrival-time measurements for ultracold atoms. It treats the limit of continuous photon modes under the assumption that the Markov property holds. In this talk, the domain of applicability of the quantum jump approach is extended beyond quantum optics. In particular, we investigate the application of the quantum jump approach to a spin-boson model. We also investigate by means of numerical examples the validity of the quantum jump approach as a convenient and accurate approximation to situations where one actually has to deal with a number of discrete bath modes.

1. G. C. Hegerfeldt, J. T. Neumann, and L. S. Schulman, J. Phys. A **39**, 14447 (2006)
2. G. C. Hegerfeldt, J. T. Neumann, and L. S. Schulman, quant-ph/0610041 (2006), to appear in Phys. Rev. A [scheduled: issue 1 of Phys. Rev. A **75** (2007)]

Q 21.4 Di 11:15 5E

Quantum Efficiency of Atomic Extraction from an Ultracold Atomic Reservoir — Bernd Mohring[1], Giovanna Morigi[2], •Eric Lutz[3], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik, Universität Ulm, 89069 Ulm, Germany — [2]Grup d'Optica, Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain — [3]Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

We study the efficiency of coherent extraction of cold atoms from a reservoir, a Bose-Einstein condensate (BEC), as in the setup proposed in [1]. Here, the atoms are coherently transferred from a BEC to the ground state of a steep microtrap in the collisional blockade regime by means of a laser. In this setup, the condensate excitations constitute a source of quantum noise, which is non-Markovian in the parameter regime of interest. To describe the dynamics for this realization of quantum tweezers we derive a master equation. Using the time-convolutionless projection operator technique [2] we obtain a closed equation for the reduced system — ground state of the condensate and ground state of the microtrap — which allows us to investigate the quantum efficiency of extraction.

[1] B. Mohring *et al.*, Phys. Rev. A **71**, 053601 (2005)
[2] H.-P. Breuer *et al.*, Ann. Phys. (NY) **291**, 36 (2001)

Q 21.5 Di 11:30 5E

Repulsively bound atom paris in an optical lattice — Gregor Thalhammer[1], Klaus Winkler[1], •Florian Lang[1], Rudolf Grimm[1,3], Johannes Hecker Denschlag[1], Andrew Daley[2,3], Adrian Kantian[2,3], Hans Peter Büchler[2,3], and Peter Zoller[2,3] — [1]Institut für Experimentalphysik, Universität Innsbruck, Österreich — [2]Institut für Theoretische Pysik, Universität Innsbruck, Österreich — [3]Institut für Quantenoptik und Quanteninformation, Innsbruck, Österreich

Throughout physics, stable composite objects are usually formed by way of attractive forces, which allow the constituents to lower their energy by binding together. Repulsive forces separate particles in free space. However, in a structured environment such as a periodic potential and in the absence of dissipation, stable composite objects can exist even for repulsive interactions. We have recently[1] observed such an exotic bound state, which comprises a pair of ultracold rubidium atoms in an optical lattice. Consistent with our theoretical analysis, these repulsively bound pairs exhibit long lifetimes, even under conditions when they collide with one another. Signatures of the pairs are also recognized in the characteristic momentum distribution and through spectroscopic measurements. There is no analogue in traditional condensed matter systems of such repulsively bound pairs, owing to the presence of strong decay channels.

[1] *Nature* **441**, 853 (2006)

Q 21.6 Di 11:45 5E

Eine neue 4π-Geometrie zur Anregung eines einzelnen Ions — •Robert Maiwald, Hildegard Konermann, Norbert Lindlein und Gerd Leuchs — Institut für Optik, Information und Photonik, Max-Planck-Forschungsgruppe, Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1, Bau 24, 91058 Erlangen, Germany

Es wird eine Methode vorgestellt, welche die optische Anregung eines Dipolübergangs in einem Ion praktisch aus dem gesamten 4π-Raumwinkel ermöglicht. Hierbei wird radial polarisiertes Licht verwendet, welches sowohl kleinste Foki als auch starke Dipolkopplung ermöglicht. Durch eine Kombination aus einer diffraktiven Linse und einem Parabolspiegel wird das Licht konditioniert und fokussiert. Eine für den Zweck optimierte Ionenfalle lässt nahezu den gesamten Raumwinkel als optischen Zugang zu. Durch die vorgeschlagene Anordnung werden direkte Untersuchungen der Photonenabsorption an Ionen möglich, gleichzeitig ist die Methode im Bereich der 4π-Mikroskopie zur effizienten Detektion anwendbar.

Q 21.7 Di 12:00 5E

AC-control of single particle tunneling — •Elisabeth Kierig, Arne Schietinger, Ute Schnorrberger, Jiri Tomkovic, Joachim Welte, and Markus Oberthaler — Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

We report on the results of our experimental studies of periodically driven quantum tunneling systems. By changing the symmetry of the double-well at a special frequency it is possible to strongly suppress tunneling. This effect is known as coherent destruction of tunneling [1].

The experimental setup utilizes a slow intensive beam of metastable argon atoms combined with spatially resolved single atom detection.The periodic double-well potential is realized adding two standing light waves with periodicity λ and $\lambda/2$. A further standing light wave resonant with an open transition allows the preparation of atoms localized in every second well. The driving is implemented by changing the phase between the two standing light waves creating the double-wells.

We compare our experimental findings with the full solution of the Floquet theory and the prediction within the simple two mode model. We find quantitative agreement of the tunneling time as a function of driving frequency and driving amplitude.

[1] F. Grossmann, T. Dittrich, P. Jung, and P. Hänggi, Phys. Rev. Lett. **67**, 516 (1991)

Q 21.8 Di 12:15 5E

Photon emission of a single trapped ion into a cavity — •Carlos Russo[1], Eoin Philips[1], Helena Barros[1], Andreas Stute[1], Christoph Becher[1,3], Piet Schmidt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck,Technikerstraße 25, A-6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, A-6020 Innsbruck, Austria — [3]Fachrichtung 7.3 (Technische Physik), Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken, Germany

In our setup, a single trapped $^{40}Ca^{+}$ ion is coupled to an optical resonator. We generate photons in the cavity mode continuously, by exploiting vacuum-stimulated Raman transitions between the Zeeman substates of the $S_{1/2}$ and $D_{3/2}$ manifolds. The pump laser at 397 nm is off-resonant to the $S_{1/2} \rightarrow P_{1/2}$ transition, and the cavity is detuned from the $P_{1/2} \rightarrow D_{3/2}$ transition. The $D_{3/2}$ state is continuously repumped by a near-resonant laser at 866 nm. Depending on the pump laser polarisation, we can choose between two photon emission patterns with different spectral properties. In either case, the polarisation of the generated photons is well defined. We find good qualitative agreement of the experimental results with density matrix simulations. A variation of the scheme using pump laser pulses allows for the implementation of a deterministic single photon source.

Q 22: Ultrakalte Plasmen und Rydberg-Gase (gemeinsam mit A)

Zeit: Dienstag 10:30–12:15 Raum: 5M

Hauptvortrag Q 22.1 Di 10:30 5M

Rydberg atom and molecule optics — •Frederic Merkt, Edward Vliegen, and Stephen Hogan — ETH Zurich, Zurich, Switzerland

Recent experiment are reviewed in which the velocity distributions of Rydberg atoms and molecules have been influenced by the use of inhomogeneous fields. The experiments rely on the very large dipole moments exhibited by Rydberg Stark states and the large forces that can be applied on the particles by inhomogeneous electric fields. Typical experiments rely on the photoexcitation of cold atoms and molecules in skimmed supersonic beams to Rydberg Stark states. When propagating through regions of space in which inhomogeneous electric fields are applied, the particles are subject to strong forces [1]. Carefully designed electrode configurations enable the application of very large forces. By optimizing the time dependence of the applied electric fields the forces applied on the atoms can be adapted to the instantaneous positions of the particles [2,3]. Based on these principles, we have realised several devices such as Rydberg atom deflectors [1], accelerators and decelerators [1-4], a Rydberg atom mirror [5], and two-dimensional and three-dimensional traps for Rydberg atoms and molecules.

[1] S. R. Procter, Y. Yamakita, F. Merkt and T. P. Softley, Chem. Phys. Lett. 374, 667 (2003) [2] E. Vliegen, H.J. Woerner, T.P. Softley and F. Merkt, Phys. Rev. Lett. 92, 033005 (2004) [3] E. Vliegen and F. Merkt, J. Phys. B 38, 1623 (2005) [4] E. Vliegen and F. Merkt, J. Phys. B 39, L241 (2006) [5] E. Vliegen and F. Merkt, Phys. Rev. Lett. 97, 033002 (2006)

Fachvortrag Q 22.2 Di 11:00 5M

Rydberg excitation in the strong blockade regime: from thermal cloud to BEC — •Vera Bendkowsky[1], Rolf Heidemann[1], Ulrich Raitzsch[1], Björn Butscher[1], Helmar Bender[1], Robert Löw[1], Luis Santos[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [2]Institut für Theoretische Physik, Universität Hannover, Appelstraße 2, 30167 Hannover

The van der Waals interaction of Rydberg atoms can - depending on the atomic density and the excitation strength - lead to a supression of Rydberg excitation in a cloud of ground state atoms. In this blockade regime the atomic sample can be considered as consisting of many blockade spheres with N ground state atoms within a sphere but only one excited Rydberg atom.

In our experiments we excite magnetically trapped Rubidium atoms at temperatures between a few μK and BEC to the 43S state. In the thermal cloud we observe saturation in the Rydberg excitation for a large range of densities and Rabi frequencies Ω_0. As expected for coherent collective excitation of any mesoscopic system the initial excitation rate is proportional to $\sqrt{N}\Omega_0$. The scaling of the saturation value is investigated with respect to N and Ω_0.

Furthermore we present first results on Rydberg excitation in a BEC. The measurements show a clear signature of Rydberg excitation within the BEC. The results are compared with a mean field calculation for the quantum dynamics above and below T_c.

Q 22.3 Di 11:30 5M

Observation of Rabi cycles and coupling to continuum states in the excitation of a mesoscopic cloud of cold atoms to Rydberg levels — •Markus Reetz-Lamour, Thomas Amthor, Johannes Deiglmayr, Sebastian Westermann, Janne Denskat, and Matthias Weidemüler — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg

Ultracold Rydberg gases are a possible candidate for quantum information processing combining the coherence properties of ground state atoms with strong Rydberg-Rydberg interaction for fast quantum gates [1]. While the coherent character of Rydberg-Rydberg interaction has been confirmed in a number of experiments [2], the realization of q-bits itself turned out to be rather challenging.

We will present the experimental ingredients to drive Rabi cycles between the electronic ground states and Rydberg states in a mesoscopic cloud of ∼100 laser-cooled ^{87}Rb atoms, which is the essential ingredient for constructing qbits with Rydberg atoms. We will also show how this coherent excitation can be used to study coupling to a quasi-continuous large subset of Rydberg states. This leads to effects very similar to Fano resonances.

[1] Jaksch *et al.*, PRL **85**, 2208 (2000), Lukin *et al.*, PRL **87**, 037901 (2001)
[2] *E.g.* Anderson *et al.*, PRA **65**, 063404 (2002), Westermann *et al.*, EPJ D **40**, 37 (2006)

Q 22.4 Di 11:45 5M

Simulating the dynamics of strongly coupled many-particle plasmas at low temperatures. — •Michael Bussmann[1], Ulrich Schramm[2], and Dietrich Habs[1] — [1]Department f. Physik, Ludwig-Maximilians-Universität Muenchen, Am Coulombwall 1, 85748 Garching — [2]Forschungszentrum Dresden Rossendorf, Bautzner Landstraße 128, 01328 Dresden

The dynamics of strongly coupled plasmas at mK temperatures are studied for the special case of stopping highly charged ions in a laser cooled plasma of $N = 10^5$ $^{24}Mg^+$ ions [1].
Using a parallel simulation code the stopping process is studied with respect to stopping times, plasma stability and recooling efficency [2]. It is shown that the proposed cooling scheme is feasible for cooling highly charged rare ions to mK temperatures without suffering from ion loss due to charge exchange.
In the outlook we present examples of simulations of strongly coupled plasmas in beam and trap physics illustrating the capabilities of the simulation with regard to investigating many-particle systems at low temperatures.

[1] M. Bussmann, U. Schramm, V. Kolhinen, J. Szerypo, D. Habs, *Int. J. of Mass Spectrometry* **251** (2006) 179-189
[2] M. Bussmann, U. Schramm, D. Habs, *AIP Conference Proceedings* **862** (2006), 221-231

Q 22.5 Di 12:00 5M

Ultracold negative ions — •Jan Meier — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029

Currently no technique exists which allows the cooling of negative ions to a temperature lower than that of the surrounding trap. Laser cooling of negative osmium ions holds the prospect of achieving temperatures well below 1 mK. Cooling antiprotons with this technique might open the door to forming antihydrogen at ultra-cold temperatures, thus allowing precision antimatter studies.

Q 23: Kalte Moleküle I (gemeinsam mit MO)

Zeit: Dienstag 10:30–12:45 Raum: 6B

Hauptvortrag Q 23.1 Di 10:30 6B

Ultracold Molecular Ions in Radiofrequency Traps - Production and Spectroscopy — •Bernhard Roth, Jeroen Koelemeij, Chaobo Zhang, David Offenberg, Andreas Wicht, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, Universitätsstr. 1, D-40225 Düsseldorf

A general method for the production of translationally cold charged molecules is sympathetic cooling by laser-cooled atomic ions. Recently, we have shown that using two coolant species only (beryllium and barium ions) molecular ions with masses from 2 to 470 amu can be cooled to temperatures of 10-100 mK. The wide range of coolable species makes the method attractive for many studies in chemical physics, molecular physics, fundamental physics, and astrochemistry. Since the molecular ions can be trapped for times exceeding minutes in a near-

collision-less environment, light-molecule and molecule-molecule interactions in a new regime can be studied. Examples are precise spectroscopy, molecular quantum state preparation, internal coherence, interactions with neutral particles, spontaneous emission. In this talk we will describe preparation methods, spectroscopy results and outline future developments.

Q 23.2 Di 11:00 6B

Chemical Probing Spektroskopie von H_3^+ in einer kryogenen RF-Falle — •Max Berg, Annemieke Petrignani, Dennis Bing, Andreas Wolf und Holger Kreckel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Das H_3^+ Molekülion spielt eine fundamentale Rolle in der Chemie des interstellaren Mediums, insbesondere für das Reaktionsnetzwerk in kalten Molekülwolken. Um aussagekräftige Messungen bei niedrigen Temperaturen (10-100 K) zu machen muss H_3^+ aktiv gekühlt werden, da wegen des fehlenden Dipolmoments die radiative Kühlung zu ineffektiv ist. Zu diesem Zweck wurde am Speicherring TSR eine 22-Pol Injektor-Falle entwickelt in der H_3^+ Ionen durch Stösse mit Helium Puffergas auf interstellare Temperaturen gekühlt werden können. Um die Population in den niedrigsten Rotationszuständen von H_3^+ nachzuweisen wird eine Chemical Probing Spektroskopie eingesetzt deren gesteigerte Sensitivität Messungen mit wenigen hundert Ionen ermöglicht. Besonderes Augenmerk wird dabei auf den Kernspin von H_3^+ gelegt und es wird gezeigt, dass die Nutzung von para-H_2 Gas eine Manipulation des ortho/para-Verhältnisses von H_3^+ erlaubt.

Q 23.3 Di 11:15 6B

A negative ion proton transfer reaction at extremely low temperatures — •Rico Otto, Jochen Mikosch, Sebastian Trippel, Christoph Eichhorn, Markus Debatin, Matthias Weidemüller, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Using a low-temperature 22-pole ion trap we have studied the reaction of NH_2^- with molecular hydrogen in the temperature interval from 300 down to 8 Kelvin. We access in this experiment the, for negative ions previously unexplored, temperature regime below 25 Kelvin. For NH_2^- + H_2 we observe an unexpected decrease of the reaction rate coefficient at low temperatures, which is indicative of a very small reaction barrier. In this presentation we will present the new low-temperature 22-pole trap setup, the employed experimental scheme to obtain absolute reaction rate coefficients, and the measurements for the proton transfer from H_2 to NH_2^-. We will then discuss the current status of the interpretation of the measured rate coefficient. In future experiments we will investigate in how far the temperature dependence of the studied proton-transfer reaction represents a general behaviour of negative ion reactions at low temperature.

Q 23.4 Di 11:30 6B

Photodetachment of cold OH^- in a multipole ion trap — •Sebastian Trippel, Jochen Mikosch, Raphael Berhane, Rico Otto, Matthias Weidemüller, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Negative ion photodetachment is the basis of many photoelectron spectroscopy studies. It is also a fundamental destruction process for negative ions in the environment. We have developed a method to deterimine the absolute photodetachment cross section of negative ions using a 22-pole radiofrequency ion trap. Previous studies have shown that these traps are well suited for collisional cooling of molecular vibrational and rotational states. In this work we present results for the photodetachment of trapped OH^- ions at 170 K rotational temperature. We obtain the absolute cross section in a direct and model-independent approach by measuring the decay constant of the trapped ions due to photodetachment. The density of ions interacting with the laser is measured in a tomography scan through the trap. In comparison with previous results, the cross section shows a sensitive dependence on the initial rotational state distribution. These results indicate that the rotational state dependence of the cross section is given by $(2J + 1)$, where J is the rotational quantum number of OH^-. This rotational-state dependence might be relevant for models of the abundance of negative ions in the atmosphere or in interstellar space.

[1] S. Trippel *et al.*, Phys. Rev. Lett. 97, 193003 (2006)

Q 23.5 Di 11:45 6B

Production of Cold Neutral Molecules via the Deceleration and Photodetachment of Anions — •Andreas Osterwalder, Thomas Middelmann, and Gerard Meijer — Fritz-Haber-Institut der MPG, 14195 Berlin

A new method for the production of cold neutral molecules is presented: the molecules are prepared as negative ions, decelerated, and subsequently neutralized by photodetachment.

The neutrals shall be investigated by high-resolution spectroscopy and used for chemical dynamics research in the range below 10 K. Experiments in this temperature range are essential for a complete understanding of astrochemistry and of many fundamental aspects of scattering dynamics. Nevertheless, no experimental data are available.

The new approach has the following advantages over existing techniques:

1. It is very general since it can be applied to any neutral molecule that possesses a stable anion (which is the case for many molecules, ranging from small diatomics to large bio molecules);

2. A single species can be selected for the deceleration by coupling a mass-spectrometer to the deceleration apparatus;

3. Because the neutral is formed only at the very end of the deceleration procedure the technique is also well-suited for short-lived and reactive species (in particular also for radicals);

4. The choice of the detachment wave length allows the production of the neutral in the ground state or in an excited state.

Q 23.6 Di 12:00 6B

A molecular synchrotron — •Cynthia E. Heiner[1], David Carty[1], Hendrick L. Bethlem[1,2], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Laser Centre Vrije Universiteit, Amsterdam, The Netherlands

The tools for manipulating the motion of neutral atoms and molecules are inspired from the techniques developed for charged particles. Traps for atoms, akin to the Paul trap for ions, are widely implemented; surprisingly however, little attention has been paid to developing a neutral analog of a synchrotron. One great advantage of a synchrotron over a trap is that (many) bunches of cold molecules can be made to interact repeatedly, at well defined times and distinct positions with electromagnetic field and/or particles.

I will present recent results demonstrating a molecular synchrotron consisting of two hexapoles bent into a semi-circle separated by a 2 mm gap. I will detail our simple scheme for exploiting the fringe fields in these gaps to accelerate, decelerate, and focus along the longitudinal direction ("bunch") a packet of ammonia molecules. The stored bunch of cold molecules (T=0.5 mK) is confined to a 3 mm packet even after completing 40 roundtrips, which corresponds to a flight distance of over 30 meters. Furthermore, the injection of multiple packets into the ring will be shown.

Q 23.7 Di 12:15 6B

Efficient Cooling in Supersonic Jet Expansions of Supercritical Fluids — •Wolfgang Christen[1], Klaus Rademann[1], and Uzi Even[2] — [1]Institut für Chemie, Humboldt-Universität zu Berlin, Brook-Taylor-Strasse 2, 12489 Berlin, Germany — [2]Sackler School of Chemistry, Tel Aviv University, 69978 Tel Aviv, Israel

Pulsed, supersonic beams of carbon monoxide and carbon dioxide at stagnation conditions above their critical point have been investigated by time-of-flight measurements as a function of pressure and temperature[2]. Surprisingly large speed ratios (above 100) have been achieved that are indicative of very low translational temperatures ($\leq$ 0.1 K). In particular, the supersonic expansion of CO_2 at stagnation temperatures slightly above the phase transition to the supercritical state results in unprecedented cold beams. This efficient cooling is attributed to the large values of the heat capacity ratio of supercritical fluids in close vicinity of their critical point.

[1] Wolfgang Christen, Klaus Rademann, Uzi Even, *J. Chem. Phys.* **125**, 174307 (2006).

Q 23.8 Di 12:30 6B

Beams of slow and heavy molecules for interferometry — •András Major, Hendrik Ulbricht, Sarayut Deachapunya, and Markus Arndt — Fakultät für Physik, Universität Wien, Boltzmanngasse 5, A-1090 Wien

We show experimentally that an effusive source can create a slow beam of large molecules. Owing to the very slow speeds achieved with these molecules, whose molecular weights are comparable to that of insulin, this source promises exciting new possibilities in interferometry as well as the cooling and trapping of these molecules. This report also

presents a theoretical evaluation of the results with the emphasis on supersonic expansion of the beam.

Q 24: Quantengase (Bosonische Gitter II)

Zeit: Dienstag 14:00–16:00 Raum: 6J

Q 24.1 Di 14:00 6J

A tunable quantum gas in an optical lattice — •Elmar Haller, Mattias Gustavsson, Gabriel Rojas-Kopeinig, Anton Flir, Manfred Mark, and Hanns-Christoph Nägerl — Insitut für Experimentalphysik, Innsbruck, Austria

We report on the experimental progress of loading a Bose-Einstein condensate (BEC) with 1e5 Cs atoms into 1D and 3D optical lattices to observe its dynamics as a function of interaction strength. A BEC with Cs atoms represents a tunable quantum gas as the s-wave scattering length can be widely tuned near Feshbach resonances. In the 1D case Bloch oscillations and Bragg scattering can be investigated as the interaction strength is tuned. Collisional dephasing is expected to be suppressed in the limit of weak interactions. In the 3D case the superfluid-to-Mott-insulator transition can be studied as a function of the scattering length. In particular, for a given finite depth of the 3D lattice the transition can be induced via a variation of the on-site interaction energy.

Q 24.2 Di 14:15 6J

Dynamics of correlations and quantum phase transitions in bosonic lattice systems — •Oliver Buerschaper, Ignacio Cirac, and Michael Wolf — Max-Planck-Institute of Quantum Optics, Garching, Germany

We establish upper bounds on the propagation velocity of correlations in bosonic systems on arbitrary lattices for a wide class of interactions. It is shown that there exists an effective causal cone outside of which correlations between distant regions of the lattice are suppressed exponentially. Furthermore we discuss the implications of this result on the dynamics of quantum phase transitions in the Bose-Hubbard model.

Q 24.3 Di 14:30 6J

Bose-Fermi-Gemische in einem 3D optischen Gitter — •Thorsten Best, Dries van Oosten, Tim Rom, Ulrich Schneider, Sebastian Will, Lucia Hackermüller, Martin Zwierlein und Immanuel Bloch — Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

Sympathetisches Kühlen von Mischungen verschiedener atomarer Spezies hat eine Vielzahl neuer Experimente ermöglicht. Die Untersuchung der reichhaltigen Phasendiagramme steht erst am Anfang, dennoch wurden bereits Hinweise auf eine Vielzahl nichttrivialer Wechselwirkungseffekte gefunden. Diese reichen von Phasenseparation über Kollapsdynamik bis zur Veränderung von Transporteigenschaften.

In unserem Experiment kühlen wir eine Mischung von bosonischem ^{87}Rb und fermionischem ^{40}K zur Quantenentartung in einer gekreuzten Dipolfalle. Mittels adiabatischer Radiofrequenz- und Mikrowellenübergänge können wir verschiedenste Zustandskombinationen präparieren. Die Mischung wird dann in ein dreidimensionales optisches Gitter geladen.

Wir berichten über den aktuellen Stand unserer Experimente mit Bose-Fermi-Mischungen. Der Schwerpunkt liegt dabei auf der Dynamik und der Rolle der Wechselwirkung beim Einladen ins optische Gitter. Ziel dieser Untersuchungen ist die effiziente und zuverlässige Präparation von Paaren fermionischer und bosonischer Atome auf den Gitterplätzen. Diese können als Startpunkt für vielfältige weitere Experimente dienen, z.B. für die effiziente Bildung heteronuklearer Moleküle.

Q 24.4 Di 14:45 6J

Ultra cold atomic gases in non-Abelian gauge fields — •Andreas Jacob[1], Luis Santos[1], Patrik Öhberg[4], Michael Fleischhauer[3], Julius Ruseckas[2], and Gediminas Juzeliunas[2] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Institute of Theoretical Physics and Astronomy of Vilnius University — [3]Universität Kaiserslautern — [4]Heriot-Watt University, Edinburgh

We analyze the physics of ultra cold neutral atoms subject to non-Abelian gauge fields. Such fields can be generated either by manipulating the hopping rates in optical lattices or by employing degenerated dark states. We pursue the latter possibility and discuss a simple laser arrangement that allows for the observation of non-Abelian effects in atom interferometers. Additionally, we discuss the effects that the non-Abelian character of the gauge fields have in the spectrum of the corresponding Landau levels, showing that the non-Abelian effects can become evident in experiments with fermionic gases, by monitoring the corresponding de-Haas-van-Alphen effect.

Q 24.5 Di 15:00 6J

Vielteilchendynamik von repulsiv gebundenen Teilchenpaaren in einem periodischen Potential — David Petrosyan[1,2], •Bernd Schmidt[1], James R. Anglin[1] und Michael Fleischhauer[1] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Institute of Electronic Structure & Laser, FORTH, 71110 Heraklion, Crete, Greece

Kürzlich wurden von Winkler *et al.* [Nature **441**, 853 (2006)] repulsiv gebundene Atompaare in einem optischen Gitter vorhergesagt und beobachtet. Die Dynamik eines solchen Gittersystems lässt sich gut durch das Bose-Hubbard Model beschreiben, wenn die Teilchen auf das niedrigste Energieband beschränkt sind. Wenn die Abstoßung zwischen Teilchen größer ist als die Einteilchentunnelrate zwischen benachbarten Töpfen des periodischen Potentials, dann sind solche Dimerzustände an einem Gitterplatz lokalisiert und stabil auf einer Zeitskala auf der man die Energiedissipation vernachlässigen kann.

Wir stellen einen effektiven Vielteilchen-Hamiltonoperator für ein Gitter vor, das nur eine gerade Anzahl von Teilchen pro Gitterplatz hat. Einige Implikationen dieses Hamiltonoperators für die Dynamik werden diskutiert. Insbesondere zeigen wir, dass sich Dimere auf benachbarten Seiten anziehen, was zu einer Clusterbildung von Dimeren mit gleichmäßiger, kommensurabler Gitterplatzfüllung führt.

Q 24.6 Di 15:15 6J

Response of Bose Gases in time-dependent Optical Superlattices — •Markus Hild, Felix Schmitt, Ilona Tuerschmann, and Robert Roth — Institut fuer Kernphysik, Technische Universitaet Darmstadt

We discuss dynamical signatures of quantum phase transitions in inhomogeneous one-dimensional lattice potentials. The many-body system is treated in the framework of the Bose-Hubbard model in a basis spanned by the physically relevant Fock states. Based on the explicit time-evolution of the many-body state we simulate recent experiments using Bragg spectroscopy via modulation of the lattice amplitude. The response of the gas is characterised by the energy transfer. Beyond the direct evaluation of the energy transfer we also investigate the connection between energy transfer and the matter-wave interference patterns, which are accessible in experiments.

Q 24.7 Di 15:30 6J

Ultracold Gases in 1D Optical Lattices: Exact Diagonalisation vs. Perturbation Theory — •Felix Schmitt, Markus Hild, Ilona Tuerschmann, and Robert Roth — Institut fuer Kernphysik, Technische Universitaet Darmstadt

We discuss several approaches to treat ultracold atomic gases in inhomogeneous 1D optical lattices within the Bose-Hubbard framework. Exact diagonalisation techniques, as one of these approaches, suffer from the restriction in system size due to the factorial growth of the many-particle basis. Employing a physically motivated adaptive basis truncation scheme we can reduce the basis size by more than two orders of magnitude without significant errors in all accessible observables. Moreover, a straightforward perturbative method is used to extend the system size further. Our aim is to reach experimentally relevant system sizes, to study inhomogeneous lattice topologies, and to investigate finite-size effects.

Q 24.8 Di 15:45 6J

Glassy behavior of Bose-Bose mixtures in one-dimensional optical lattices — •Tommaso Roscilde and Juan Ignacio Cirac — Max-Planck-Institut fuer Quantenoptik, Garching b. Muenchen

We numerically investigate the properties of strongly repulsive two-boson mixtures in one-dimensional optical lattices, targeting their ground state either by slow cooling from high temperature, or by a slow change in the Hamiltonian parameters starting from the weakly interacting regime. The two bosonic species have very different effective masses, so that the slow bosons can act as an effective potential to the faster ones. When the interspecies repulsion is strong compared with the intraspecies one, a phase-separated ground state is masked by an exponentially large number of metastable *quantum emulsion* states, in which the two species are fragmented into microscopic droplets. The quantum emulsion states can be regarded as the out-of-equilibrium realization of a localization phenomenon, in which each species acts as a random potential to the other one, effectively localizing it. Quantum Monte Carlo investigations reveal an extremely slow relaxation of the system towards equilibrium, typical of a glassy phase. Increasing the intraspecies repulsion for the fast bosons drives them through a quantum phase transition to the superfluid state.

Q 25: Quanteninformation (Verschränkung und Dekohärenz II)

Zeit: Dienstag 14:00–16:30 Raum: 5L

Gruppenbericht Q 25.1 Di 14:00 5L

Entanglement in Cavity-QED Systems — •Tatjana Wilk[1], Simon Webster[1], Gerhard Rempe[1], and Axel Kuhn[2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, UK

Creating entanglement between distant nodes of a quantum network is a major objective in quantum information processing. Realization of atom-photon entanglement is a big step towards this aim since photons can travel large distances without decoherence. In particular, entanglement swapping between photon pairs and distant atoms should be a feasible way to realize a quantum repeater. However, all atom-photon entanglement schemes that have been demonstrated so far [1] are plagued by low event rates and poor photon collection efficiencies. Therefore the anticipated entanglement swapping is hard to achieve. To overcome these limitations, atom-cavity systems could be used as photon emitters, since their overall efficiency is more than three orders of magnitude higher [2]. Here, we show a way to achieve entanglement in a strongly coupled atom-cavity system. The proposed scheme is well supported by first experimental results.

[1] Blinov et al., *Nature* **428**, 153 (2004), Volz et al., *Phys. Rev. Lett.* **96**, 30404 (2006).
[2] Kuhn et al., *Phys. Rev. Lett.* **89**, 67901 (2002).

Q 25.2 Di 14:30 5L

Estimating entanglement measures in experiments — •Otfried Gühne[1], Michael Reimpell[2], and Reinhard Werner[2] — [1]Institut für Quantenoptik und Quanteninformation, A-6020 Innsbruck — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, D-38106 Braunschweig

The characterization of entanglement in experiments is an important problem in quantum information science. In this talk we present a method to estimate entanglement measures in experiments. We show how a lower bound on a generic entanglement measure can be derived from the measured expectation values of any finite collection of entanglement witnesses. Hence witness measurements are given a quantitative meaning without the need of further experimental data. We apply our results to a recent multi-photon experiment [M. Bourennane et al., Phys. Rev. Lett. 92, 087902 (2004)], giving bounds on the entanglement of formation and the geometric measure of entanglement in this experiment.

Q 25.3 Di 14:45 5L

Zwei-Farben-Verschränkung — •Moritz Mehmet[1], Nicolai Grosse[2], Nico Lastzka[1], Ping Koy Lam[2] und Roman Schnabel[1] — [1]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover — [2]Quantum Optics Group, Department of Physics, The Australien National University, ACT 0200, Australia

Die Wechselwirkung zweiter Ordnung in nichtlinearen Kristallen ist wohlbekannt und in zahlreichen Experimenten demonstriert worden. Diese $\chi^{(2)}$-Prozesse eignen sich aber nicht nur zur Frequenzverdopplung oder zur Erzeugung von gequetschtem Licht durch optisch-parametrische Abschwächung. Kürzlich konnte gezeigt werden [1], dass Auf- und Abwärtskonversion, durch entsprechende Wahl der experimentellen Parameter, für maximale Verschränkung zwischen dem fundamentalen und harmonischen Feld sorgen. Wir stellen die zugrunde liegende Theorie vor und präsentieren einen in Planung befindlichen Aufbau zur Erzeugung dieser Zwei-Farben-Verschränkung.

[1] Phys. Rev. Lett. 96, 063601 (2006).

Q 25.4 Di 15:00 5L

Experimentelle Verschränkungsreinigung atomarer Zustände — •Rainer Reichle[1], Dietrich Leibfried[2], Emanuel Knill[2], Joe Britton[2], Rodney Blakestad[2], John Jost[2], Chris Langer[2], Roee Ozeri[2], Signe Seidelin[2] und Dave Wineland[2] — [1]Institut für Quanteninformationsverarbeitung, Universität Ulm, D-89069 Ulm — [2]NIST, Boulder, Colorado 80305, USA

Verschränkungsreinigung wurde 1996 von Bennett et al.[1] vorgeschlagen und ist ein Protokoll der Quanteninformation, welches erlaubt, aus mehreren identisch entstandenen Kopien eines verschränkten Zustandes einen Zustand verbesserter Fidelität zu destillieren. Für die Demonstration dieses Protokolls[2] benutzen wir zwei Paare atomarer Qubits in einer Ionenfalle. Eine moderate Verschränkung mit unbestimmtem Restanteil wird mittels eines Phasengatters in einem ersten Schritt in den Zuständen der Qubits der zwei separaten Ionenpaare eingestellt, also in zwei identischen Kopien. Im Bereinigungsprozeß wird dann das erste Qubit des einen Paares mit dem zweiten Qubit des anderen Paares, und umgekehrt, paarweise miteinander verschränkt (CNOT Gatter). Nach räumlicher Trennung der Paare, wird der Zustand des ersten Paares gemessen und eine Rotation auf dem zweiten Paar vollzogen. Das zweite Paar erscheint in einem Zustand mit höherer Fidelität als ursprünglich[1,2]. Das Hinzuziehen weiterer, identischer Paare könnte in zukünftigen Experimenten durch Iteration eine hohe Bereinigung eines beliebigen Zustandes ermöglichen.

[1] Bennett, C. H. et al. PRL **76**, 722 (1996)
[2] R. Reichle et al., Nature **443**, 838 (2006)

Q 25.5 Di 15:15 5L

Entanglement dynamics in Markovian open systems: a diffusive quantum trajectories approach — •Marc Busse[1,2], Carlos Viviescas[1], Andre Carvalho[1], Olivier Brodier[1], and Andreas Buchleitner[1] — [1]Max-Planck-Institut fuer Physik Complexer Systeme, Dresden — [2]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München

Recently, a dynamical characterization of entanglement through the continuous observation of a quantum system evolving under incoherent coupling to an environment has been proposed [1]. In this contribution we further explore these ideas by means of diffusive quantum trajectories to describe the conditional quantum evolution of the system. It is shown that an optimal measurement scheme on the environment can be found, for which the entanglement of the time evolved, mixed state is given by the average entanglement over the pure state decomposition generated by this optimal unraveling of the master equation. For the cases studied, the optimal measurement scheme is time independent, rendering the method to be a computationally efficient tool for the study of entanglement dynamics in Markovian open systems.

[1] A.R.R. Carvalho, M. Busse, O. Brodier, C. Viviescas, and A. Buchleitner, quant-ph/0510006

Q 25.6 Di 15:30 5L

Quantum Walks with Decoherence — •Annette Maria Gattner and Reinhard Werner — Institut für mathematische Physik, TU Braunschweig, www.imaph.tu-bs.de

The transition from classical to quantum walks implies the introduction of an additional coin degree of freedom to obtain unitary but non-trivial quantum walks. This unitarity can be destroyed by decoherence, e.g., the use of a different quantum coin with a certain probability. The effects of such kinds of decoherence as well as errors in the position degree of freedom have already been studied numerically by several

groups. The study of decoherence is especially important with regard to the experimental realization of quantum walks and the occurring imperfections.

When decoherence is allowed, one can consider translationally invariant local discrete time dynamics without any additional coin degree of freedom. We present the possible decoherence maps under such conditions and determine their probability distribution for large times. These results are extended to the quantum walk with a coin degree of freedom.

Q 25.7 Di 15:45 5L

Decoherence in dynamical quantum phase transition — •Sarah Mostame and Ralf Schuetzhold — Institut fuer Theoretische Physik, Technische Universitaet Dresden, 01062 Dresden

The quantum Ising model is one of the basic models for the understanding of quantum phase transitions. Ground state entanglement, which is responsible for long-range correlations in quantum phase transitions, is also a key factor for this quantum phenomenon. We study the dynamics of a quantum phase transition in the quantum Ising model weakly coupled to a general bath. Under the assumption of fully adiabatic evolution our results show that the first order corrections due to decoherence increase linearly with the system size.

Q 25.8 Di 16:00 5L

Verschränkung eines Vier-Parteien-Zustandes und experimenteller Nachweis — •Jessica Schneider[1], Oliver Glöckl[1], Gerd Leuchs[1] und Ulrik Andersen[1,2] — [1]Institut für Optik, Information und Photonik, Max-Planck Forschungsgruppe, Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1, 91058 Erlangen — [2]Technical University of Denmark, Department of Physics, 2800 Kgs. Lyngby, Denmark

Wir stellen ein Protokoll zur Erzeugung und zur Detektion eines stark korrelierten Vier-Parteien-Quantenzustandes vor. Der Zustand wird aus vier hellen gepulsten Lichtzuständen erzeugt, die durch den Kerr-effekt in Glasfasern gequetscht wurden.

Im ersten Schritt werden zwei EPR-Strahlenpaare durch eine Interferenz miteinander verschränkt. Dies erfolgt wie in einem früheren Experiment zum Verschränkungsaustausch [1]. Im zweiten Schritt werden die verschränkten Strahlen durch ein Strahlteilernetzwerk entkoppelt. Die ursprüngliche Verschränkung macht sich dann in einer reduzierten Varianz der direkt detektierten einzelnen Teilstrahlen bemerkbar. Die Vier-Parteien-Verschränkung wird durch verschiedene Kombinationen von Amplitudenquadraturen überprüft [2].

[1]O. Glöckl et al., Phys. Rev. A 68, 012319 (2003)
[2]P. van Loock et al., Phys. Rev. A 67, 052315 (2003)

Q 25.9 Di 16:15 5L

Experimental Bell tests for quantum state discrimination — •Christian Schmid[1,2], Nikolai Kiesel[1,2], Wieslaw Laskowski[3], Witlef Wieczorek[1,2], Reinhold Pohlner[1,2], and Harald Weinfurter[1,2] — [1]Max-Planck-Institute for Quantum Optics, Garching — [2]Department for Physics, LMU Munich — [3]Instytut Fizyki Teoretycznej i Astrofizyki, Uniwersytet Gdański, Poland

Bell inequalities provided the first experimental approach to reveal the discrepancy between quantum and classical correlations. For characterizing entangled states, recently, entanglement witnesses were developed. These turned out to be a mighty tool to distinguish multipartite states with a higher degree of separability from states with a lower one (e.g. [1]). However, quantum states composed of more than two qubits additionally offer a variety of types of entanglement. Here, we provide an approach how to construct Bell inequalities that are tailored to certain multipartite entangled states. They are constructed such that they witness non-classicality, non-separability and in addition distinguish between certain types of entanglement. We present two new Bell inequalities that are violated maximally by two important four-photon entangled states, $D_4^{(2)}$ [2] and $\Psi^{(4)}$ [3], respectively. We demonstrate the resulting possibility to distinguish these states quantitatively from other relevant four-photon entangled states. Finally, we perform an experimental analysis of the state $D_4^{(2)}$ based on this approach.

[1] M. Bourennane et al., Phys. Rev. Lett. **92**, 087902 (2004),
[2] N. Kiesel et al., quant-ph/0606234 (2006),
[3] M. Eibl et al., Phys. Rev. Lett. **90**, 200403 (2003)

Q 26: Anwendung ultrakurzer Lichtimpulse II

Zeit: Dienstag 14:00–16:00 Raum: 5K

Q 26.1 Di 14:00 5K

Sub-femtosecond control of electron localization in molecular dissociation — •Matthias Kling — AMOLF, Amsterdam, Niederlande

Laser light with a controlled evolution of the electric field $E(t) = a(t) * cos(\omega(t) + \phi)$ recently became available when, in addition to the amplitude $a(t)$ and frequency ω control of the carrier-envelope phase ϕ was accomplished. The well-controlled force varying on a sub-femtosecond timescale that such a wave exerts on electrons permitted the reliable and reproducible generation of single sub-femtosecond pulses by means of high-order harmonic generation, controlled electron emission from atoms and made possible precision attosecond metrology. The question remains if this capability can be extended to electrons in molecular orbitals and - if so - can light-driven electronic motion in chemical bonds affect reaction dynamics?

We present experiments on the dissociation of D_2^+ into $D^+ + D$ by intense few-cycle laser pulses with controlled field evolution and report a pronounced dependence of the direction of the D^+ ejection (and hence of the localization of the electron in the system) on the waveform driving the reaction [M.F. Kling *et al.*, *Science* **312** (2006) 246]. Quantum-classical computations reveal that light-field control of molecular electron dynamics is responsible for the observed phenomenon.

Q 26.2 Di 14:15 5K

Ultrafast electron emission from sharp tungsten tips — •Peter Hommelhoff, Catherine Kealhofer, and Mark Kasevich — Department of Physics, Stanford University, Stanford, CA, USA

We present an experimental and numerical study of electron emission from a sharp tungsten tip triggered by sub-8 femtosecond low power laser pulses. This process is non-linear in the laser electric field, and the non-linearity can be tuned via the DC voltage applied to the tip. Numerical simulations of this system show that electron emission takes place within less than one optical period of the exciting laser pulse, so that an 8 fsec 800 nm laser pulse is capable of producing a single electron pulse of less than 1 fsec duration. Furthermore, we find that the carrier-envelope phase dependence of the emission process is smaller than 0.1% for an 8 fsec pulse but is steeply increasing with decreasing laser pulse duration.

Q 26.3 Di 14:30 5K

Adaptive Kontrolle optischer Nahfelder mit Subwellenlängenauflösung — Martin Aeschlimann[1], Michael Bauer[2], Daniela Bayer[1], •Tobias Brixner[3], F. Javier García de Abajo[4], Walter Pfeiffer[5], Martin Rohmer[1], Christian Spindler[3] und Felix Steeb[1] — [1]Fachbereich Physik, TU Kaiserslautern, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Kiel, Leibnizstr. 19, 24118 Kiel, Germany — [3]Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [4]Instituto de Optica, Serrano 121, 28006 Madrid, Spain — [5]Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, 33516 Bielefeld, Germany

Wir verknüpfen die zwei bislang separierten Forschungsgebiete adaptive Quantenkontrolle und Nanooptik, um elektromagnetische Intensität mit räumlicher Subwellenlängenauflösung dynamisch zu lokalisieren. Dies wird experimentell durch Femtosekunden-Polarisationspulsformung und Photoemissions-Elektronenmikroskopie (PEEM) demonstriert. Dabei wird das elektrische Nahfeld in der Umgebung von Ag-Nanostrukturen durch ultrakurze Laserimpulse gesteuert, die speziell angepasste Vektoreigenschaften aufweisen. Über Zweiphotonen-PEEM wird die laterale Intensitätsverteilung gemessen und dient als Rückkopplungssignal in einem iterativen Lernalgorithmus. Das externe Feld wird so moduliert, dass das elektrische Nahfeld an den gewünschten Orten lokalisiert ist. So werden Pulsfor-

mungsstrategien und Quantenkontrollverfahren auch mit nanoskopischer räumlicher Auflösung möglich.

Q 26.4 Di 14:45 5K

Ein schneller Wavelet-basierter Algorithmus zur Phasenrekonstruktion aus SPIDER-Messungen — •Jens Bethge, Christian Grebing und Günter Steinmeyer — Max-Born-Institut, Max-Born-Straße 2a, D-12489 Berlin

Die SPIDER-Methode hat sich als eines der Standardverfahren zur vollständigen Charakterisierung von Femtosekundenpulsen etabliert [1]. Zur Rekonstruktion der spektralen Phase aus gemessenen Interferogrammen wird hierbei in der Regel der sog. Takeda-Algorithmus verwendet, der zwei Fouriertransformationen benötigt [2]. Kürzlich wurde gezeigt, daß ein Wavelet-basierter Algorithmus robuster gegenüber Rauschen ist und den Takeda-Algorithmus oft übertrifft [3]. Leider ist eine komplette Wavelet-Analyse des Spektrogramms ungleich viel aufwendiger als die Fourier-Analyse, was eine direkte Echtzeitanwendung unmöglich macht. Uns ist es nun gelungen den Algorithmus so zu beschleunigen und in einem kompakten SPIDER-Spektrometer zu implementieren, daß damit eine Pulsanalyse mit hohen Wiederholraten von über 10 Hertz möglich ist.

[1] G. Stibenz and G. Steinmeyer, Rev. Sci. Instrum. **77**, 073105 (2006).
[2] M. Takeda et al., J. Opt. Soc. Am. A **72**, 156 (1982).
[3] Y. Deng et al., Opt. Express **13**, 2120 (2005).

Q 26.5 Di 15:00 5K

Femtosecond pump-supercontinuum probe investigation on laser induced shape transformation of silver nanoparticles in glass — •Armin Warth, Gerhard Seifert, Jens Lange, and Heinrich Graener — Fachbereich Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle

Soda lime-glasses containing spheroidal silver nanoparticles are very useful as base material for production of high-quality polarizers, dichroic optical microstructures or long-time optical data storage. In such materials, a permanent shape transformation of the nanoparticles can be induced by irradiation with femtosecond laser pulses above a certain intensity threshold. Our pump-probe setup allows us to investigate the ultrafast dynamics of the deformation process by monitoring the changes of the sample's optical density with spectrally broad femtosecond probe pulses covering the spectral range from ˜ 350nm to 550nm, with a typical time resolution of 100fs. While the surface plasmon dynamics of metal particles in glass has been studied at low intensities (no permanent changes) by many groups, only few is known so far about the dynamics of the processes leading to shape transformation above the intensity threshold for permanent changes.

In this contribution, we present novel results on the dynamics of permanent modification of nanoparticles in glass. These very challenging experiments require high experimental accuracy because, due to the permanent optical changes induced by each pump pulse, only a single laser shot can be used at one spot of the sample to probe the transient optical changes at a well-defined delay time.

Q 26.6 Di 15:15 5K

Beschleunigung von Elektronen durch intensive Laser-Pulse im Vakuum — •Nicolas Kowarsch und Werner Scheid — Institut für Theoretische Physik, Justus-Liebig-Universität Giessen

Elektronen lassen sich durch Laser-Pulse auf kurzen Distanzen bis in den TeV-Bereich beschleunigen. Hier wird eine ebene, linear polarisierte Welle angesetzt, deren Einhüllende eine Gauß-Funktion ist: $E_x(u) = cB_y(u)$ mit $E_x(u) = E_0 \exp(-\alpha k^2 u^2)\cos(ku)$ und $u = z - ct$. Läuft ein solcher Lichtpuls über ein zu Anfang ruhendes Elektron, so wird das Elektron auf Energien $(\gamma - 1)m_0c^2 = (0.5\pi/\alpha)\exp(-0.5/\alpha)a_0^2 m_0 c^2$ mit $a_0 = eE_0/(m_0c^2k)$ gebracht. Für $E_0 = 10^{13}$V/m, was einer Intensität von $(\varepsilon_0/\mu_0)^{1/2}E_0^2 = 2.65 \cdot 10^{23}$W/m^2 entspricht, $\lambda = 1\mu$m und $\alpha = 0.5$ erhalten wir $a_0 = 3.115$ und $\gamma = 12.2$. Die Beschleunigungsstrecke in z-Richtung beträgt 8μm, und der Energiegewinn pro Länge ist $0.223 km_0c^2 = 0.715$TeV/m. Rechnungen mit Lichtpulsen endlicher transversaler Ausdehnung sind in Vorbereitung.

Q 26.7 Di 15:30 5K

Wavefront measurement of high-order harmonics with a Hartmann-sensor — •Matthias Weger, Stefan Eyring, Jan Lohbreier, Robert Spitzenpfeil, Dominik Walter, and Christian Spielmann — University of Würzburg, Department of Physics, Am Hubland, 97218 Würzburg, Germany

High-order harmonics from gas provide an ultrafast, coherent, EUV and tabletop light source. We measure the wavefront aberrations stemming from the generation process and the propagation over reflective optics of the harmonics.

We present an experimental setup and first measurements, which use a Hartmann-sensor for radiation in the EUV to measure the wavefront of high-order harmonics. A pinhole array aperture is placed in the beamline. From the pattern recorded with a x-ray CCD-camera the wavefront can be reconstructed and developed in Zernike polynomials, which correspond to basic optical aberrations.

Future measurements can be made at any desired position of the EUV beamline.

Q 26.8 Di 15:45 5K

Volumenstrukturierung von Kristallen mit fs-Laserpulsen — •Jörg Siebenmorgen[1], Hanno Scheife[1], Günter Huber[1], Jonas Burghoff[2] und Stefan Nolte[2] — [1]Institut für Laser-Physik, Universtität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

Femtosekundenpulse können dazu genutzt werden, um durch nichtlineare Absorption Strukturen in transparenten Materialen zu erzeugen. In vielen Gläsern geht mit der laserinduzierten Materialveränderung auch eine Brechungsindexänderung im Bereich von 10^{-3} bis 10^{-2} einher. Wir berichten über die Strukturierung einiger für Laseranwendungen interessanter Kristalle, wie z.B. YAG, YGG und GGG. Für die Strukturierungsexperimente wird der fs-Laserstrahl mit einem Mikroskopobjektiv (NA = 0,35) etwa 300 μm unter die Oberfläche des Materials fokussiert, während die Probe senkrecht zum einfallenden Strahl verschoben wird. Die so in das Volumen geschriebenen Spuren mit einer Länge von etwa 1 cm und einem Querschnitt von etwa $5 \times 25\,\mu$m wurden mit verschiedenen Mikroskopieverfahren charakterisiert. Hierbei zeigte sich, dass die sichtbaren Spuren einer Zerstörung des Kristalls entsprechen. Einzig bei den untersuchten YAG- und YGG-Kristallen konnte aufgrund des elasto-optischen Effekts eine spannungsinduzierte Änderung des Brechungsindex beobachtet werden. In mehreren Kanälen in der Umgebung der Spuren konnte bei diesen Kristallen Wellenleitung beobachtet werden.

Q 27: Kalte Moleküle II (gemeinsam mit MO)

Zeit: Dienstag 14:00–16:15 Raum: 6B

Hauptvortrag Q 27.1 Di 14:00 6B

Manipulating large molecules: selecting isomers, orienting, and slowing polar molecules with strong electric fields — •Jochen Küpper — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

Polar molecules can be manipulated using strong electric fields. Small molecules, for example OH or NH_3, have been focused and state selected by electrostatic multipole guides, they have been slowed in Stark decelerators and stored in rings or traps. Practically all these experiments have been performed on molecules in low-field-seeking quantum states. For larger molecules, however, all states are high-field seeking at the relevant electric field strengths.

To manipulate the motion of large molecules one has to use Alternate Gradient (dynamic) focusing. In prototype experiments small molecules in high-field seeking states have been decelerated [1]. We are extending these methods to the focusing and deceleration of large molecules. For large (bio-)molecules typically a number of different conformers (structural isomers) are present in a supersonic jet. Using switched electric fields in a "quadrupole" guide such conformers can spatially be separated due to their different mass-to-dipole (m/μ) ratios, similar to a quadrupole mass-to-charge (m/q) filter for ions. Moreover, the molecular packets transmitted through the guide are very well suited for brute-force orientation.

We have also set up a modular Alternate Gradient deceleration ex-

periment, which allows us to slow polar molecules in low- and high-field seeking states. We have successfully decelerated several molecules, for example benzonitrile (C_7H_5N), in different quantum states.

I will discuss the prospects for novel studies on such molecular systems that these experiments on the structural and spatial separation and the deceleration of large molecules offer. For example, oriented samples of individual conformers of large molecules will greatly benefit scattering experiments for direct structure determination.

[1] H. L. Bethlem, M. Tarbutt, J. Küpper, D. Carty, K. Wohlfart, E. Hinds, and G. Meijer, *J. Phys.* B **39**, R263 (2006)

Q 27.2 Di 14:30 6B

Molecular fine structure of strong dipolar molecules — •J. Deiglmayr, M. Aymar, and O. Dulieu — Laboratoire Aimé Cotton, CNRS, Bâtiment 505, Campus d'Orsay, 91405 Orsay Cedex, France

Recently the production of ultracold heteronuclear molecules in their electronic ground state either via photoassociation [1] or Feshbach resonances [2] has been achieved. Such heteronuclear molecules, if deeply bound, have a significant permanent electric dipole moment leading to strong, long-range, and alignment dependent intermolecular forces, which offer control by external electromagnetic fields. We have calculated the R-dependent polarizabilities for all heteronuclear dimers in the ground state using quantum chemistry methods [3]. We also follow a new approach to include spin-orbit coupling in ab-initio calculations of molecular potentials: a full configuration interaction calculation with effective core potentials and a diabatization procedure is used to determine potential curves with fine structure. These new insights will be used to find efficient routes to produce and stabilize polar molecules, to model the dynamics of a dipolar gas in an optical dipole trap and to explore external field dependent scattering properties.

[1] A Kerman *et al.*, PRL 92 (2004) 153001; D Wang *et al.*, PRL 93 (2004) 243005; MW Mancini *et al.*, PRL 92 (2004) 133203; C Haimberger *et al.*, PRA 70 (2004) 021402(R); SD Kraft *et al.*, J. Phys B 39 (2006) S993
[2] C. Ospelkaus *et al*, PRL 97 (2006) 120402
[3] M. Aymar, O. Dulieu, J.Chem.Phys 122 (2005) 204302

Q 27.3 Di 14:45 6B

Electrostatic extraction of buffer-gas-cooled polar molecules — •Laurens D. van Buuren, Joseph Bayerl, Vincent Dugrain, Sebastian Pohle, Christian Sommer, Pepijn W.H. Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

High-density samples of cold molecules are required to investigate their collisional and chemical properties at low temperatures. Once polar molecules can be cooled to the ultracold regime, where the dipole-dipole interaction dominates, new quantum phenomena can be studied. Cold polar molecules are also of interest for high-resolution spectroscopy, metrology, and quantum computation [1].

We present first results with a new cryogenic source delivering a dense and slow beam of internally cold molecules. The beam is produced by combining two powerful techniques. Molecules are cooled (translationally and internally) in a helium buffer gas at low temperature (T $\sim$ 5 K) [3]. With an electric guide slow buffer-gas-cooled molecules are filtered out of the (non-polar) helium and transported to a high-vacuum region [2], where the flux is analysed. Once the source is optimized, the cold molecules can easily be loaded into an electrostatic trap [4] for further investigations.

[1] J. Doyle et al., European Physical Journal D **31**, 149 (2004)
[2] T. Junglen et al., European Physical Journal D **31**, 365 (2004)
[3] S.E. Maxwell et al., Physical Review Letters **95**, 173201 (2005)
[4] T. Rieger et al., Physical Review Letters **95**, 173002 (2005)

Q 27.4 Di 15:00 6B

Cavity Cooling of internal and external degrees of freedom of molecules. — •Giovanna Morigi[1], Pepijn Pinkse[2], Markus Kowalewski[3], and Regina de Vivie-Riedle[3] — [1]Departament de Fisica, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Spain — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [3]LMU Department Chemie, Butenandt-Str. 11, 81377 München

A proposal is presented for effectively cooling vibrational, rotational, and translational degrees of freedom of molecules. The molecules are driven by off-resonant laser light and cooled through Raman processes, where photons are scattered into the resonator, which then decays into free space. Photon emission occurs at a multitude of cavity resonances in a suitably designed resonator. The cooling efficiency is investigated numerically for the case of the OH radical, using ab-initio data and taking into account the rovibrational dependence of the Raman scattering into the cavity modes. Extentions to more complex molecules will be considered.

Q 27.5 Di 15:15 6B

Alternate Gradient deceleration of large molecules — •Kirstin Wohlfart, Frank Filsinger, Jochen Küpper, and Gerard Meijer — Fritz-Haber-Institut der MPG, Faradayweg 4–6, 14195 Berlin

Over the last years fascinating progress has been made in the spectroscopy of large (bio-)molecules, e.g. the *building blocks of life*. Meanwhile, our group has been developing methods to decelerate and cool neutral, polar molecules using time varying electric fields. In order to extend these techniques to the deceleration of large or heavy molecules, which have practically only high-field seeking states, or molecules in their absolute ground state, Alternate Gradient focusing must be applied. We showed that this technique can be used to focus and decelerate molecules in high-field seeking states [1].

Using a modular Alternate Gradient deceleration experiment different states of benzonitrile (C_7H_5N) and OH, in both high-field and low-field seeking components of its ground state, have been decelerated. The time-of-flight profiles are quantum-state-selectively measured using high-resolution laser induced fluorescence spectroscopy. We compare the efficiency of different high voltage switching schemes and will discuss the prospects of future experiments for the deceleration of larger molecules.

[1] H. L. Bethlem, M. Tarbutt, J. Küpper, D. Carty, K. Wohlfart, E. Hinds, and G. Meijer, *J. Phys. B* **39**, R 263 (2006)

Q 27.6 Di 15:30 6B

Supersonic Beams at High Stagnation Pressures: Thermodynamics and Translational Cooling — •Wolfgang Christen, Tim Krause, Sibylle Rabeus, and Klaus Rademann — Institut für Chemie, Humboldt-Universität zu Berlin, Brook-Taylor-Strasse 2, 12489 Berlin, Germany

Pulsed, supersonic beams of rare gases at high stagnation pressures ($10 < p_0 < 120$ bar) have been investigated by time-of-flight measurements as a function of gas temperature T_0. The numerical evaluation of the arrival time distribution $f(t)dt$ permits an accurate determination of the velocity distribution, characterized by the flow velocity v_0 and the velocity spread $\Delta v_\parallel$ of the expanded beam. We compare the experimental results $v_0(p_0, T_0)$ with values calculated for a supersonic expansion of an ideal gas. Because the translational cooling of a supersonic jet is usually characterized by the speed ratio $S = v_0/\Delta v_\parallel$, we discuss the applicability of this approach at high pressure conditions. The effect of condensation on cooling is investigated by retarding field measurements, determining the cluster size distribution in the beam.

Q 27.7 Di 15:45 6B

Deceleration of polar molecules using a microstructured electrode array — •Samuel Meek, Hendrick Bethlem, Horst Conrad, and Gerard Meijer — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

By utilizing the forces that polar molecules experience in inhomogenous electric fields, a variety of molecular-optical elements have been experimentally demonstrated. While previous electrode configurations at the *mm* scale require potential differences of tens of *kV* at the electrodes, similar fields can be produced between $10\mu m$-sized electrodes using potentials of hundreds of volts. Here, we present trajectory calculations for a recently constructed electrostatic decelerating and trapping device consisting of a periodic array of 1254 microstructured linear electrodes deposited on a planar glass substrate. Application of harmonic waveforms to periodic groups of six electrodes forms a series of periodic minima which move along the array in a continuous manner without changing their distances above the electrodes. Deceleration is achieved by linearly reducing the frequency of the applied waveforms.

First experiments have already been performed using beams of $a^3\Pi_1$ CO, which has a lifetime of a few milliseconds. Such a long lifetime allows laser excitation directly after the nozzle where the densities are higher, followed by detection of the fluorescence with a photomultiplier tube, or using Auger deexcitation at a microchannel plate or a gold surface. Operating the device in a mirror mode by applying a static dipole field, we were able to vary the deflection of the molecules from one to four degrees, simply by changing the tilt of the structure.

Q 27.8 Di 16:00 6B

Trapping ground-state molecules — •Melanie Schnell, Jacqueline van Veldhoven, Peter Lützow, Bretislav Friedrich, Hendrick Bethlem, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin

Trapping of neutral molecules in high-field seeking states is important since the absolute molecular ground state and most of the states of heavier molecules with small rotational constants are high-field seeking. When molecules are trapped in their absolute ground state with a high enough density and the trap depth can be varied, increasing their phase-space density via evaporative cooling will be possible, as trap loss due to inelastic collisions can be avoided. This is one important step towards the realization of a molecular Bose-Einstein condensate. Another application is located in the field of high-resolution spectroscopy. Due to the long interaction times of the trapped molecules with the electromagnetic radiation an increased resolution in the spectroscopic experiment can be reached.

Trapping ground state molecules, however, is challenging since the realization of a maximum of a static electric field in free space is not possible. It can be achieved using time-dependent fields. One approach is to employ dynamic confinement using switched electric fields (AC trap). So far, both a cylindrically symmetric and a linear AC trap have been realized. We will present our newest results on AC trapping, which include the characterization of the two traps, and we will discuss some future applications of AC trapping of ground state molecules.

Q 28: Poster Festkörperlaser

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 28.1 Di 16:30 Poster C

Ranging with Frequency-shifted Feedback Laser — •vladimir ogurtsov[1], leonid yatsenko[1], vladimir khodakovskyy[1], bruce shore[2], gerd bonnet[2], and klaas bergmann[2] — [1]Institute of Physics, Ukrainian Academy of Sciences, Ukraine — [2]Department of Physics, University of Kaiserslautern, Kaiserslautern

We present experimental characteristics of an Yb^{3+}-doped fiber ring laser operating with frequency-shifted feedback (FSF) through an acousto-optic modulator (AOM) and seeded by both a stationary continuous-wave (CW) laser and spontaneous emission. We show the spectrum and output characteristics for operations with several effective gain bandwidths created by Fabry-Perot etalons inside the cavity and compare spectral parameters with theoretical estimation. The experimental results are in excellent quantitative agreement with the theory developed earlier [L. Yatsenko, et al., Opt. Comm. **236**, 183-202 (2004)]. We also demonstrate that the FSF laser, when seeded by a phase-modulated narrow-band radiation field, is a powerful tool for distance measurements to accuracy better than 10 μm and resolution better than 100 μm, for distances of a few meters. The amplitude of the output-signal modulation exhibits a resonance for every distinct signal delay, i.e. for each distinct distance within the laser spot on the target. The use of a phase-modulated input seed allows one to use a very narrow-bandwidth filter when measuring the return signal. These results are in excellent agreement with previous theoretical predictions [L. Yatsenko et al., Opt. Comm. **242**, 581 (2004)].

Q 28.2 Di 16:30 Poster C

Passiv modengekoppelter YB:KYW-Scheibenlaser mit cavity dumping — •Guido Palmer, Marcel Schultze und Uwe Morgner — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30453 Hannover

Viele Anwendungen, wie z.B. die nichtlineare Spektroskopie oder die Laser-Mikromaterialbearbeitung profitieren von hochenergetischen Laserpulsen im Sub-Pikosekunden-Regime. Für diese Anwendungen sind Pulsrepetitionsraten im MHz-Bereich häufig von Vorteil. Der Einsatz von passiv modengekoppelten Lasersystemen mit langen Resonatoren aber auch die Verwendung von passiv modengekoppelten Systemen mit Cavity-Dumping ermöglicht die Erschließung dieses energetischen Bereiches mit Oszillatoren ohne weitere Verstärkungseinheiten. Bei solitären Festkörperlasern mit Millimeter-dicken Kristallen, die mit passiver Modenkopplung und Cavity-Dumping betrieben werden, konnten für Lasermedien wie z.B. Yb:Glas und Yb:KYW bereits Erfolge in diesem Bereich erzielt werden. Das Konzept des Scheibenlasers bietet die Möglichkeit in noch höhere Energiebereiche vorzudringen. Wir präsentieren einen auf Yb:KYW basierten Scheibenlaser mit passiver Modenkopplung und Cavity-Dumping. Die Modenkopplung wird durch einen sättigbaren Absorberspiegel realisiert. Aufgrund der hohen Nichtlinearitäten, die im Resonator in diesem Pulsenergiebereich entstehen ist eine große Anzahl negativ dispersiver Spiegel erforderlich. Das System arbeitet bei 1 MHz im Mikrojoule-Bereich mit Sub-Pikosekunden Pulsen.

Q 28.3 Di 16:30 Poster C

Yb-Faserverstärker als Pumpquelle für einen MHz OPA — •Andy Steinmann, Claudia Hoffmann, Moritz Emons und Uwe Morgner — Institut für Quantenoptik, Leibniz Universität Hannover

Optische parametrische Verstärker (OPA) sind geeignet, durchstimmbare ultrakurze Pulse mit hoher Spitzenleistung zu erzeugen. Um gleichzeitig hohe Pulswiederholraten zu realisieren, können als Pumpquellen Femtosekunden-Laseroszillatoren mit Cavity-Dumping eingesetzt werden, die Pulsenergien von über 1 μJ bei Repetitionsraten von 1 MHz erreichen. Eine weitere Skalierung dieses Konzepts hin zu noch höheren Pumpenergien scheitert allerdings bisher an den Nichtlinearitäten im Pumplaser.

Wir präsentieren ein CPA-Konzept, das mittels externer Nachverstärkung eine weitere Steigerung der Pulsenergie ermöglicht. Zum Strecken der Pulse dient dabei ein reflektiver Gitterstretcher, der aus einem einzelnen Gitter und zwei konzentrischen Spiegeln besteht (Offner Triplet), als Verstärkerfaser kommt eine 50 cm lange Yb-dotierte rod-type Faser zum Einsatz und als Kompressor wird ein Paar Quarz-Transmissionsgitter verwendet. Auf diese Weise können sub-ps-Pulse mit mehreren Mikrojoule Energie als Pumpstrahlung für den OPA realisiert werden.

Q 28.4 Di 16:30 Poster C

Höchstempfindlicher Nachweis von rückgekoppeltem Laserlicht — •Tim Bonin, Oliver Back, Klaus Sengstock und Valeri Baev — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Zusätzlich zu den bekannten Relaxationsschwingungen während des Einschaltvorganges zeigen Festkörperlaser auch im cw-Betrieb periodische Schwankungen, die durch Quantenfluktuationen, mechanische Störungen und Fluktuationen der Pumpleistung ständig angetrieben werden. Bei Vielmoden-Festkörperlasern treten zusätzlich zu diesen inphasigen Hauptrelaxationsoszillationen aller Moden noch gegenphasige Oszillationen in den einzelnen Moden mit niedrigerer Frequenz auf, die sich in der Gesamtleistung herausmitteln. Jede Störung des Lasers von außen führt zu einer Veränderung der Laserdynamik, die im Leistungsspektrum von Einmoden-Lasern beobachtet wurde [1]. Die höchste Empfindlichkeit wird bei Resonanz mit Relaxationsfrequenzen erwartet. Wir nutzten diesen Effekt aus, um Laserlicht, welches in den Resonator zurückgestreut wird, mit höchster Empfindlichkeit nachzuweisen. Hierfür wird das gestreute Licht leicht in der Frequenz verstimmt, so dass es zu einer Schwebung mit dem Laserfeld im Resonator kommt. Mit der besten Nachweiskonfiguration konnte um 13 Größenordnungen abgeschwächtes Laserlicht detektiert werden, indem gezielt resonant mit der gegenphasigen Oszillation in eine Lasermode zurückgekoppelt wurde. Die Detektion erfolgte dann über die Reaktion einer anderen Mode.

[1] K.Otsuka, K.Abe, J.-Y.Ko, T.-S.Lim, Opt.Lett. 27, 1339 (2002)

Q 28.5 Di 16:30 Poster C

Kristallzucht, Spektroskopie und Lasereigenschaften von hochreinem $Yb:Lu_2O_3$ — •Rigo Peters, Christian Kränkel, Christian Hirt, Nils-Owe Hansen, Klaus Petermann und Günter Huber — Institut für Laser-Physik, Universität Hamburg

Yb^{3+}:Lu_2O_3 ist wegen der herausragenden thermomechanischen Eigenschaften des Wirtskristalls und des bekannt geringen Quantendefektes von Yb^{3+} ein hervorragend geeignetes Material für Hochleistungs-Scheibenlaseranwendungen.

Um die Effizienz gegenüber Laserexperimenten mit Kristallen aus früheren Zuchten weiter zu verbessern, wurden erfolgreich Kris-

tallzuchten mit hochreinen Ausgangsmaterialien nach dem HEM-Verfahren (*heat exchanger method*) aus Rhenium-Tiegeln durchgeführt.

Die Kristalle wurden mit spektroskopischen Untersuchungen, wie Absorptions-, Fluoreszenz- und Lebensdauermessungen charakterisiert. Die hergestellten Kristalle weisen deutlich weniger Verunreinigungen als Kristalle aus früheren Zuchten auf. Die Abnahme der Fluoreszenzlebensdauern durch Konzentrationslöschung, sowie die parasitäre Fluoreszenz von Er^{3+}-Verunreinigungen konnten vermindert werden.

Erste Laserexperimente mit hochreinem Yb:Lu_2O_3 werden auf der Konferenz präsentiert.

Q 28.6 Di 16:30 Poster C

Ytterbium-dotierte Vanadate als aktive Materialien im Scheibenlaseraufbau — •Christian Kränkel, Rigo Peters, Nils-Owe Hansen, Christian Hirt, Klaus Petermann und Günter Huber — Institut für Laser-Physik, Universität Hamburg

Yb(1,5 at.%):YVO_4 und Yb(1,5 at.%):$LuVO_4$ wurden in Hinblick auf ihre Eignung als breitbandig emittierende Hochleistungs-Lasermaterialien im Scheibenlaser-Setup untersucht.

In diesen Untersuchungen konnten die höchsten jemals mit diesen Materialien erzielten Ausgangsleistungen von über 10 W erreicht werden. Differentielle Wirkungsgrade im Bereich von 50 % bei einer kontinuierlichen Durchstimmbarkeit über einen weiten Wellenlängenbereich lassen gleichzeitig auf hervorragende Eigenschaften auch für die Erzeugung ultrakurzer Pulse mit diesen Materialien schließen.

Q 28.7 Di 16:30 Poster C

Neue THz-Strahlquelle auf Basis eines Zweifarben - Nd:LSB - Mikrochiplasers und LT-GaAsSb - Antennen zur Photomischung — •Stefan Böttger[1], Ulrike Willer[1], Wolfgang Schippers[1], Tobias Schossig[2] und Wolfgang Schade[1,2] — [1]TU Clausthal, Institut für Physik und Physikalische Technologien, Leibnizstr. 4, 38678 Clausthal-Zellerfeld — [2]TU Clausthal, LaserAnwendungsCentrum, Arnold-Sommerfeld-Str. 6, 38678 Clausthal-Zellerfeld

Ein Nd:LSB-Mikrochiplaser (cw), der gleichzeitig bei $\lambda = 1061{,}3$ nm und $\lambda = 1063{,}9$ nm Strahlung emittiert, wird für THz-Photomischung eingesetzt. Die zwei Farben werden mit Hilfe eines Etalons aus dem 4 nm breiten Verstärkungsprofil des Nd:LSB selektiert. Da konventionelle LT-GaAs-Antennen bei dieser Wellenlänge nicht mehr effizient angeregt werden können, wird erstmalig LT-GaAsSb als Antennenmaterial eingesetzt. Mit diesem Aufbau wird THz-Strahlung bei 0,7 THz erzeugt und mit einem Bolometer detektiert. Es ist geplant weitere Laserkristalle im Hinblick auf die Erzeugung dual-frequenter Laserstrahlung zu testen. Darüber hinaus werden Methoden zur Erzeugung von gepulster Laserstrahlung über das Q-switching-Verfahren geprüft.

Q 29: Poster Ultrakurze Lichtimpulse

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 29.1 Di 16:30 Poster C

Characterization and compression of photonic crystal fiber supercontinuum with ZAP-SPIDER — •Jens Möhring, Tiago Buckup, Bernhard von Vacano, and Marcus Motzkus — Physikalische Chemie, Philipps Universität Marburg, D-35032 Marburg, Germany

Photonic crystal fibers (PCFs) feature unusual nonlinear optical properties, which can be tuned for very efficient generation of broad spectra. However, to efficiently drive nonlinear processes with high intensities, a PCF generated supercontinuum (SC) still has to be compressed. Here we describe the successful compression of a PCF supercontinuum, obtained from a PCF pumped by 1 KHz femtosecond amplified system. The necessary SC phase characterization is performed with zero-additional phase spectral shear interferometry for direct electric field reconstruction (ZAP-SPIDER) [1]. A femtosecond pulse shaper is used to actively compress the SC pulse by inverting the phase obtained with the ZAP-SPIDER. Besides that, the SC spectral properties and stability are discussed. Finally, as an example of a first application of this light source, an ultrafast spectrally resolved transient absorption experiment of a prototype molecule is conducted.

[1] Baum, P. et al, Optics Letters 29 (2004) 210

Q 29.2 Di 16:30 Poster C

Erzeugung hoher Pulsspitzenleistungen direkt aus einem Laser- Resonator — •Martin Siegel[1], Julia Meyer - Ilse[1], Uwe Morgner[1] und Sebastian Tschuch[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland — [2]Max - Planck Institut für Kernphysik, Heidelberg, Deutschland

In den letzten Jahren ist es durch die Entwicklung so genannter Long-Cavity-Oszillatoren mit positiver resonatorinterner Gesamtdispersion möglich geworden, Pulsenergien von bis zu 0,56 μJ und Pulsdauern unter 50 fs bei einer Repetitionsrate von 6 MHz zu erreichen [1]. Durch Fokussierung dieser Laserpulse mittels eines parabolischen Spiegels können damit Spitzenintensitäten von über 10^{14} W/cm^2 erreicht werden. Die gegenüber bisher verwendeten Verstärker-Systemen um drei Größenordnungen höhere Repetitionsrate eröffnet bereits heute neue Möglichkeiten bei der Messung von Ionisationsvorgängen in Edelgasen. Durch weitere Verbesserungen des Long-Cavity Laser Konzeptes wird es in den nächsten Jahren möglich sein, die erreichbaren Pulsenergien nochmals zu steigern.

Der Beitrag stellt das bereits bestehende System sowie Verbesserungsansätze vor. Daneben werden auch zukünftige Anwendungen im Bereich der Erzeugung hoher Harmonischer diskutiert.

[1] S. Dewald, M.Siegel, T. Lang, C.D. Schröter, R. Mooshammer, J. Ullrich, U. Morgner ,Opt. Lett. 31 (2006)

Q 29.3 Di 16:30 Poster C

Prismenloser Titan:Saphir-Laseroszillator mit oktavbreitem Spektrum — •Thomas Binhammer[1], Stefan Rausch[1], Franz Kärtner[3], Volker Scheuer[2], Matthias Pospiech[1] und Uwe Morgner[1] — [1]Institut für Quantenoptik, Universität Hannover — [2]Nanolayers GmbH, Rheinbreitbach — [3]MIT Cambridge, USA

Ultrakurze Laserpulse stellen eine ideale Lichtquelle für zeitaufgelöste Messungen oder hochaufgelöste Bildgebungsverfahren dar. Zur Erzeugung oktav-breiter Spektren ist dabei eine genaue Kontrolle der resonatorinternen Dispersion erforderlich. Durch die Verwendung von Paaren so genannter double chirped mirrors und einer CaF_2-Prismenstrecke im Oszillator konnten Pulsdauern von 4.2 fs nachgewiesen werden, wobei die externe Dispersionskompensation durch einen Prismen-basierten Pulsformer realisiert wurde.

Wir präsentieren hier einen weiterentwickelten Laser-Oszillator, der durch ein verändertes Spiegel-Design keine Prismen im Resonator benötigt. Das erzeugte Spektrum reicht von 580 nm bis 1280 nm und zeigt somit eine deutlich verbesserte Bandbreite sowie mehr Leistung im infraroten Spektralbereich, was die direkte Stabilisierung der Träger-Einhüllenden-Phase ermöglicht.

Durch Kombination mit einem Phasen- und Amplituden-Pulsformer können damit beliebige Pulsformen auf fs-Zeitskala erzeugt und für Experimente im Bereich der kohärenten Kontrolle genutzt werden. Die extreme spektrale Breite ermöglicht zudem Optische Kohärenz-Tomographie mit einer Tiefenauflösung unter 1 μm.

Q 29.4 Di 16:30 Poster C

Verkürzung von hochenergetischen Laserpulsen durch Filamentation — •Emilia Schulz, Thomas Binhammer, Stefan Rausch, Milutin Kovacev und Uwe Morgner — Institut für Quantenoptik, Leibniz Universität Hannover

Das Streben nach immer kürzeren Laserpulsen ist ein immer noch wachsendes Forschungsgebiet. Dabei ist für viele Experimente, wie für die Erzeugung eines einzelnen Attosekunden-Pulses, nicht nur eine sehr geringe Pulsdauer im Bereich von wenigen optischen Zyklen, sondern auch die Pulsenergie entscheidend. Das von uns verwendete Lasersystem erzeugt mit einer Multipass-Anordnung um einen kryogenisch gekühlten Ti:Saphir-Kristall Pulse einer Dauer von 30 fs und Energien von 2,5 mJ bei einer Repetitionsrate von 2 kHz. Um Pulsdauern von nur noch wenigen optischen Zyklen zu erreichen wird das Spektrum mit Hilfe von Selbstphasenmodulation deutlich verbreitert, z.B. durch ein Filament in einer gasgefüllten Zelle wie in [1], und danach durch spezielle ultra-breitbandige dispersive Spiegel komprimiert. Wir präsentieren erste Ergebnisse und berichten über Anwendungen in

der Erzeugung von Attosekunden-Pulsen.

[1] C.P.Hauri et al., Appl. Phys. B 79,673-677 (2004)

Q 29.5 Di 16:30 Poster C

High-contrast Multiphoton Microscopy based on Shaper-Assisted Collinear SPIDER Pulse Compression — •Bernhard von Vacano, Tiago Buckup, and Marcus Motzkus — Physikalische Chemie, Philipps-Universität Marburg, D-35032 Marburg, Germany

Broadband femtosecond pulses can be characterized and shaped *in situ* in microscopy with a simplified SPIDER scheme: the use of a femtosecond pulse shaper eliminates the need of an interferometer setup and allows characterization, compression and tailoring of complex pulses at the same time. Here, we present the design considerations and details of the experimental implementation of this shaper-assisted collinear (SAC-) SPIDER[1], as well as the application to multiphoton microscopic imaging. The technique is compared with independent cross-frequency resolved optical gating (XFROG) measurements. The simplicity and versatility of SAC-SPIDER make it very useful for next-generation nonlinear microscopy with broadband femtosecond laser pulses.

[1] B. von Vacano, T. Buckup, and M. Motzkus, Optics Letters 31, 1154 (2006).

Q 29.6 Di 16:30 Poster C

Optimierung des Linsensystems eines Elektronenflugzeitspektrometers für die zeitaufgelöste Spektroskopie im weichen Röntgenbereich — Alexander Paulus, Dominik Walter, Carsten Winterfeldt, Sebastian Jung, •Nico Franke und Christian Spielmann — Physikalisches Institut, Experimentelle Physik I, Universität Würzburg, Am Hubland, 97074 Würzburg

Wir zeigen, dass durch die Anwendung eines evolutionären Algorithmus verbesserte elektrostatische Linsensysteme für Elektronenflugzeitspektrometer entworfen werden können. Neben angelegter Blendenspannung werden auch geometrische Parameter der Blenden wie Länge und Durchmesser adaptiv optimiert, um ein möglichst effizientes Linsensystem zu erhalten, so dass viele Elektronen mit guter Auflösung detektiert werden können. Als wichtige Voraussetzung bringen wir ein Indiz dafür, dass nicht nur einzelne Messungen gut mit Computersimulationen abgebildet werden können, sondern auch adaptive Optimierungen.

Q 29.7 Di 16:30 Poster C

Adaptive spatiotemporal control of laser-pulses using a high-resolution LCD pulse-shaper — Dominik Walter, Stefan Eyring, Jan Lohbreier, Robert Spitzenpfeil, Matthias Weger, •Sebastian Jung, Nico Franke, and Christian Spielmann — Physikalisches Institut, Universität Würzburg

We demonstrate adaptive spatiotemporal control of laser pulses using a 2D programmable phase modulator (Hamamatsu X8267). Our approach takes advantage of the full resolution of the active area while simultaneously reducing the problem to a limited set of free parameters. This becomes particularly important for pulse optimizations using evolutionary algorithms where the initially huge parameter set has to be reduced significantly. The simplification is achieved by dividing the active area of the 2D phase modulator into quadratic regions whose pixels are combined and represented by tilted planes. Pulse distortions introduced by the pulse shaper can be avoided by realization of a smooth phase surface at the edges of each pixel-plane. We show results that demonstrate successful implementation of our experimental setup and an evolutionary algorithm to both spatially and temporally optimize Ti:sapphire laser pulses close to the bandwidth limit.

Q 29.8 Di 16:30 Poster C

Ein Experiment zur Paarerzeugung mit laserbeschleunigten Elektronen — •Hans-Peter Schlenvoigt[1], Kerstin Haupt[1], Michael Behmke[1], Heinrich Schwoerer[1], Roland Sauerbrey[2], Stefan Becker[3], Ulrich Schramm[2] und Dieter Habs[3] — [1]Institut für Optik und Quantenelektronik, Max-Wien-Platz 1, 07743 Jena — [2]Forschungszentrum Dresden - Rossendorf, Bautzner Landstraße 128, 01328 Dresden — [3]Department für Physik der LMU München und Maier-Leibnitz-Laboratorium, Am Coulombwall 1, 85748 Garching

Wir präsentieren ein Experiment, bei dem mit einem Hochintensitätslaser zwei gegenläufige Elektronenstrahlen erzeugt werden, die bei der Kollision Teilchenpaare erzeugen.

Es werden zwei hochintensive, gegenläufige Laserpulse in einen Gasjet fokussiert. Jeder Laserpuls beschleunigt Plasmaelektronen in Laserrichtung auf relativistische Geschwindigkeiten. Die Foki der Laserpulse sind etwas getrennt, sodass die beschleunigten Elektronen in der Mitte kollidieren können. Dabei entstehen e^+e^--Paare. Die Zahl der entstehenden Positronen hängt vom Durchmesser der Elektronenstrahlen ab. Somit kann die Quellgröße für laserbeschleunigte Elektronenpulse experimentell bestimmt werden.

Es wurden Rechnungen zur Erzeugungsrate und zur Energie- und Winkelverteilung der Positronen durchgeführt. Darauf basierend wurde zum Nachweis der Positronen eine spezielle, auf Magnetfeldern beruhende Strahlführung zum Detektor außerhalb des Plasmas konstruiert. Die Transmission und Nachweiseffizienz wurden sorgfältig kalibriert. Die Einflüsse parasitärer Effekte wurden gemessen.

Q 29.9 Di 16:30 Poster C

Aufbau einer Anlage zur ultraschnellen Elektronenbeugung — •Marc Winter, Matthias Wollenhaupt und Thomas Baumert — Universität Kassel, Institut für Physik, Heinrich-Plett-Str. 40, D-34132 Kassel

Um strukturelle Umordnungen auf der Femtosekunden- / Pikosekundenzeitskala mit atomarer Auflösung direkt zu beobachten, ist eine Kombination von optischen Techniken mit hoher Zeitauflösung (fs Pump-Probe) mit Strukturuntersuchungsmethoden, wie Röntgen- und insbesondere Elektronenbeugung [1-3], notwendig. In diesem Beitrag wird der Aufbau einer Anlage zur zeitaufgelösten Elektronenbeugung auf Basis eines 1 Watt fs-Lasersystems vorgestellt und der aktuelle Status beschrieben.

[1] B.J. Siwick, J.R. Dwyer, R.E. Jordan, R.J.D. Miller, Science 302 (2003) 1382

[2] W. E. King, G. H. Campbell, A. Frank, B. Reed, J. F. Schmerge, B. J. Siwick, B. C. Stuart, P. M. Weber, J. Appl. Phys. 97 (2005) 11101

[3] A. H. Zewail, Annu. Rev. Phys. Chem. 57 (2006) 65

Q 29.10 Di 16:30 Poster C

A flexible setup for high resolution femtosecond pulse shaping — •Jens Köhler, Cristian Sarpe-Tudoran, Matthias Wollenhaupt, and Thomas Baumert — Universität Kassel, Institut für Physik und CINSaT, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

We present a flexible setup for femtosecond laser pulse shaping on the basis of a 2 x 640-pixel LC-SLM (liquid crystal-spatial light modulator). The constructed pulse shaper allows either spectral phase and amplitude modulation or spectral phase and polarization control independent of each other. The polarization dependent losses normally present in the polarization shaping mode of similar devices could be minimized by the use of VPHGs (Volume Phase Holographic Gratings). The very high spectral resolution of this device provides generation of nearly arbitrarily shaped optical pulses on a wide temporal window. Further key features of our setup are compactness and high reproducibility. By applying various phase functions to the LC-SLM experimental tests of the pulse shaper have been carried out. Results will be presented.

Q 29.11 Di 16:30 Poster C

Undulatorstrahlung mittels laserproduzierter Elektronenstrahlen — •Kerstin Haupt[1], Hans-Peter Schlenvoigt[1], Fabian Budde[1], Alexander Debus[1], Heinrich Schwoerer[1], Enrico Brunetti[2], Jordan Gallacher[2] und Dino Jaroszynski[2] — [1]Institut für Optik und Quantenelektronik, Max-Wien-Platz — [2]Department of Physics, University of Strathclyde, Glasgow G4 0NG, United Kingdom

Wir präsentieren ein Experiment zur Erzeugung von Undulatorstrahlung unter Verwendung von laserbeschleunigten Elektronen. Ein in einen Helium-Gasjet fokussierter hochintensiver Laserpuls beschleunigt Elektronen auf relativistische Geschwindigkeiten. Diese Elektronenstrahlen passieren unseren neuen Undulator und sollen dabei Strahlung mit Wellenlängen im sichtbaren bis infraroten Bereich erzeugen. Der Undulator wurde speziell konstruiert um für die mit dem JETI-Lasersystem erzeugten Elektronenstrahlen optimale Ergebnisse zu liefern. Genaue Messungen des optimierten magnetischen Feldes des Undulators werden präsentiert. Im Experiment konnte festgestellt werden, dass die Elektronen den Undulator ohne Abweichung von ihrer ursprünglichen Richtung verlassen. Daher kann das Energiespektrum der Elektronen mittels eines Elektronenspektrometers hinter dem Undulator beobachtet werden. Gleichzeitig kann Undulatorstrahlung mit einem optischen Spektrometer detektiert werden. Der Versuchsaufbau erlaubt die simultane Detektion von Elektronen- und Strahlungsspektren für jeden individuellen Laserschuss. Dies ist notwendig für die eindeutige Identifikation des Ursprungs der detektierten Strahlung.

Q 30: Poster Nichtlineare optische Effekte und Lichtquellen

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 30.1 Di 16:30 Poster C

Diodengepumpter cw-OPO aus MgO:PPLN für Anwendungen in der Frequenzkonversion von Einzelphotonen — •Sebastian Zaske[1,2], Peter Haag[1], Johannes L'huillier[1] und Christoph Becher[2] — [1]Technische Universität Kaiserslautern, Fachbereich Physik, Erwin-Schrödinger-Strasse 46, 67663 Kaiserslautern — [2]Universität des Saarlandes, Fachrichtung 7.3, Postfach 151150, 66041 Saarbrücken

Ein elementarer Bestandteil quantenkryptographischer Verfahren ist eine Lichtquelle, die deterministisch einzelne Photonen emittiert. Eine neuartige Realisierungsmöglichkeit für diese Lichtquellen sind Si-basierte Defektzentren in Diamant [1] mit Emissionen im nahinfraroten Spektralbereich bei 737 nm. Für die Entwicklung langreichweitiger Quantennetzwerke ist die Konversion der Einzelphotonen in den Wellenlängenbereich der Telekommunikationsfenster (1550 nm) unabdingbar. Eine interessante Möglichkeit für diesen Konversionsprozess ist die Differenzfrequenzerzeugung (DFG) mit der Pumpquelle bei 1405 nm. Bei dieser Wellenlänge existieren bisher keine geeigneten Halbleiter- oder Festkörperlaser genügend hoher Leistung. Im Rahmen unserer Untersuchungen wurde daher ein Diodenlaser gepumpter cw-OPO auf Basis eines periodisch gepolten MgO dotierten $LiNbO_3$ (MgO:$LiNbO_3$) realisiert, der Strahlung bei 1405 nm erzeugt. Die experimentellen Ergebnisse zu dem OPO sowie den aktuellen Stand der Experimente zur Frequenzkonversion der einzelnen Photonen im DFG Prozess werden vorgestellt.

[1] C. Wang et al., J. Phys. B: At. Mol. Opt. Phys. **39**, 37 (2006).

Q 30.2 Di 16:30 Poster C

High-order harmonic generation as a possible seed source for the BESSY-FEL — •Torsten Leitner, Atoosa Meseck, and Eberhard Jaeschke — Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H., Germany

The "Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung"(BESSY) is planning to build a free electron laser (FEL), which is based on the concept of high-gain harmonic generation. In this concept, the FEL process is initiated by an external light field, the so-called seed. It is planned to use tunable lasers as seeding sources with wavelengths ranging from 230 nm to 460 nm. After this, a cascade of undulator–magnetic delay–undulator units has to be passed, where in each unit the light field is converted to a higher harmonic order until the desired output of 1 nm to 51 nm is achieved. A new approach is seeding directly at shorter wavelengths close to or in the final output range. To produce these short wavelengths high-order harmonic generation (HHG) in gases can be used. If a gas is irradiated by a high intensity laser, some of the atoms are ionized. Upon recombination, the atoms coherently radiate at integer multiples of the fundamental laser frequency. For this purpose a numerical simulation based on the "strong-field approximation"after M.Lewenstein et al. was developed, which calculates the single atom spectra and the propagation of the produced light through the gas. Using this radiation as the seed, the FEL process is analyzed via a Genesis 1.3 simulation, with special attention on the tranversal behavior of the seed and the produced FEL-light, as well as the frequency filtering effects in the FEL radiator.

Q 30.3 Di 16:30 Poster C

Development of the mid-IR CW narrowband 5 - 15 μm tunable laser source for molecular spectroscopy — •Sergey Vasilyev, Alexander Nevsky, and Stephan Schiller — Institut fuer Experimentalphysik, Heinrich-Heine-Universitaet Duesseldorf

Specific features of molecular gases spectra in mid-IR (MIR) range attract a growing interest for a number of applications. Yet, many promising results have remained confined to laboratories for lack of suitable MIR laser sources. The objective of our research project is the development of a widely tunable narrowband MIR laser source, emitting from 5 to 15 μm. This source will be based on an optical parametric oscillator (OPO) using as nonlinear frequency converting medium a semiconductor crystal: Orientation-Patterned Gallium Arsenide (OP-GaAs). A tunable Thulium-doped fiber laser MOPA at 1.8-2 μm will be used as the OPO pump.

First-order quasi-phase-matched difference frequency generation (DFG) and second harmonic generation (SHG) in OP-GaAs crystal have been investigated on the preliminary stage of the research project. The OP-GaAs sample with 14 mm length and 27.6 μm grating period has been used in both experiments. Narrowband tunable lasers at 1.56 μm (1 W EDFA) and 3.6 μm (30 mW PPLN OPO) were mixed to obtain sub-μW DFG output at 2.76 μm. The same PPLN OPO source, but tuned to the 3.14 μm, was used for SHG experiment. Measured power levels and QPM bandwidths were found to be in agreement with theoretical estimates, indicating good uniformity of tested OP-GaAs crystal sample.

Q 30.4 Di 16:30 Poster C

Effiziente Frequenzverdopplung von Laserlicht der Wellenlänge 738 nm — •T. Collath[1], L. Bohatý[2], P. Becker[2] und Chr. Wunderlich[1] — [1]Universität Siegen, Institut für Physik, Walter-Flex-Straße 3, 57072 Siegen — [2]Universität Köln, Institut für Kristallographie, Zülpicher Straße 49b, 50674 Köln

Zur Laserkühlung und zum zustandsselektiven Nachweis von Ytterbium-Ionen, gespeichert in einer Paul-Falle, auf der optischen Resonanz $^2S_{1/2}, F = 1 \leftrightarrow {}^2P_{1/2}, F = 0$ wird Laserlicht der Wellenlänge 369 nm benötigt [1], das wir mittels eines Ti:Saphir Lasers (738 nm) und Frequenzverdopplung erzeugen. Für diese Wellenlängen können die nichtlinearen optischen Kristalle Lithiumtriborat (LiB_3O_5), β-Bariumborat β-BaB_2O_4), Lithiumiodat ($LiIO_3$) und Bismuttriborat (BiB_3O_6) zum Einsatz kommen [2]. Ein Ringresonator in symmetrischer Doppel-Z Konfiguration dient zur Leistungsüberhöhung. Um die Frequenzkonversionseffizienz zu optimieren werden die Parameter des Resonators (Fokusdurchmesser, Länge, Brennweite und Abstand der Hohl- und Planspiegel, Einfallswinkel) auf das verwendete nichtlineare Medium abgestimmt. Zur Verbesserung der Langzeitstabilität soll eine kurze Resonatorlänge verwirklicht und das Gehäuse des Resonators aus einem Block gefertigt werden. Ein für den genannten Zweck optimiertes System wird vorgestellt.

[1] Chr. Wunderlich, Chr. Balzer, Adv. At. Mol. Opt. Phys. **49**, Academic Press, 295 (2003).

[2] D.N. Nikogosyan, *Nonlinear Optical Crystals: A Complete Survey.* Springer, New York, 2005.

Q 30.5 Di 16:30 Poster C

Spektrale Formung von Weißlicht-Filamenten — •Alexander Sävert[1], Marcus Beutler[1], Sebastian Höfer[1] und Roland Sauerbrey[2] — [1]Institut für Optik und Quantenelektronik, Jena — [2]Forschungszentrum Dresden Rossendorf, Dresden

Untersuchungen der letzten Jahre haben gezeigt, dass Laserpulse mit Leistungen oberhalb von einigen 10 GW Lichtfilamente in Luft bilden. Wir untersuchen die Beeinflussung der Ausbreitungseigenschaften ultrakurzer intensiver Pulse in optischen Materialien mit phasenmodulierten Lichtimpulsen. Mit Hilfe von evolutionären Algorithmen wurden Impulsformen gefunden, die das Weißlichtspektrum verbreitern bzw. in bestimmten Spektralbereichen intensivieren.

Q 30.6 Di 16:30 Poster C

Optimierte Erzeugung Hoher Harmonischer mittels Pulsformung und Strahlcharakterisierung der Röntgenstrahlung — •Robert Spitzenpfeil, Stefan Eyring, Jan Lohbreier, Dominik Walter, Matthias Weger und Christian Spielmann — Universität Würzburg, Physikalisches Institut, Lehrstuhl für Experimentelle Physik 1

Die von einem standard tabletop Ti:Sa Lasersystem (800nm, 1kHz, 1mJ, 30fs) erzeugte Strahlung wird zur spektralen Verbreiterung durch Selbstphasenmodulation in eine Gaszelle geleitet. In dieser entsteht ein stabliles, selbstführendes Filament. Durch räumliche Formung der Phasenfront vor Eintritt in die Gaszelle durch einen 2D LCD Pulsformer, wird das Filament so beeinflußt, so daß das u.A. der räumliche Chirp der Spektrums minimiert wird. Hierdurch steht der gesamte Querschnitt des Strahls zur anschließenden Rekompression in einem Prismenkompressor zur Verfügung. Mit diesen nun kurzen und intensiven Pulsen erzeugen wir die Hohen Harmonischen in einem Gas-Jet. Die räumliche Charakterisierung der erzeugten Röntgenstrahlen erfolgt mittels eines Knifeedge-Scanners zur M^2 Bestimmung und eines Hartmann-Sensors zur Messung der Phasenfront des Strahls.

Q 30.7 Di 16:30 Poster C

The dependence of the Fe K_α yield on the chirp of the

femtosecond exciting laser pulse — •Martin Silies[1,2], Steffen Linden[1,2], Henrik Witte[1,2], and Helmut Zacharias[1,2] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität, Münster — [2]Centrum für Nanotechnologie, Münster

The hard x-ray yield generated with femtosecond laser pulses is studied for differently chirped irradiating laser pulses. The radiation of a Ti:sapphire CPA laser system (29 fs, 750 μJ, 1 kHz) is focussed onto a iron containing solid state target producing incoherent hard x-ray radiation, Bremsstrahlung as well as target-specific K_α and K_β lines. The hard x-ray yield has been optimized by introducing negative and positive group delay dispersion (GDD) and third order dispersion (TOD) to the femtosecond laser pulse. The K_α yield could be enhanced by a factor of 1.7 and reached $1.9 \cdot 10^8$ Fe K_α photons/s in 4π with the laser pulse positively chirped, and $1.5 \cdot 10^8$ Fe K_α photons/s in 4π with the pulse negatively chirped. When the pulse energy is lowered to about 400 μJ the yield maximum vanishes and only the maximum at positive chirp remains. We explain the behaviour with induced third order dispersion that led to an asymmetric change of the pulse structure. Furthermore the diameter of the x-ray source has been determined by using a pinhole camera to be about 10 μm (FWHM) and therefore also smaller than the diameter of the applied laser pulse. The diameter of the x-ray source was also independent of the chirp of the laser pulse showing that the expansion of the plasma due to the increased pulse duration is negligible.

Q 30.8 Di 16:30 Poster C

The fiber amplifier system for laser cooling of indium atoms — •Jae-Ihn Kim, Dietmer Haubrich, and Dieter Meschede — Institute for applied physics, University of Bonn, Bonn, Germany

A fiber amplifier system at $\lambda = 976$ nm is demonstrated, which will form the basis for the generation of ultra-violet light at 325 nm, a resonant transition($|5^2D_{5/2}$,F=7⟩-$|5^2P_{3/2}$,F=6⟩) of indium. We have employed a special Yb-doped double-clad fiber(YDCF) in which the inner cladding has a small diameter to increase the pump overlap factor as well as air-hole structures around the inner cladding to increase the numerical aperture. The performance of the YDCF system, such as the slope efficiency and the spectral and polarization characteristics of the output were investigated. The output of the YDCF amplifier will ultimately be frequency-trippled through the use of enhancement cavities.

Q 30.9 Di 16:30 Poster C

Towards the detection of single chromium centers — •Anoush Aghajani-Talesh, Jimmy Sebastian, Axel Griesmaier, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut

In order to demonstrate the ability of controlled single atom deposition using ultracold chromium, we require reliable methods for the preparation and detection of single chromium atoms. A novel approach tries to convert single deposited chromium atoms into Cr^{3+} centers. It uses an optical detection scheme based on a confocal microscope to detect photo luminescence from single Cr^{3+} centers in a transparent substrate.
Using indiffusion and ion-implantation techniques we have incorporated chromium in lithium niobate ($LiNbO_3$). In $LiNbO_3$, chromium impurities predominantly occur as octahedrally coordinated Cr^{3+}-ions, which decay via a broadband $^4T_2 \rightarrow {}^4A_2$ transition with a peak wavelength of 850 nm and lifetime of 10 μs. Using a confocal microscope setup, we were able to perform spatially resolved luminescence measurements. Our results indicate that the detection of single Cr^{3+} centers is feasible, provided the host substrate is sufficiently pure. We therefore extended our investigations to ultra pure fused silica (SiO_2).

Q 30.10 Di 16:30 Poster C

Rb filled Hollow Core Photonic Band-Gap Fibre — •Wenjia Zhong[1], Christoph Marquardt[1], Ulrik L. Andersen[2], and Gerd Leuchs[1] — [1]Institute of Optics, Information and Photonics (Max Planck Research Group), University of Erlangen-Nuremberg, Günther-Scharowsky-Str. 1, Building 24, 91058 Erlangen, Germany — [2]Department of Physics, Technical University of Denmark, Building 309, 2800 Kgs. Lyngby, Denmark

Hollow core photonic band-gap fibres can guide light in the inner hollow core, surrounded by a microstructure that creates a photonic band-gap. If the hollow core is filled with gaseous or liquid media, a collimated beam with a diameter of only a few micrometers could be guided over many meters inside the media. This is ideal for achieving self-induced transparency (SIT) solitons over large distances.

We developed a method for filling Rb into hollow core fibres. We plan to evaporate the Rb inside the fiber and exploit the nonlinearity inherent in detuned SIT for the generation of squeezed states.

Q 30.11 Di 16:30 Poster C

A precise laser spectrometer for optical cavities — •Simone Bux, Sebastian Slama, Gordon Krenz, Claus Zimmermann, and Philippe Courteille — Physikalisches Institut der Universität Tübingen, Deutschland

We analyze the coupled dynamics of ultracold atomic clouds interacting with the modes of an optical high-finesse resonator. Therefore, a precise control of the laser frequency is necessary. To avoid excessive heating of the atomic cloud by Rayleigh scattering, the light should be tuned far away from an atomic resonance and the amount of injected laser power should be low. In practice, however, to generate collective coupling, the atom-light detuning has to be sufficiently small. Also, the stabilization of the laser to a cavity resonance requires a minimum amount of injected light.

We present a simple scheme for a laser spectrometer circumventing this problem. We are using two lasers, one probing the cavity resonance on a higher TEM-mode not interfering with the atoms. The other one is close to an atomic resonance and phase-coherently stabilized on the first laser, so that it can be tuned over a cavity resonance. Furthermore, it can be switched quickly. We will present first experimental results of this locking scheme.

Q 31: Poster Laserspektroskopie

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 31.1 Di 16:30 Poster C

Photodynamics of OLED Triplet Emitters $Ir(ppy)_3$ and PtOEP — •Ashu Kumar Bansal[1], Alfons Penzkofer[1], Wolfgang Holzer[1], and Taiju Tsuboi[2] — [1]Institut II - Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, D-93053 Regensburg, Germany — [2]Faculty of Engineering, Kyoto Sangyo University, Kamigamo, Kita-ku, Kyoto 603-8555, Japan

The absorption behaviour and the emission dynamics of the triplet emitters $Ir(ppy)_3$ and PtOEP in the singlet emitters polystyrene (PS) and dicarbazole-biphenyl (CBP) are studied. Thin films are prepared by spin-coating. The host (PS, CBP) - guest ($Ir(ppy)_3$, PtOEP) interaction is investigated. The luminescence behaviour in the case of guest excitation (excitation frequency in transparency region of hosts) is compared with the luminescence behaviour in the case of host excitation (excitation frequency in absorption region of hosts). Efficient host to guest energy transfer is observed. It is thought to be due to Förster-type energy transfer from the excited singlet system of the host to the excited singlet system of the guest [S_1(host) + S_0(guest) → S_0(host) + S_1(guest)] followed by singlet - triplet intersystem-crossing in the guest system and subsequent guest phosphorescence emission). Phosphorescence quantum yields of 0.9 for 4 wt-% $Ir(ppy)_3$ in PS and of 0.1 for 4 wt-% PtOEP in PS were obtained.

Q 31.2 Di 16:30 Poster C

Spektroskopie an CVD-Diamantfilmen — •Anne Bochow, David Steinmetz, Elke Neu und Christoph Becher — Universität des Saarlandes, Fachrichtung 7.3: Technische Physik, Im Stadtwald, 66041 Saarbrücken

Einzelne Farbzentren in Festkörpern können wegen ihrer optischen Eigenschaften, wie schmale Fluoreszenzlinienbreite und lange Kohärenzzeiten, als „künstliche Atome“ angesehen werden. Geeignete Farbzentren für Anwendung in der Quanteninformation sind z.B. Si-basierte Farbzentren in Diamant, deren Null-Phonon-Linie bei etwa 738nm liegt (Bandbreite bei Raumtemperatur = ca. 6nm) [1]. Die von uns untersuchten Proben werden in einem CVD-Verfahren hergestellt und liegen in Form von ultra-nanokristallinen Diamantfilmen

vor. Die Dicke der Diamantschicht liegt zwischen 140 und 500nm. Zur Anregung werden Wellenlängen im Bereich von 532-740nm verwendet, sodass sowohl nicht-resonante als auch resonante Anregung möglich ist. Mit Hilfe eines konfokalen Mikroskops können einzelne Farbzentren spektroskopisch untersucht werden. Wir diskutieren die gemessenen spektralen Eigenschaften der Si-basierten Farbzentren in unterschiedlichen Diamantfilmen und untersuchen die Photonenstatistik der Fluoreszenzstrahlung.

[1] C. Wang et al., J. Phys. B **39** (2006) 37-41

Q 31.3 Di 16:30 Poster C

Fasergekoppeltes LIBS-Sensor-System zur Detektion gefährlicher Substanzen — •Christian Bohling[1], Konrad Hohmann[1], Wolfgang Schippers[1], Dirk Scheel[1] und Wolfgang Schade[1,2] — [1]TU Clausthal, Institut für Physik und Physikalische Technologien (IPPT), Leibnizstr. 4, 38678 Clausthal-Zellerfeld — [2]TU Clausthal, LaserAnwendungsCentrum (LAC), Arnold-Sommerfeld-Str. 6, 38678 Clausthal-Zellerfeld

LIBS ist eine viel versprechende Technologie zur Detektion von gefährlichen Substanzen, wie z.B. von Explosivstoffen oder biologischen Gefahrstoffen. Für die Detektion derartiger Substanzen an schwer zugänglichen Orten wird ein fasergekoppeltes LIBS System vorgestellt. Als Strahlquelle kommt ein mit einem Yb-Faserverstärker nachverstärkter Microchiplaser zum Einsatz (E_p = 1.5 mJ, λ = 1064 nm). Die Auswertung der spektral und zeitlich aufgelösten LIBS Signale erfolgt durch die Anwendung von Principal Components Analysis (PCA) und Neuronalen Netzen. Durch den vollautomatischen Auswertealgorithmus eignet sich der fasergekoppelte LIBS Sensor zur Verwendung in Robotersystemen. Die Detektion von im Boden verborgenen Anti-Personenminen wird anhand von ersten Feldversuchen diskutiert. Des Weiteren wird untersucht, in wieweit sich das System zur Unterscheidung biologischer Substanzen, sowie zur Detektion von Explosivstoffkontaminationen auf Oberflächen eignet.

Q 31.4 Di 16:30 Poster C

Simulation of optical properties of ZnO nanowires for evanescent field sensors — •Sandra Börner[1], Christian Rueter[1], Tobias Voss[2], and Wolfgang Schade[1] — [1]Institute of Physics and Physical Technologies, Clausthal University of Technologies, Clausthal-Zellerfeld — [2]Institute of Solid State Physics, University of Bremen, Bremen

Optical waveguides within the diameter range of micrometers are successfully applicated in optical communication or optical sensing. Optical μm fibers are used for evanescent detection of gas species or molecules in liquid media. Nanorods or nanowires are efficient waveguides in a certain diameter range. It is reported that the ratio of the evanescent field to the total electric field can increase to almost hundred percent at diameters smaller than the guided wavelength. A miniaturized setup of high efficiency is possible using a single nanowire or nanowire arrays for evanescent field based sensors. As ZnO nanowires can be produced in good crystalline quality and well aligned arrays they are simulated for the applicability in such sensors. Therefore in a first approach the optical properties of ZnO nanorods are studied using a free available block-iterative frequency-domain method (MPB). The analysis was done for different wavelengths, diameters and distances between the nanorods. An experimental setup and first experimental results are presented.

Q 31.5 Di 16:30 Poster C

Giant Kerr Effect in the presence of Electromagnetically Induced Transparency or Absorption — •Luca Spani Molella, Gerrit Kühn, Katrin Dahl, Rolf-Hermann Rinkleff, and Karsten Danzmann — Albert-Einstein-Institut, Max-Planck-Institut für Gravitationsphysik und Institut für Gravitationsphysik, Leibnitz Universität Hannover, Hannover, Germany

The phenomena of electromagnetically induced transparency and electromagnetically induced absorption were investigated in two similar degenerate closed transitions within the D_2 line of caesium. With a three-beam heterodyne interferometer the dispersion and absorption signals of two orthogonally polarised probe and coupling lasers could be measured after the interaction with a caesium beam propagating orthogonally to the direction of propagation of the lasers. On the basis of the measured probe dispersion signals it could be calculated that the Kerr effect of the analysed system was several orders of magnitudes greater than that measurable in common Kerr media, while the corresponding absorption coefficient remained comparable with that measurable within glass.

Q 31.6 Di 16:30 Poster C

Optical spectroscopy of single silicon nanocrystals — •Mathias Grün[1,2], Patrice Miska[2], François Montaigne[2], Hervé Rinnert[2], Michel Vergnat[2], David Steinmetz[1], and Christoph Becher[1] — [1]Fachrichtung 7.3 (Technische Physik), Universität des Saarlandes, 66041 Saarbrücken — [2]Laboratoire de Physique des Matériaux - UMR-CNRS 7556, Université Henri Poincaré Nancy I, Faculté des Sciences et Techniques, 54506 Vandoeuvre-lés-Nancy, France

Silicon crystals with sizes of few nanometers embedded in a silica matrix show an improved quantum efficiency for optical emission in comparison with bulk silicon yielding an intense photoluminescence signal in the spectral region around 700-800 nm. This surprising property is attributed to the quantum confinement of excitons in these nanocrystals, also called "silicon quantum dots". Such nanostructures are promising candidates for the realization of photonic devices and quantum optics experiments. Although the properties of an ensemble of silicon nanocrystals are well known the optical properties of a single silicon quantum dot are still not well understood. Thus, the investigation of single silicon nanocrystals will contribute to the understanding of their intense photoluminescence. Isolating single silicon nanocrystals would also allow for their emplyoment in quantum optics experiments. Here, we report on the fabrication of silicon nanocrystals with sizes of about 3 nm embedded in thin silica films. The samples show intense luminescence at 770-800 nm depending on fabrication parameters. We discuss the luminescence properties and strategies to experimentally isolate single nanocrystals.

Q 31.7 Di 16:30 Poster C

Photoinische Sensoren zur Optimierung industrieller Verbrennungsprozesse — •Andreas Pohlkötter[1], Claus Romano[1,3], Joachim Deubener[2,3] und Wolfgang Schade[1,3] — [1]Institut für Physik und Physikalische Technologien, TU-Clausthal — [2]Institut für Nichtmetallische Werkstoffe, TU-Clausthal — [3]Laser Anwendungs Centrum, TU-Clausthal

Ein in-situ und online Monitoring der Gaskonzentrationen industrieller Verbrennungsprozesse ist für die Optimierung der Verbrennung und des Designs neuartiger Brennerkonzepte von großer Bedeutung. Durch den Einsatz von DFB Laserdioden und Quantenkaskadenlasern im mittleren infraroten Bereich und Faseroptiken für die Konzipierung kompakter Sensorsysteme ist eine echtzeit Detektion von CO_2, NO_x und H_2O möglich. Neben der Absorptionsspektroskopie wird die stimmgabel verstärkte akustooptische Spektroskopie eingesetzt. Dabei wird zur Detektion der Schallwellen eine Quarzstimmgabel anstelle einer akustischen Zelle verwendet. Durch diesen Messaufbau ist es möglich einen miniaturisierten Gassensor herzustellen, der direkt in einem kleinen, zu probenden Gasvolumen eingesetzt werden kann. Die Kombination des Systems mit Lichtquellen im nahen und mittleren Infrarot ermöglicht zudem die Anwendung auf einen weiten Bereich von Spurengasen. Erste Ergebnisse dieses Sensors für verschiedene Gase werden gezeigt und diskutiert.

Das Projekt wird gefördert durch die Arbeitsgemeinschaft industrieller Forschungsvereinigungen und die Hüttentechnische Vereinigung der Deutschen Glasindustrie (AiF-ZUTECH project no.181 ZN).

Q 31.8 Di 16:30 Poster C

Towards an optical clock with neutral Yb — •Florian Baumer, Ulf Bressel, Sven Kroboth, Nils Nemitz, Alexander Nevsky, Maxim Okhapkin, Andreas Wicht, Stephan Schiller, and Axel Görlitz — Institut für Experimentalphysik, HHU Düsseldorf, Germany

Neutral ytterbium (Yb) is an interesting candidate for the realization of an optical clock at a wavelength of 578 nm [1]. Without application of external fields, the corresponding transition $^1S_0 \rightarrow {}^3P_0$ is strictly forbidden in the bosonic isotopes, while hyperfine interactions shorten the radiative lifetime of the $^3P_0$ state in the fermionic isotopes to ≈ 20 s leading to transition linewidths of 43.5 mHz for ^{171}Yb and 38.5 mHz for ^{173}Yb.

A promising scheme for the realization of an optical clock with Yb involves trapping of laser-cooled atoms in an optical lattice [2], where recoil shifts and Doppler shifts can be practically eliminated. The light shift on the clock transition can be minimized by tuning the lattice laser to the so-called "magic" wavelength at 759 nm as has been demonstrated recently by Barber et al. [2]. It is estimated that perturbations to the transition frequency by the lattice light can be held at the level of 10^{-18} [1].

We report on our experimental progress towards the realization of

an optical lattice clock with ytterbium.
[1] S. Porsev et al., Phys. Rev. A **69**, 021403
[2] Z. Barber et al., Phys. Rev. Lett. **96**, 083002 (2006)

Q 31.9 Di 16:30 Poster C

Bestimmung der Grundzustands-Streulänge von ^{40}Ca mit Photoassoziations-Spektroskopie — •Felix Vogt[1], Christophe Grain[1], Tatiana Nazarova[1], Uwe Sterr[1], Fritz Riehle[1], Christian Lisdat[2] und Eberhard Tiemann[2] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Bei der Photoassoziation (PA) bilden stoßende Grundzustandsatome durch Absorption eines resonanten Photons ein angeregtes Molekül. Die zugehörigen PA-Spektren erlauben Aussagen über atomare Eigenschaften und über Streueigenschaften der betreffenden Atome. Im vorliegenden Experiment wurden PA-Spektren unterhalb der Dissoziationsgrenze 4s4s $^1S_0$-4s4p $^1P_1$ von ^{40}Ca gemessen und mit theoretisch berechneten Spektren verglichen. Die Grundzustands-Streulänge von ^{40}Ca konnte so auf einen Bereich von 340 a_0 bis 800 a_0 (a_0: Bohrscher Radius) eingegrenzt werden, wodurch die Diskrepanz zwischen PA-Spektroskopie [1] und klassischer Molekülspektroskopie [2] beseitigt werden konnte. Aus der energetischen Position der durch PA beobachteten Molekülniveaus wurde das langreichweitige Molekülpotential bestimmt. Aus diesem läßt sich mit hoher Präzision die Lebensdauer des atomaren Zustands 4s4p $^1P_1$ ableiten.
[1] C. Degenhardt *et al.*, Phys. Rev. A **67**, 043408, 2003.
[2] O. Allard *et al.*, Eur. Phys. J. D **26**, 155, 2003.

Q 32: Poster Laser in Medizin und Umwelttechnik

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 32.1 Di 16:30 Poster C

Laser Spectroscopic Online Monitoring of Ethane Traces in Exhaled Breath — •Sven Thelen, Manfred Tamminga, Peter Hering, and Manfred Mürtz — Institut für Lasermedizin, Universitätsstr. 1, 40225 Düsseldorf, www.ilm.uni-duesseldorf.de

The quantitative and time resolved analysis of trace gases contained in human breath is of considerable interest for medical diagnostics. An important example is ethane, a bio-marker for the free radical induced lipid peroxidation in the human body. This chemical process is related to diseases like Alzheimer's and artherosclerosis, therefore a rapid and non-invasive detection of ethane is very desirable.
Our detection method is based on Cavity Leak-Out Spectroscopy (CALOS), a highly sensitive and specific variant of laser absorption spectroscopy well suited for time resolved breath measurements. As laser source we have implemented a Difference Frequency Generation (DFG) system ($\Delta\nu$ = 3.30-3.67 μm, P = 280 μW).
We currently achieve an ethane detection limit of 400 ppt or 0.4 nl/l and a time resolution of better than 1 s [1]. We present the latest results of time-resolved online measurements of single breath exhalations of ethane.
[1] D. Halmer et al., Appl. Phys. B **85**, 437 (2006).

Q 32.2 Di 16:30 Poster C

Non invasive and real time analysis of skin pigmentation and cutaneous hemoglobin oxygenation: An experimental and theoretical approach — Eleni Drakaki[1] and •Ioannis Sianoudis[2] — [1]Physics Department, National Technical University of Athens, Zografou Campus, 15780, Athens, Greece, email: edrakaki@central.ntua.gr — [2]Department of Physics Chemistry & Material Sciences, Technological Educational Institute (T.E.I.) of Athens, Ag. Spyridonos, 12210, Athens, Greece, e-mail: jansian@teiath.gr

We present here a technique for examining human skin, based on the in vivo measurement of diffuse reflectance spectra in the visible and near-infrared ranges of the electromagnetic spectrum for non-invasive characterisation of haemoglobin oxygenation and pigmentation in skin. Spectra were measured by means of a fiber optic probe, and they were analyzed using an analytical model, based on the Kubelka-Munk theory of scattering and absorption within inhomogeneous materials. To evaluate the utility of the model, skin sites with variable melanin content were studied on individuals with different skin types or with pathological skin conditions. The results of the analysis indicated that it is possible to obtain quantitative information about main skin pigments, as well as basic information regarding the scattering properties of the skin. In addition to quantification of haemoglobin and melanin, qualitative information on the redox state of the blood may also be obtained. The proposed analytical model could be a helpful tool to monitor and evaluate the variations in the biological skin tissue data and its medical conditions.

Q 32.3 Di 16:30 Poster C

Optimierung und Verbesserung eines ECDLs durch Kombination verschiedener Methoden zum Aufbau eines praxistauglichen Absorptionssensors im UV-Bereich — •Thorsten Führer, Andreas Roth und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, D-64289 Darmstadt

Die bei Verbrennungsprozessen entstehenden Abgase enthalten unter anderem Stickoxide, deren Konzentrationen mittels Laserabsorptionsspektroskopie hochpräzise und in situ bestimmt werden können. Um eine Beeinflussung der Messung durch weitere Bestandteile der Abgase wie beispielsweise Wasser und Kohlendioxid weitestgehend auszuschließen verwenden wir eine Absorptionslinie des Stickstoffs im UV-Bereich. Die benötigte Wellenlänge wird durch Summenfrequenzbildung zweier Laser in einem nichtlinearen Kristall erzeugt. Neben einem intern frequenzverdoppelten Nd:YAG Laser kommt ein ECDL zum Einsatz, welcher die Durchstimmbarkeit ermöglicht. Die Stickstoffkonzentration lässt sich so durch Abfahren einer Absorptionslinie bestimmen. Nach erfolgreichem Test des Laboraufbaus stand nun die Weiterentwicklung des ECDLs im Vordergrund. Unter Verwendung von Standard-Komponenten und Kombination verschiedener Methoden soll sowohl ein größerer modensprungfreier Abstimmbereich als auch eine größere Stabilität und Ausgangsleistung erreicht werden.

Q 32.4 Di 16:30 Poster C

Ein Brillouin-LIDAR zur Messung von Temperaturprofilen in Wasser: Status der Strahlquelle — •Kai Schorstein, Alexandru Popescu, Peer Fietzek, Ingo Massmann, Gerrit Scheich und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Schlossgartenstr. 7, 64289 Darmstadt

Für die berührungslose Aufnahme von Temperaturprofilen in Wasser kann ein Brillouin-LIDAR genutzt werden. Dabei erlaubt die Brillouin-Verschiebung eines zurückgestreuten Laserpulses Rückschlüsse auf die Temperatur im Wasser. Durch das Zeitverhalten dieser Frequenzverschiebung, welche im Bereich von 7-8 GHz für typische Wassertemperaturen liegt, wird ein Tiefenprofil erhalten. Durch solch ein System lassen sich verhältnismäßig schnell große Wasserflächen erfassen und die gewonnenen Daten können in Klimastudien oder Wettervorhersagen Anwendung finden. Da das LIDAR von einem Helikopter oder Flugzeug aus betrieben werden soll, ist ein mechanisch robustes kompaktes System mit geringem Gewicht und Stromaufnahme erforderlich.

In diesem Beitrag wird das Messverfahren erläutert, welches die Brillouin-Streuung als Temperaturmarker im Wasser ausnutzt. Weiterhin wird die prinzipielle Funktionsweise der Strahlquelle und des Detektors vorgestellt. Der Schwerpunkt liegt dabei bei dem Aufbau der Strahlquelle einem mehrstufigen gepulsten Yb:dotierten Faserverstärker. Dieser erzeugt 10 ns Pulse mit einer Bandbreite in der Nähe des Fourier-Limits und mit einer Wiederholrate im unteren kHz-Bereich. Der aktuelle Entwicklungsstand des Verstärkersystems wird präsentiert.

Q 33: Poster Präzisionsmessungen

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 33.1 Di 16:30 Poster C

Ein einfaches Verfahren zur hochpräzisen Laser-Frequenzstabilisierung — Andreas Wicht[1], Nadine Strauss[1], •Ingo Ernsting[1], Stephan Schiller[1], Rolf-Hermann Rinkleff[2] und Karsten Danzmann[2] — [1]Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf — [2]Institut für Gravitationsphysik, Leibniz-Universität Hannover

Die Entwicklung eines komplett analogen Frequenz-Phasen Detektors wird vorgestellt, dessen variable Arbeitsfrequenz einen Bereich von ca. 10 MHz bis 1 GHZ abdeckt und eine Modulations-Bandbreite von > 10 MHz erfaßt. Einen typischen Anwendungsbereich dafür stellt die relative Frequenz- oder Phasenstabilisierung zweier Laser zueinander unter Verwendung des RF-Schwebungssignals dar. Im Frequenzdetektor Modus wird eine Langzeitstabilität von ca. 25 kHz über Wochen und wenigen kHz über Stunden erreicht.

Die Mixer-basierende Phasendetektor-Einheit unterstützt auch die Phasenstabilisierung bei kleinem Signal/Rausch Verhältnis, was einen Vorteil gegenüber digitalen Phasendetektoren darstellt. Zur Charakterisierung des Frequenz-Phasen Detektors werden das Detektorrauschen und Detektorbandbreite, die Frequenz/Spannungs Transferfunktion und das Übersprechen von Amplitudenmodulation des RF-Signals auf das Phasen- und Frequenzsignal angeführt.

Das Leistungsvermögen des Systems wird anhand einer Frequenzstabilisierung eines Diodenlasers mit Emission bei 1,4 μm auf einem Ti:Sa basierendem Frequenzkammes demonstriert.

Q 33.2 Di 16:30 Poster C

Narrow linewidth diode laser system for coherent precision spectroscopy — •K. Döringshoff[1], A. Wicht[1], N. Strauss[1], I. Ernsting[1], J. Koelemeij[1], B. Roth[1], R.-H- Rinkleff[2], and S. Schiller[1] — [1]Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf — [2]Institut für Gravitationsphysik, Leibnitz-Universität Hannover

Phase-locking of diode lasers to a frequency comb is challenging because of the low signal-to-noise ratio of the corresponding RF beat notes and the large frequency or phase noise bandwidth of grating diode lasers. One approach to ease locking is to develop diode lasers which feature a reduced noise bandwidth. A reduction of the noise bandwidth corresponds to a reduction of the necessary RF-detector bandwidth which in turn results in an improved signal-to-noise ratio of the RF-beat note detection. Here we present a diode laser system which is based on merging the concepts underlying the grating diode laser and the diode laser with resonant optical feedback (GEECDL, grating enhanced external cavity diode laser). Thus we combine the good over-all (few 10 nm) and continuous tuneability (up to 20 GHz) and the simple operation of grating lasers with the narrow line width (few 10 kHz) provided by diode lasers with resonant optical feedback. We frequency lock a GEECDL operating at 1394 nm to an H-maser referenced fs-frequency comb and analyze its relative linewidth and frequency stability. We then demonstrate the lasers capability for high precision spectroscopy by investigating the $(\nu' = 4, J' = 3) \rightarrow (\nu = 0, J = 2)$ of cold ($\sim$ 10mK) HD+ molecular ions.

Q 33.3 Di 16:30 Poster C

THz-operation of Quantum Dot based Semiconductor Optical Amplifiers — •Sabine Dommers[1], Vasily Temnov[1], Ulrike Woggon[1], Jordi Gomis[2], Juan Martinez-Pastòr[2], Matthias Lämmlin[3], and Dieter Bimberg[3] — [1]FB Physik, Universität Dortmund, 44221 Dortmund — [2]nstitut de Ciència dels Materials, Universitat de València, 46071 València, Spanien — [3]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin

The amplification of ultrashort pulse trains in an electrically pumped quantum dot (QD) based semiconductor optical amplifier is investigated by ultrafast pump-probe spectroscopy. The amplifier consists of an electrically contacted deeply etched ridge waveguide with a width of 2 μm and a length of 1 mm. The active medium is formed by 15 layers of MBE-grown InGaAs QD-in-a-well nanostructures. Ultrashort pulse trains consisting of up to four identical 150-fs-long Ti:Saphire laser pulses with a controllable delay in a picosecond time range are obtained using two unbalanced Michelson interferometers. The gain dynamics after amplification of ultrashort pulse trains are monitored as a function of pump-probe delay time. We report on a complete gain recovery in the amplification of double pulses separated by 5 picoseconds (equivalent of 200 GHz repetition rate) [1] and discuss the limits of THz amplification (pulse separation 1 ps) on the basis of the experiments with four pulse trains.

[1] Dommers, et al., Appl. Phys. Lett. (in print)

Q 33.4 Di 16:30 Poster C

Ultradünne hochreflektierende Wellenleiter-Beschichtung — •Michael Britzger, Oliver Burmeister, Alexander Bunkowski, Daniel Friedrich, Karsten Danzmann und Roman Schnabel — Albert-Einstein-Institut Hannover, Max-Planck-Institut für Gravitationsphysik und Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover

Eine limitierende Rauschquelle bei laserinterferometrischen Hochpräzisionsmessungen ist das thermische Rauschen der Spiegel. Heutige Laserspiegel verwenden ein dickes dielektrisches Mehrschichtsystem, um eine hohe Reflektivität zu gewährleisten. Obwohl die Dicke des Schichtsystems klein gegenüber der Gesamtdicke des Substrats ist, ist das thermische Rauschen der Beschichtung dominant. Das Konzept eines hochreflektierenden dielektrischen Spiegels auf Basis einer Wellenleiterstruktur in einer einzelnen sehr dünnen Schicht wird vorgestellt. Dieser Ansatz bietet die Möglichkeit hohe Reflektivität zu erzielen, jedoch mit geringerem thermischen Rauschen als bei konventionellen Beschichtungen. Ein mögliches Design für die optische Wellenlänge von heutigen Gravitationswellendetektoren wird diskutiert. [1] A. Bunkowski et al., Class. Quantum Grav. 23, 7297 (2006).

Q 33.5 Di 16:30 Poster C

Stabilitätsverhalten optischer Resonatoren — •Ingo Ernsting, Maxim Okhapkin, Andreas Wicht, Christian Eisele, Alexander Nevsky und Stephan Schiller — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

Optische Resonatoren eignen sich durch ihre hohe Kurzzeitstabilität und geringe Langzeit-Driftraten als Referenzelemente für Präzisionslaserquellen. In Verbindung mit einer absoluten Lichtfrequenzmessung über einen optischen Frequenzkamm, welcher auf einen H-Maser referenziert ist, lassen sich sowohl Aussagen über Linienbreite bzw. Stabilität des Frequenzkamms als auch zur Stabilität der optischen Resonatoren treffen. Es wird eine Charakterisierung eines ULE-Resonators bei Raumtemperatur sowie eines kryogenen Saphir-Resonators bei 3,5 K mittels Messung der Schwebungssignale gegen den Frequenzkamm präsentiert. Zusätzlich werden die Resonator-Driftraten in Abhängigkeit von der Resonatortemperatur über mittlere (Stunden) und lange Zeitskalen (Tagen, Wochen), sowie der Ausdehnungskoeffizient bestimmt. Diese Untersuchungen können zur Entwicklung einer RF-Referenzquelle dienen, die die Kurzzeitstabilität optischer Resonatoren mit der Stabilität eines H-Maser über mittlere Zeiten kombiniert.

Q 33.6 Di 16:30 Poster C

Data processing and noise subtraction for the LISA technology package — •Frank Steier, Felipe Guzman, Antonio Garcia, Vinzenz Wand, Gerhard Heinzel, and Karsten Danzmann — Zentrom für Gravitationsphysik Hannover, Callinstr. 38, 30167 Hannover

The LISA technology package is a technology demonstration for the future Gravitational Wave detector LISA. On board LISA Pathfinder the length change between two free falling test masses is measured interferometrically with picometer accuracy in a frequency range between 1 mHz and 30 mHz.
We show how redundant interferometrical signals are combined, noise subtraction for the longitudinal measurement is done and control loops with downsampling and asynchronous data transfer are implemented.

Q 33.7 Di 16:30 Poster C

Cold Atom Sagnac Interferometer — •Thijs Wendrich, Michael Gilowski, Tobias Müller, Waldemar Herr, Cristian Schubert, Ernst M. Rasel, and Wolfgang Ertmer — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

The very high sensitivity of matter-wave interferometry for detecting accelerations and rotations has made it to an ideal tool for applications in fundamental physics and metrology [1]. We report on the sta-

tus of our dual atom interferometer for the precise determination of inertial forces. In this project we use synchronous operation of two counterpropagating atominterferometers to discriminate between accelerations and rotations. The ensembles of 10μk cold ^{87}Rb atoms are launched with a velocity of about 4.4m/s from two double-mot sources on precisely controlled parabolas into the interferometer chamber. The interferometer itself uses optical Raman transitions for the coherent splitting of the atoms. This allows for a compact and transportable setup while still enabling sensitivities comparable to the best conventional sensors. In the current low resolution mode, we optimize critical interferometer components such as atom preparation and detection and analyse systematic effects. Finally we will present the scheme to upgrade the experiment to the full sensitivity of $2 * 10^{-9}$ rad/s for $1 * 10^8$ atoms per shot at a velocity of 3m/s. [1] C. Jentsch, T. Müller, E.M. Rasel, and W. Ertmer, Gen. Rel. Grav. 36(10), 2197(2004)

Q 33.8 Di 16:30 Poster C

Precision spectroscopy of trapped HD^+ ions and the electron-to-proton mass ratio — •Jeroen Koelemeij, Bernhard Roth, Andreas Wicht, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, Universität Düsseldorf

Recently, we successfully demonstrated infrared rovibrational spectroscopy of trapped and sympathetically cooled HD^+ ions at millikelvin temperatures. The long (tens of minutes) storage time of HD^+, together with the low translational temperature and near absence of background-gas collisions in our ultrahigh vacuum apparatus, provide excellent circumstances for precision spectroscopy. Being one of the simplest molecules, HD^+ is also highly accessible to theory. As the rovibrational energy levels of HD^+ depend on the electron-proton mass ratio m_e/m_p, the calculated and measured energy differences between those levels can be combined to extract this fundamental mass ratio. Our latest experimental result agrees with the most accurate available *ab initio* theory to within the measurement accuracy (2 ppb), whereas the theoretical uncertainty is 0.2 ppb. This allows confirmation of the 2002 CODATA recommended value for m_e/m_p to within 5 ppb. For comparison, the 2002 CODATA value itself has a relative accuracy of 0.46 ppb. Our experimental uncertainty is currently limited by substantial Doppler broadening of the observed spectra, even at the low translational temperatures achieved here. Therefore, a new ion trap is under construction, which should enable Doppler-free infrared spectroscopy in the Lamb-Dicke regime. This is expected to improve the spectroscopic accuracy by more than one order of magnitude.

Q 33.9 Di 16:30 Poster C

A mobile atom interferometer for precise measurements of local gravity — •Malte Schmidt, Alexander Senger, Ulrich Eismann, Evgeny Kovalchuk, and Achim Peters — Humboldt Universität zu Berlin, Institut für Physik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

In recent years, matter wave interferometry has developed into a powerful tool for the ultra precise measurement of accelerations and rotations. It is used in various laboratories for experiments in the fields of fundamental physics and metrology.

We present a new design for a gravimeter based on atom interferometry which is optimized for mobility and mechanical stability. This setup will open up the possibility to perform on-site high precision measurements of local gravity. We report on first tests of subsystems including a rack-mounted cooling laser system.

This gravimeter is developed within the FINAQS project, a collaboration of five European research groups that aims at developing new atomic quantum sensors.

Q 33.10 Di 16:30 Poster C

Towards High Precision Spectroscopy of 1s-2s in He+ — •Sebastian Knünz, Maximilian Herrmann, Valentin Batteiger, Thomas Udem, and Theodor W. Hänsch — Max-Planck-Institut für Quantenoptik, Hans-Kopfermannstr. 1, 85748 Garching

Recent progress in the development of XUV frequency combs opens the opportunity to perform high precision spectroscopy on the 1s-2s two photon transition in hydrogen-like helium at 60nm, an interesting candidate for high precision tests of bound state QED. Our approach of storing and cooling helium by co-stored magnesium ions in a linear ion trap will be presented together with an approach to detect the transition and our recent experimental progress.

Q 34: Poster Quanteninformation

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 34.1 Di 16:30 Poster C

True Quantum Dephasing of 2 Qubits — •Julius Helm and Walter Strunz — Theoretical Quantum Dynamics, Institute of Physics, University of Freiburg, Hermann-Herder-Strasse 3, 79104 Freiburg, Germany

A thorough understanding of dephasing processes is of fundamental importance in quantum information. It is known that for a single qubit general dephasing may always be described by random unitary dynamics (so-called random external field (REF)-channels), yet this seizes to be true for two or more qubits [1]. Our aim is to investigate differences between REF-dephasing channels and dephasing originating from entanglement with an environment. As a toy model we consider a system of two qubits that are independently coupled to an "environment" consisting of another qubit.

[1] L. J. Landau and R. F. Streater, Lin. Alg. Appl. 193: 107-127 (1993)

Q 34.2 Di 16:30 Poster C

Setup of an Improved Single-Photon Source — •Jörg Bochmann[1], Gunnar Langfahl[1], Christoph Erbel[1], Axel Kuhn[2], and Gerhard Rempe[1] — [1]MPI für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [2]Clarendon Laboratory, Parks Road, Oxford OX1 3PU, United Kingdom

Single atoms coupled to cavities provide unique systems to study the interaction of light and matter in the quantum regime. Deterministic generation of single photons has been demonstrated [1], but the interaction time of atom and cavity is short (35μs). However, recently discovered cavity-cooling schemes enable deterministic coupling of atom and cavity for more than 10 s [2,3]. Using these techniques in an improved single photon source will tremendously increase duty-cycles for single photon generation and enable experiments on atom-photon and atom-atom entanglement.

In our new setup, we have trapped ^{87}Rb atoms in a MOT and transported to a high finesse cavity in a dipole trap. The cavity parameters put the system at the boundary of the strong coupling regime and coupling of atoms to the cavity has already been observed. Improvements regarding single atom detection and stabilization of the cavity to a non-atomic resonance using an optical frequency comb are under way, latest results will be presented.

[1] T. Wilk, et al., arXiv:quant-ph/0610227 (2006)
[2] S. Nußmann et al, Nature Physics **1**, 122 (2005)
[3] K. Murr, et al., Phys. Rev. A **73**, 063415 (2006)

Q 34.3 Di 16:30 Poster C

Quantum optical measurements with nonclassical ruler states — •Sabine Wölk, Michael Busshardt, and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We propose a generalized scheme to measure a quantum state via quantum comparison of the unknown state with certain classes of ruler states. This comparison is realized via joint measurements of commuting observables on both states. Such measurements can be done in the optical domain. The arising probability distribution contains the complete information on the unknown quantum state. With the help of suitable ruler states, for example the Wigner function can be reconstructed. In the case of other ruler states a simple algorithm can be applied to reconstruct the Fock coefficients of the unknown state. This approach can be particularly suitable to estimate few-photon states.

Q 34.4 Di 16:30 Poster C

Entanglement purification for all graph states — •Caroline Kruszynska[1,2], Akimasa Miyake[1,2], Hans Briegel[1,2], and Wolfgang Dür[1,2] — [1]Institut für theoretische Physik, Universität Inns-

bruck. Austria — [2]Institut für Quantenoptik und Quanteninformation der ÖAW, Innsbruck, Austria

We present multiparty entanglement purification protocols that are capable of purifying arbitrary graph states directly. We have developed recurrence and breeding protocols and compared our methods with strategies based on bipartite entanglement purification in static and communication scenarios. In a static scenario, the parties get several copies of given noisy multiparty entangled states, while in communication scenarios, they are allowed to generate (arbitrary) multiparty states locally before distributing them through noisy quantum channels. We found that direct multiparty purification is of advantage with respect to achievable yields and minimal required fidelity in static scenarios, and with respect to obtainable fidelity in the case of noisy operations in both scenarios. The work is published in Phys. Rev. A **74**, 052316 (2006).

Q 34.5 Di 16:30 Poster C

A quasi-permanent single-photon source with online verification. — •Bernhard Weber, Markus Hijlkema, Holger Specht, Tobias Müller, Simon Webster, and Gerhard Rempe — MPI für Quantenoptik, Hans-Kopfermann-Str.1, 85748 Garching, Germany

We combine very long trapping times of single atoms in an optical dipole trap inside a high-finesse microcavity with a pulsed scheme for single-photon generation. In our setup, a standing-wave optical dipole trap orthogonally oriented to the cavity mode is loaded with a few cold Rb atoms extracted from a magneto-optical trap. A pump laser illuminating the intersection of the trap lasers and the cavity mode provides, when slightly red-detuned from the cavity, three dimensional cooling forces. They allow for trapping a single atom up to a minute under constant observation via the scattering signal into the cavity. Applying a pulsed sequence of pump pulses and repumping intervals with cooling parameters, we show the antibunching behavior of the photons emitted from the cavity in just one trapping event with a single atom. This enables us to first specify the properties of the emitted light online and second guarantee its subsequent performance as a quasi-permanent single photon source.

Q 34.6 Di 16:30 Poster C

Theoretical investigation of single-photons storage in media with electromagnetically induced transparency — •Gor Nikoghosyan[1], Michael Fleischhauer[1], Mathew Eisaman[2], and Mikhail Lukin[2] — [1]Technische Universität Kaiserslautern, Germany — [2]Harvard University, Cambridge, MA, USA

Recently the storage of narrow bandwidth single photons in a room-temperature ensemble of Rb atoms using electromagnetically induced transparency has been experimentally investigated (M. D. Eisaman, A. Andre, F. Massou, M. Fleischhauer, A. S. Zibrov and M. D. Lukin, Nature **438**, 837 (2005)). These experiments verified that the quantum statistics of single photons were preserved under EIT propagation by measuring their second order correlation function. At certain single-photon frequencies, the second order correlation function exhibited an unexpected increase above the classical limit. In the present work we discuss a theoretical model of the single-photon generation and EIT-based propagation that accurately describes such an enhancement in the second-order correlation function, and is in good agreement with experimental observations.

Q 34.7 Di 16:30 Poster C

Classical correlations, Bell inequalities, and communication complexity — •Johannes Wilms[1], Gernot Alber[1], and Ian C. Percival[2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt — [2]Department of Physics, Queen Mary College, University of London, Mile End Road, London E1 4NS, UK

A computer program is presented which is capable of exploring generalizations of Bell-type inequalities for arbitrary numbers of classical inputs and outputs. Thereby, polytopes can be described which represent classical local realistic theories, classical theories without signaling, or classical theories with explicit signaling. These latter polytopes may also be of interest for exploring basic problems of communication complexity. As a first application the influence of non-perfect detectors is discussed in simple Bell experiments.

Q 34.8 Di 16:30 Poster C

Adaptives Schätzen eines Qubits durch Symmetriemessungen — •Christof Happ und Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, 89069 Ulm

Wir beschreiben Methoden zur adaptiven Bestimmung eines Qubits, die auf reinen Symmetrieargumenten beruhen. Dazu werden Produktzustände $|\psi\rangle\,|r_\nu\rangle$ bestehend aus Kopien des zu messenden Zustands $|\psi\rangle$ und frei wählbaren Referenzzuständen $|r_\nu\rangle$ verwendet, und deren Symmetrie bezüglich Teilchenaustausch betrachtet. Mit Hilfe von Monte-Carlo-Simulationen wird untersucht, wie auf Grundlage von bereits durchgeführten Symmetriemessungen einerseits der unbekannte Zustand $|\psi\rangle$ möglichst genau geschätzt und andererseits der Referenzzustand $|r_{\nu+1}\rangle$ einer weiteren Messung am besten gewählt werden können.

Q 34.9 Di 16:30 Poster C

Implementation of universal two qubit processes using elementary gates — Jaroslav Novotny[1], •Gernot Alber[2], and Igor Jex[1] — [1]Department of Physics, FJFI CVUT, Brehova 7, 115 19 Praha 1 - Staré Město, Czech Republic — [2]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany

We present a network of quantum gates which is capable of implementing a large variety of universal two qubit processes. The design is based on several interesting properties of universal two-qubit processes which are discussed briefly. In particular, applications are presented for implementing optimal universal NOT processes.

Q 34.10 Di 16:30 Poster C

Quantum simulations under translational symmetry — •Christina Kraus, Michael Wolf, and Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Garching

We investigate the power of quantum systems for the simulation of Hamiltonian time evolutions on a cubic lattice under the constraint of translational invariance. Given a set of translationally invariant local Hamiltonians and short range interactions we determine time evolutions which can and those that can not be simulated. Whereas for general spin systems no finite universal set of generating interactions is shown to exist, universality turns out to be generic for quadratic bosonic and fermionic nearest-neighbor interactions when supplemented by all translationally invariant on-site Hamiltonians.

Q 34.11 Di 16:30 Poster C

Semiclassical approach to laser-matter interaction for quantum information — •Christoph-Marian Goletz and Frank Grossmann — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

A pi-laser pulse is near optimal to achieve population inversion in a diatomic OH-molecule, which may serve as a NOT-gate, respectively as a qubit in quantum information [1]. In this poster we show that the time-dependent semiclassical approach by Herman and Kluk [2] is capable to describe this fundamental phenomenon.

[1]T. Cheng and A. Brown, J.Chem. Phys. 124, 034111 (2006)
[2]M.F. Herman and E. Kluk, Chem. Phys. 91, 27 (1984)

Q 34.12 Di 16:30 Poster C

Entanglement of Collectively Interacting Harmonic Strings — •Razmik Unanyan[1], Michael Fleischhauer[2], and Dagmar Bruss[1] — [1]Theoretische Physik III, Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf — [2]Fachbereich Physik, Technische Universität Kaiserslautern, 67663, Kaiserslautern

We study the ground-state entanglement of one-dimensional harmonic strings that are coupled to each other by a collective interaction as realized e.g. in an anisotropic ion crystal. Due to the collective type of coupling, where each string interacts with every other one in the same way, the total hamiltonian has a vanishing energy gap and thus shows critical behavior even though the isolated harmonic strings are gapped and thus non-critical. We derive lower and upper bounds for the entanglement, quantified by the von Neumann entropy, between a compact block of oscillators and its environment. For sufficiently large size of subsystems the bounds coincide and show that the area law for entanglement is violated by a logarithmic correction.

Q 34.13 Di 16:30 Poster C

The ion trap not as an universal, but as an "universe-quantum-computer" — •Hector Schmitz, Axel Friedenauer, Steffen Kahra, Lutz Petersen, and Tobias Schätz — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Paul-style ion traps can be used for quantum simulation purposes in

versatile ways. Besides the proposal of universal quantum computing with stroboscopic gates one can benefit from the quantum dynamics of trapped ions directly: additional interaction with laser beams allow for a wide range of Hamiltonians that evolve probe systems in the laboratory in analogy to their often hard to access pendants in nature. By adjusting lasers and electrical potentials with the same ions totally different Hamiltonians can be implemented, like quantum phase transitions in different Ising model families or the quantum random walk.

Another interesting Hamiltonian arises from quantum field theory on curved space times—applied to the evloving universe. The Robertson-Walker-metric leads to a wave equation in which a scale parameter describes the cosmological expansion. Starting with a vacuum state a non-adiabatic time variation of this scale parameter might lead to the generation of particle pairs. This amplification of quantum fluctuations probably seeded the observed distribution of matter in the universe and its background radiation. In strong analogy we predict for the non-adiabatic change of the ion trapping potential the generation of phonon pairs.

Q 34.14 Di 16:30 Poster C

Towards Simulations of Quantum Systems in Ion Traps — •Axel Friedenauer, Hector Schmitz, Lutz Petersen, Steffen Kahra, Günther Leschhorn, and Tobias Schätz — MPQ Garching

We report on the progress of building a quantum simulator or analog quantum computer designed to simulate quantum mechanical systems as e.g. quantum spin models, the Hubbard model or quantum random walks. Using hyperfine levels of Magnesium ions aligned in a linear chain in a Paul trap and applying optical dipole forces we are able to taylor interactions between these and control coupling strengths. Thus we can adapt our simple system to many interesting quantum single or many-body systems. We recently demonstrated ground-state cooling and are now heading for simulations with a single ion.

Q 35: Poster Quantenkommunikation

Zeit: Dienstag 16:30–18:30 Raum: Poster C

Q 35.1 Di 16:30 Poster C

Long-distance atom-photon entanglement — •Fredrik Hocke[1], Florian Henkel[1], Michael Krug[1], Wenjamin Rosenfeld[1], Jürgen Volz[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, 80799 München — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching

Entanglement is a key element of quantum information and communication applications. For future applications as e.g. the realization of quantum networks or the quantum repeater, entanglement between different species like atoms and photons is necessary, because it provides an interface between atomic quantum memories and photonic quantum communication channels.

In our experiment, a single optically trapped ^{87}Rb-atom is excited to a state with two decay channels in a Λ-type configuration. In the following spontaneous decay the spin state of the atom is entangled with the polarization of the emitted photon[1]. So far, we have demonstrated this atom-photon entanglement over distances of a few meters. However, for future applications in quantum communication the spatial separation has to be extended to macroscopic distances.

Here we report first experimental steps towards long-distance atom-photon entanglement (with a distance of a few 100 meters) using fiber-based quantum communication channels.

[1] J. Volz et al., Phys. Rev. Lett. 96, 030404 (2006)

Q 35.2 Di 16:30 Poster C

Simultaneous retrieval of single photons from two atomic ensembles — •Markus Koch[1], Shuai Chen[1], Yu-Ao Chen[1], Thorsten Strassel[1], Zhen-Sheng Yuan[1], Bo Zhao[1], Jörg Schmiedmayer[2], and Jian-Wei Pan[1] — [1]Physikalisches Institut , Universität Heidelberg, Philosophenweg 12, Germany — [2]Atominstitut österreichischer Universitäten, TU Wien, Stadionallee 2, 1020 Wien, Austria

Duan, Lukin, Cirac and Zoller have proposed a scheme for long distance quantum communication based on atomic ensembles and linear optical elements [Duan et al., Nature 414, 413, 2001].
Here we demonstrate that one single cloud of atoms can serve as two independent ensembles. A cloud of cold ^{87}Rb atoms was prepared in a magneto optical trap. Two independent, non overlapping write beams were used to create collective excitations in two spatially seperated regions of the cloud. The excitations can be read out independently. A violation of the Cauchy-Schwartz inequality proves the non classical character of the photons from each ensemble. Using a feed forward circuit we can simultaneously recover single photons from each ensemble and we will demonstrate their indistinguishability for different degrees of freedom by their interference on a beam splitter. Our next goal is to extend the storage time in order to demonstrate entanglement of two atomic ensembles as it is required for the DLCZ protocol.

Q 35.3 Di 16:30 Poster C

Optical free-space quantum key distribution — •Sebastian Schreiner[1], Henning Weier[1], Martin Fürst[1], Tobias Schmitt-Manderbach[2], Christian Kurtsiefer[3], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU München, Schellingstr 4/III, 80799 München — [2]Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [3]Department of Physics, National University of Singapore, 2, Science Drive 3, Singapore 117542

Based on fundamental laws of quantum mechanics, it is possible to generate and to distribute cryptographic keys in a provable safe way. A potential eavesdropper will necessarily disturb the communication by his quantum measurement. This leads to an error rate in the generated keys which allows to evaluate an upper bound on the information eavesdropped.

Here we evaluate the performance of a down town demonstration system operating over a distance of about 500 m. It uses the BB84 protocol with polarized photons from attenuated laser pulses as qubits. The remote controlled system allows for continuous QKD and implements several design and electronic improvements. Furthermore with this new setup the utilization of decoy states as well as daylight operation shall be enabled. We report on experiments that investigate the limits of free-space transmission and discuss the requirements for the development of a compact, fully integrated QKD system.

Q 35.4 Di 16:30 Poster C

Comparison of Quantum Communication Protocols — •Wolfgang Mauerer and Christine Silberhorn — University Erlangen-Nuremberg, Max-Planck Research Group IOIP, Integrated Quantum Optics Group

Quantum key distribution (QKD) is presently among the most popular applications of quantum mechanics. A multitude of protocols has been proposed and security proofs have been provided which show that secret keys can be distributed between two parties even when experimental imperfections are taken into account. Solving the resulting equations for bounds on the key rates is usually not possible analytically, but requires numerical methods. We present an extensive comparison between different protocols implemented using different experimental components.

We provide a numerical tool which allows to compute many aspects of quantum key distribution systems which are of interest, especially bounds on the key generation rate. Experimental imperfections like misalignment and dark counts of detectors or channel losses are included. The analysis includes the optimisation of experimental parameters, e.g., the source intensity, to achive the best possible results. It highlights the perforance gain if improved equipment becomes available, and thus serves as a guideline as to which parts of an experiment are most benefical to be enhanced. For most protocols, both one- and two-way communication are considered.

Q 35.5 Di 16:30 Poster C

robust creation of entanglement between remote memory qubits — •bo zhao[1], zeng bing chen[1,2], yu ao chen[1], joerg schmiedmayer[1], and jian wei pan[1,2] — [1]physikalisches institut, universitaet heidelberg, philosophenweg 12, 69120 heidelberg — [2]hefei na-

tional laboratory for physical sciences at microscale and department of modern physics, university of science and technology of china, hefei, anhui 230026, china

we propose a robust quantum repeater using similar sources as DLCZ scheme, i.e. atomic ensembles and linear optics. Our protocol entails the advantage of two photon interference and requires stable interferometry over only the coherence length of photons which is about 8 orders of magnitude more robust than single photon interference used in DLCZ scheme. Our proposal provides an exciting possiblity for robust and realistic long distance quantum communication.

Q 35.6 Di 16:30 Poster C

Asymptotic correctability of Bell-diagonal qudit states and lower bounds on tolerable error probabilities in quantum cryptography — •Kedar Ranade and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt

The concept of asymptotic correctability of Bell-diagonal quantum states is generalised to elementary quantum systems of higher dimensions. Based on these results basic properties of quantum state purification protocols are investigated which are capable of purifying tensor products of Bell-diagonal states and which are based on B-steps of the Gottesman-Lo-type with the subsequent application of a Calderbank-Shor-Steane quantum code. Consequences for maximum tolerable error rates of quantum cryptographic protocols are discussed.

Q 35.7 Di 16:30 Poster C

Quantum processing photonic states in optical lattices — •Christine Muschik, Ines de Vega, Diego Porras, and Ignacio Cirac — Max Planck Institute for Quantumoptics, Garching, Germany

The mapping of photonic states to collective excitations of atomic ensembles is a powerful tool which finds a useful application in the realization of quantum memories and quantum repeaters. In this work we show that cold atoms in optical lattices can be used to perform an entangling unitary operation on the transferred atomic excitations. After the release of the quantum atomic state, our protocol results in a deterministic two qubit gate for photons. The proposed scheme is feasible with current experimental techniques and robust against the dominant sources of noise.

Q 36: Robert-Wichard-Pohl Preisträgervortrag

Zeit: Mittwoch 11:30–12:00 Raum: 6J

Preisträgervortrag Q 36.1 Mi 11:30 6J

Atom für Atom zu beherrschbaren Quantensystemen — •Dieter Meschede — Institut für Angewandte Physik, Universität Bonn — Träger des Robert-Wichard-Pohl-Preises

Im Laufe des 20. Jahrhunderts ist unser Verständnis der materiellen Welt durch die Quantenphysik grundlegend transformiert worden. Um die Quantentheorie zu testen und zur Illustration haben Experimentalphysiker über viele Jahrzehnte Methoden entwickelt, um einzelne Quantensysteme zu isolieren und Quantenphänomene in besonderer Reinheit zu beobachten. Seit etwa 1990 werden die Experimentatoren mehr und mehr auch zu „Quanten-Ingenieuren“: Sie konstruieren aus wohlverstandenen, isolierten Quantensystemen komplexere Systeme, die nicht nur die Realisierung neuer funktionaler Systeme z. B. für die Quanteninformationsverarbeitung versprechen, sondern auch helfen sollen, unser Verständnis des Übergangs von den mikroskopischen Eigenschaften einzelner Teilchen zur makroskopischen Welt der Vielteilchensysteme zu verbessern. Gespeicherte neutrale Atome sind ein interessantes System für dieses Projekt, weil einerseits schon gezeigt worden ist, dass sie als einzelne Quantensysteme sehr gut beherrscht werden können, andererseits auch kontrollierte, das heisst schaltbare Wechselwirkungen in einem System aus sehr vielen Atomen schon realisiert worden sind. Es wird vorgestellt, welche Methoden zur Verfügung stehen und welche Chancen neutrale Atome bieten könnten.

Q 37: Quantengase (Tunneln I)

Zeit: Mittwoch 12:00–13:00 Raum: 6J

Gruppenbericht Q 37.1 Mi 12:00 6J

Resonant tunnelling of Bose-Einstein condensates in periodic potentials — •Sandro Wimberger[1,2], Donatella Ciampini[1], Oliver Morsch[1], Riccardo Mannella[1], and Ennio Arimondo[1] — [1]CNR-INFM and Dipartimento di Fisica "Enrico Fermi", Università degli Studi di Pisa, Largo Bruno Pontecorvo 3, I-56127 Pisa — [2]Dipartimento di Fisica, Politecnico di Torino, Corso Duca degli Abruzzi 24, I-10129 Torino

Resonantly enhanced tunnelling (RET) results from the interplay between quantum tunnelling and the discrete energy states of particles confined in potential wells. In spite of the fundamental nature of this effect and the practical interest, it has been difficult to observe experimentally. Since the 1970s, much progress has been made in constructing superlattice structures in which RET of electrons was demonstrated for the first time in 1974. Here we show that resonant tunnelling can be observed using Bose-Einstein condensates in accelerated optical lattice potentials. The near-perfect control over the parameters of this system allows us to prepare the condensates with arbitrary initial conditions and also to study theoretically and experimentally the effects of nonlinearity and a loss of coherence. Our approach can be generalized to studying noise and thermal effects in resonant tunnelling and underlines the usefulness of Bose-Einstein condensates in optical lattices as model systems for the solid state.

Q 37.2 Mi 12:30 6J

Correlated tunneling dynamics of atom pairs in double wells — •Simon Fölling[1], Patrick Cheinet[1], Stefan Trotzky[1], Artur Widera[1], Torben Müller[2], and Immanuel Bloch[1] — [1]Inst. für Physik, Johannes Gutenberg-Universität, D-55099 Mainz — [2]Institute for Quantum Electronics, ETH Zürich, CH-8093 Zürich

The interplay between the atom-atom interaction and the mobility is the dominant parameter governing the dynamics of many strongly correlated systems of ultracold atoms. The most elementary realization of such a system is a set of two potential wells occupied by two interacting atoms which can tunnel through the central barrier. By superimposing the periodic potentials of two standing light waves with a periodicity of 382.5nm and 765nm and controllable relative intensity and phase, we create a one-dimensional array of double wells with adjustable tunnel coupling. Additional standing waves on the two orthogonal axes provide axial confinement, creating a three-dimensional array of up to 10^5 double wells occupied by one to two ^{87}Rb atoms each. By initially loading only one side of each double well before initiating the tunneling dynamics, we can directly observe the dynamics of single atoms as well as of atom pairs. Since the ratio of the tunneling matrix element J and the on-site repulsive interaction U between two atoms can be modified in a wide range, the crossover from a tunneling- to an interaction-dominated regime can be observed. Here, the independent motion of two atoms changes to a correlated tunnel process of the pairs.

Q 37.3 Mi 12:45 6J

Spontaneous emergence of angular momentum Josephson oscillations in coupled annular Bose-Einstein condensates — •Igor Lesanovsky and Wolf von Klitzing — Institute of Electronic Structure and Laser, Foundation for Research and Technology -Hellas, P.O. Box 1527, GR-71110 Heraklion, Greece

We investigate the nonlinear dynamics of two coupled annular Bose-Einstein condensates. We demonstrate that for certain values of the coupling strength a non-rotating state with uniform density is unstable

with respect to fluctuations in higher angular momentum modes. We analytically derive the two-branched Bogoliubov spectrum and show that there exist distinct regions of instability enabling one to selectively occupy certain angular momentum modes. Carrying out a numerical propagation of the Gross-Pitaevskii equation we observe after a sufficiently long evolution time the spontaneous emergence of angular momentum Josephson oscillations which break the chiral symmetry of the initial state.

[1] I. Lesanovsky and W. v. Klitzing, preprint:quant-ph/0609133 (2006)

Q 38: Quanteninformation (Konzepte I)

Zeit: Mittwoch 12:00–13:00 Raum: 5L

Q 38.1 Mi 12:00 5L

Quantum simulations under translational symmetry — •Christina Kraus, Michael Wolf, and Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Garching

We investigate the power of quantum systems for the simulation of Hamiltonian time evolutions on a cubic lattice under the constraint of translational invariance. Given a set of translationally invariant local Hamiltonians and short range interactions we determine time evolutions which can and those that can not be simulated. Whereas for general spin systems no finite universal set of generating interactions is shown to exist, universality turns out to be generic for quadratic bosonic and fermionic nearest-neighbor interactions when supplemented by all translationally invariant on-site Hamiltonians.

Q 38.2 Mi 12:15 5L

General strategy for optimal Unambiguous State Discrimination of two mixed states — •Hermann Kampermann[1], Matthias Kleinmann[1], Philippe Raynal[2], and Dagmar Bruss[1] — [1]Theoretische Physik III, Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf — [2]Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

We consider the problem of unambiguous state discrimination (USD), i.e. measurements which never give the wrong answer, but may led to a nonzero probability of an inconclusive result. The optimal success probability for USD of two mixed states is only known for special situations. In this work we review partial solutions and present a general strategy to reduce/solve this problem. Conditions for USD measurements by Eldar et al. [1] are used to test optimality of upper and lower bounds on the USD success probability [2 – 4]. The discussion is closed with generic examples showing the performance and optimality of these bounds.

[1] Y.C. Eldar, M. Stojnic, and B. Hassibi, Phys. Rev. A 69, 062318 (2004)
[2] P. Raynal and N. Luetkenhaus, Phys. Rev. A 72, 022342 (2005)
[3] X.F. Zhou, Y.S. Zhang, and G.C. Guo, quant-ph/0611095
[4] T. Rudolph, and R.W. Spekkens, and P.S. Turner, Phys. Rev. A 68, 010301(R) (2003)

Q 38.3 Mi 12:30 5L

Entanglement in three-qubit mixtures from GHZ and W states — Robert Lohmayer[1], Andreas Osterloh[2], •Jens Siewert[1], and Armin Uhlmann[3] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg — [2]Institut für Theoretische Physik, Universität Hannover, 30167 Hannover — [3]Institut für Theoretische Physik, Universität Leipzig, 04009 Leipzig

We provide a complete analysis of mixed three-qubit states composed of a GHZ state and a W state orthogonal to the former. We present optimal decompositions and convex roofs for the three-tangle. These results highlight intriguing differences compared to the properties of two-qubit mixed states, and may serve as a quantitative reference for future studies of entanglement in multipartite mixed states.
From our studies we derive an analytical method to decide whether or not an arbitrary rank-2 state of three qubits has vanishing three-tangle. This result can be generalized for N-tangles of rank-2 N-qubit states ($N \geq 3$).

Reference:

R. Lohmayer, A. Osterloh, J. Siewert, A. Uhlmann, e-print quant-ph/0606071 (2006), accepted for publication in Physical Review Letters.

Q 38.4 Mi 12:45 5L

Utilizing the pure state case for the unambiguous discrimination of two mixed states — •Matthias Kleinmann[1], Hermann Kampermann[1], Philippe Raynal[2], and Dagmar Bruss[1] — [1]Heinrich-Heine-Universität Düsseldorf, Institut für Theoretische Physik III, Universitätsstraße 1, 40225 Düsseldorf, Germany — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Staudtstrasse 7, 91058 Erlangen, Germany

The optimal solution for the unambiguous discrimination of two pure states is known since 1995 [JS], while the mixed state case in general is still an open problem. We provide an operable criterion to test whether a given discrimination task for mixed states can be naturally decomposed into a collection of pure state tasks. Indeed, most problems in the literature prove to be of this particular structure. We furthermore investigate the optimality of measurements, which are blockwise composed from pure state measurements, as suggested in [RST]. The analysis of such measurements provides us with a new class of optimal solutions.

[JS] Phys. Lett. A 197, 83 (1995), [RST] Phys. Rev. A 68, 010301(R) (2003)

Q 39: Laser in der Medizin und Umweltmesstechnik II

Zeit: Mittwoch 12:00–13:00 Raum: 5J

Q 39.1 Mi 12:00 5J

Online Analyse von CO im menschlichen Atem mittels Infrarot-Laserspektroskopie — •Thomas Fritsch, Kathrin Heinrich, Peter Hering und Manfred Mürtz — Universität Düsseldorf, Institut für Lasermedizin

Im menschlichen Atem sind eine Reihe von flüchtigen Verbindungen in sehr geringen Konzentrationen vorhanden. Kohlenmonoxid (CO) entsteht im menschlichen Organismus vorwiegend durch Hämabbau und gelangt über die Blutbahn in die Atemluft. Bei verschiedenen Krankheitsbildern, wie zum Beispiel Asthma, zystische Fibrose oder COPD, wurden erhöhte CO Konzentrationen gemessen.

Die Cavity Leak-Out Spektroskopie (CALOS) basiert auf Absorptionsspektroskopie im Wellenlängenbereich um 5 μm in einem High-Finesse Resonator und bietet die Möglichkeit, CO mit einer Zeitauflösung von unter einer Sekunde und einer rauschäquivalenten Konzentration von 7 ppb (parts per billion) zu analysieren und so die Konzentration in Abhängigkeit vom ausgeatmeten Volumen (Exspirogramme) aufzuzeichnen.

Wir möchten die Abhängigkeit der CO Exspirogramme von verschiedenen Atemparametern vorstellen und mit einem mathematischen Modell der Ausatmung vergleichen.

Q 39.2 Mi 12:15 5J

Online-Analyse von Ethan im menschlichen Atem mittels Laserabsorptionsspektroskopie — •Manfred Tamminga, Sven Thelen, Peter Hering und Manfred Mürtz — Institut für Lasermedizin, Universitätsstraße 1, 40225 Düsseldorf, www.ilm.uni-duesseldorf.de

Spurengase im Atemgas kommen in Konzentrationen von ppb bis sub

ppb vor, und sind deshalb schwer zu detektieren. Heutzutage gelten sie als wichtige Biomarker für Erkrankungen des Organismus. Einer dieser Biomarker ist das Ethan, welches als Signalmolekül für oxidativen Zellstress zum Beispiel bei Organtransplantationen entsteht. Außerdem steht Ethan im Zusammenhang mit Krankheiten wie Alzheimer oder Arthereosklerose. Die Medizin ist daher an einem atemzugsaufgelösten Nachweis interessiert. Wir benutzen die Cavity Leak-Out Spektroskopie (CALOS) als zeitaufgelöste, spezifische und hochempfindliche Nachweisemethode. Dabei wird der Absorptionsweg des Laserlichts mittels hochreflektierender Spiegel in einer 0,5 m Messzelle auf mehrere Kilometer verlängert. Als Laserquelle dient uns ein Differenz-Frequenz Lasersystem (DFG), welches kontinuierlich abstimmbar von 3,30 μm bis 3,67 μm ist. Mit einer neuen Gasmischanlage und einer Atemmaske ist es möglich endogenes Ethan im Atem des Patienten nichtinvasiv, atemzugsaufgelöst und unabhängig von der Raumluft nachzuweisen. Es werden die neuesten Ergebnisse zu diesem Thema vorgestellt.

Q 39.3 Mi 12:30 5J

Holographische Topometrie zur Bestimmung der Weichteilverschiebung im Gesicht aufgrund gravitativer Effekte — •Nicola Gisbert[1], Sven Hirsch[1,2], Andrea Thelen[1], Stephanie Heintz[1,3] und Peter Hering[1,4] — [1]Stiftung caesar, Ludwig-Erhard-Allee 2, 53175 Bonn — [2]Hightech Research Center of Cranio-Maxillofacial Surgery, University Hospital Basel, Schanzenstrasse 46, CH-4031 Basel — [3]Hochschule Furtwangen University, Robert-Gerwig-Platz 1, 78120 Furtwangen — [4]Institut für Lasermedizin, Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

Mittels holographischer Geometrieerfassung wird die Gesichtsoberfläche eines Probanden in Form eines 3D-Datensatzes mit zugehöriger Textur gewonnen. Durch die kurzgepulste Aufnahmezeit von 20 ns werden Bewegungsartefakte systematisch vermieden.

Aufnahmen in verschiedener Körperhaltung (z.B. sitzend/liegend) dokumentieren eine schwerkraftbedingte Weichteilverschiebung. Die Registrierung der Modelle erfolgt über fixe Punkte die sich von der Knochenstruktur ableiten. Beim gleiten des Weichgewebes über den Gesichtsschädel ist ein Oberflächen-Shift nachzuweisen, der die volumetrische Veränderung deutlich übertrifft. Die Verschiebung wird anhand Texturmerkmalen zugeordneten Vektoren dargestellt.

Bei Registrierung und Vektorbestimmung wird die punktgenaue Texturinformation genutzt. Aussagekräftige Topologieabweichungen können durch ein technisch fortgeschrittenes Digitalisierungsverfahren und eine Optimierung der Algorithmen zur Oberflächenbestimmung sichergestellt werden.

Q 39.4 Mi 12:45 5J

Tiefenaufgelöste Temperaturmessung in Wasser - Auf dem Weg zu einem Brillouin-LIDAR — •Peer Fietzek, Ingo Massmann, Alexandru Popescu, Kai Schorstein und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstraße 7, D-64289 Darmstadt

Das berührungslose Messen von Temperaturprofilen in Wasser mittels eines Lasersystems ist ein mächtiges Hilfsmittel für viele Bereiche der Meteorologie und Ozeanographie. Optisch dopplerverschobene Rückstreuung an Dichtefluktuationen im Wasser ermöglicht die Bestimmung der lokalen Schallgeschwindigkeit und damit auch der Wassertemperatur. Frequenzverschiebung und Breite der Brillouin-Streuung in Abhängigkeit der Temperatur sind ein wichtiger Teil der Untersuchungen. Dazu wurde ein auf seiner Länge in unabhängige Kammern unterteilter Versuchsaufbau erstellt, der durch laufzeitabhängige Messungen tiefenaufgelöste Aufzeichnungen der Brillouin-Streuung ermöglicht. Sowohl konventionelle interferometrische Techniken, als auch Messverfahren, die den hohen Ansprüchen eines flugzeuggestützten LIDARs entsprechen, sollen eingesetzt werden können. Die geringe Frequenzverschiebung der Brillouin-Streuung im relevanten Temperaturbereich, stellt große Anforderungen an ein praktikables System. Ein Ansatz besteht darin, mit einem schmalbandigen ESFADOF Kantenfilter (excited state faraday anomalous dispersion optical filter) vibrationsunempfindliche Messungen durchzuführen. Als Lichtquelle wird ein frequenzverdoppelter, gepulst betriebener, nahezu fourier-limitierter Ytterbium dotierter Faserverstärker aufgebaut.

Q 40: Quantengase (Spinor-Gase)

Zeit: Mittwoch 14:00–15:45 Raum: 6J

Q 40.1 Mi 14:00 6J

Vortex quantum creation and winding number scaling in a quenched spinor Bose gas — Michael Uhlmann[1], Ralf Schützhold[1], and •Uwe R. Fischer[2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Eberhard-Karls-Universität Tübingen, Institut für Theoretische Physik, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

Motivated by a recent experiment, we study non-equilibrium quantum phenomena taking place in the quench of a spinor Bose gas through the zero-temperature phase transition separating the polar paramagnetic phase and the ferromagnetic phase. We derive the typical domain structure created by the quench arising due to spin-mode fluctuations, and establish a sample-size scaling law for the creation of spin vortices, which are topological defects in the transverse magnetization.

Q 40.2 Mi 14:15 6J

Teaching the old dog new tricks: Quantum dynamics of atomic coherence in spin-1 condensates — •Lev Plimak[1], Reinhold Walser[1], Wolfgang Schleich[1], Kai Bongs[2], and Klaus Sengstock[2] — [1]Universität Ulm, Institut für Quantenphysik, D-89069 Ulm — [2]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Recent spectacular developments in optical cooling and trapping of atoms were preceded by the thorough investigation of interactions of the polarised laser beam with atoms in the sixties, seventies and eighties, in which the concept of atomic coherence played a prominent role. We review this concept in the context of spinor condensates and show that it provides one with a physically natural viewpoint with a link to a multitude of establshed techniques. In addition, access to two-body correlations in the spinor condensates through time-resolved measurement of atomic coherence is discussed.

Q 40.3 Mi 14:30 6J

Exploring the correspondence principle with spinor condensates — •Carsten Weiss, Reinhold Walser, Wolfgang P. Schleich, and Lev Plimak — Institut für Quantenphysik, Universität Ulm, Ulm, Deutschland

Studying many-body quantum physics requires a priori insight into the nature of the quantum state. In the context of three-dimensional condensed bosonic gases, the Gross-Pitaevskii mean-field approximation proved to be very successful in the last decade. However current experiments progress towards lower dimensional and strongly correlated systems [1].

In this contribution we will discuss a basic approach to study the nature of the quantum state in Fock space. By studying a spinor condensate [2-4] in a few mode Born-Oppenheimer approximation we can describe the semi-classical as well as full quantum mechanical dynamics of the system. We find distinctively different behavior for the collective response, which can be either continuous Bogoliubov excitations or discrete Bloch oscillations in Fock space.

[1] B. Paredes *et al.*, Nature **429**, 277 (2004)
[2] W. Zhang *et al.*, Phys Rev. A, **72**, 013602 (2005).
[3] J. Kronjäger *et al.*, Phys. Rev. A, **72**, 1 (2005).
[4] L. Plimak *et al.*, Opt. Comm. **264**, 311 (2006).

Q 40.4 Mi 14:45 6J

Reversible quantum phase dispersion in ultracold spinor gases — •Artur Widera[1], Simon Fölling[1], Stefan Trotzky[1], Patrik Cheinet[1], Fabrice Gerbier[2], and Immanuel Bloch[1] — [1]Insitut für Physik; Universität Mainz, 55099 Mainz — [2]Laboratoire Kastler Brossel, Département de Physique de l'ENS, Paris 75005, France

Many experiments with ultracold quantum gases are deeply influenced by atom-atom interactions. When interactions are strong enough, they can evolve an initial state without inter-particle correlations into a correlated state. This offers the opportunity for quantum state engineering

of non-classical many-body states, with possible applications in quantum information or precision measurements. Here we report on the controlled manipulation of a quantum many-body state in an array of two-component quantum gases. Controllable atomic interactions are used to induce a collective dynamics which affects the quantum distribution of the relative phase between the two components. The ensuing quantum phase dispersion is detected by monitoring the coherence properties of the system through Ramsey interferometry, showing an interaction induced collapse of the Ramsey fringe contrast. We demonstrate the coherent nature of this interaction by timereversal of the dynamics, observing a revival of coherence in the system. Our results point towards the possibility of dynamically creating correlated spin states or even mesoscopic Schrödinger cat states, and moreover have implications on our understanding of decoherence in ultracold atomic systems.

Q 40.5 Mi 15:00 6J

Manifestation of dynamical screening in a spinor condensate — •Navez Patrick — Labo Vaste-Stoffysica en Magnetisme, Katholieke Universiteit Leuven, Celestijnlaan 200 D, B-3001, Heverlee, Belgium — Fachbereich Physik, Universitaet Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

The Landau criterion is a necessary but not sufficient condition for the occurrence of superfluidity. In particular, it ignores that the normal fluid consists of thermal excitations, some of them with a group velocity higher than the critical one. As a consequence, thermal atoms prevent dissipationless motion by colliding with the superfluid ones, unless a mechanism forbids this process. A possible mechanism is the dynamical screening of the interaction force between the thermal atoms and the superfluid ones. A local modification of the amplitude of the superfluid macroscopic wavefunction would induce a local diminution of the potential energy resulting, under some conditions, in a total screening of this interaction force. We propose an experimental setup in which the measurement of the dynamic structure factor in a spinor Bose gas could allow the visualization of this screening phenomenon.

P. Navez, Physica A **356**, 241 (2005); P. Navez and R. Graham, Phys. Rev. A **73**, 043612 (2006).

Q 40.6 Mi 15:15 6J

Spinor Bose-Einstein Kondensate in optischen Dreiecksgittern — •Christoph Becker, Jochen Kronjäger, Parvis Soltan-Panahi, Sebastian Schnelle, Simon Stellmer, Kai Bongs und Klaus Sengstock — Institut für Laserphysik, Universität Hamburg

Ultrakalte Quantengase in optischen Gittern sind Gegenstand intensiver Forschung Sie bieten einerseits ideale Voraussetzungen zur Untersuchung quantenmechanischer Phänomene wie dem Mott-Isolator Übergang oder Kohärenzeigenschaften atomarer Syteme, als auch die Möglichkeit, festkörperphysikalische Fragestellungen in sehr reinen Modellsystemen studieren zu können. Wir haben an unserem Spinor BEC Experiment ein optisches Dreiecksgitter implementiert, welches erstmals Experimente in einer neuen Geometrie zulässt und insbesondere die Untersuchng magnetischer Effekte wie z.B. Spinfrustration oder mögliche Veränderungen der Grundzustandsphasen freier Spinorsysteme [1] ermöglicht. Zusätzlich ist es in unserem Aufbau möglich durch Änderung der Polaristation ein hexagonales Gitter mit magnetischer Ordnung zu erzeugen, dessen Zusammmenspiel mit der intrinsischen magnetischen Wechselwirkung der Atome und der bosonisch verstärkten Dipol-Dipol-Wechselwirkung magnetische Ordnungsphänomene erwarten lässt. Erste Messungen zum Superfluid-Mott-Isolator Übergang und zur dynamischen Entwicklung in Anwesenheit periodischer Potentiale werden präsentiert.

[1] H. Schmaljohann et al., *PRL* **92**, 040402, 2004

Q 40.7 Mi 15:30 6J

Thermodynamic Properties of Spinor Fermi Gases — •Aristeu Lima[1] and Axel Pelster[2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

At first, we consider an ideal harmonically trapped Fermi gas in which the particles have the total angular momentum $F = 3/2$. For a fixed magnetization, we calculate the temperature dependence of thermodynamic quantities like heat capacity, chemical and magneto-chemical potential within a semiclassical approximation. Then we treat a weakly interacting spinor Fermi gas with contact interaction both perturbatively and non-perturbatively within a mean-field approach. In particular, we evaluate the influence of the contact interaction upon the ground state energy. Such fermionic spinor systems are important, for example, in the context of a ^{52}Cr-^{53}Cr boson-fermion mixture [1].

[1] R. Chicireanu et al., Phys. Rev. A **73**, 053406 (2006).

Q 41: Quanteninformation (Konzepte II)

Zeit: Mittwoch 14:00–16:00 Raum: 5L

Q 41.1 Mi 14:00 5L

Experimental Test of Nonlocal Hidden-Variable Theories — •Tomasz Paterek[1,2,3], Simon Gröblacher[3,4], Rainer Kaltenbaek[4], Caslav Brukner[3,4], Marek Zukowski[1,4], Markus Aspelmeyer[3,4], and Anton Zeilinger[3,4] — [1]Institut für Theoretische Physik und Astrophysik, Universität Gdansk, ul. Wita Stwosza 57, 08-952 Gdansk, Polen — [2]The Erwin Schrödinger International Institute for Mathematical Physics, Boltzmanngasse 9, 1090 Wien, Österreich — [3]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Boltzmanngasse 3, 1090 Wien, Österreich — [4]Institut für Experimentalphysik, Universität Wien, Boltzmanngasse 5, 1090 Wien, Österreich

I will discuss experimental incompatibility tests of a class of nonlocal hidden variable theories, which have been recently introcuded by Leggett. The theories under test maintain assumptions of physical realism while providing an explanation for current Bell experiments. However, they can be tested with a different set of experiments.

Q 41.2 Mi 14:15 5L

Practical Scheme for Noiseless Filtering of Continuous-Variable Information with Non-Gaussian Noise — •Christoffer Wittmann[1], Dominique Elser[1], Ulrik L. Andersen[1], Radim Filip[2], Petr Marek[2], and Gerd Leuchs[1] — [1]Institut für Optik, Information und Photonik, Max-Planck Forschungsgruppe, Universität Erlangen-Nürnberg, — [2]Department of Optics, Palacký University,

Every practical quantum channel degrades the quality of quantum states transmitted between two parties. In order to establish a communication with a low error rate, it is therefore important to determine and, if possible, to decrease the influence of noise in the quantum channel. We investigate an optical quantum channel with non-Gaussian noise characteristics, which transforms a signal state into a statistical mixture of signal and vacuum.

We propose and experimentally demonstrate a new scheme for a noiseless and optimal quantum filter or quantum relay filtering vacuum states from this mixture. Two different filters were implemented; one which is relying on weak homodyne measurements and one on weak on/off measurements. The performance of the two schemes is compared relative to the optimal scheme.

Q 41.3 Mi 14:30 5L

Time-continuous quantum state estimation — •Artur Scherer[1], Lajos Diosi[2], Thomas Konrad[3], and Jürgen Audretsch[1] — [1]Fachbereich Physik, Universität Konstanz, Fach M 674, 78457 Konstanz, Germany — [2]Research Institute for Particle and Nuclear Physics, 1525 Budapest 114, P.O.Box 49, Hungary — [3]School of Pure and Applied Physics, University of KwaZulu-Natal, Durban 4000, South Africa

Controlling single quantum systems is an important issue in quantum information processing technology. Recent experimental advancements have made feasible time-continuous weakly disturbing quantum measurements on a single system. New perspectives of quantum feed-back control have raised an immediate related task: the time-continuous estimation and real-time determination of a quantum state. We discuss the time-continuous quantum state estimation problem and present a new non-linear stochastic master equation that governs the time-evolution of the estimated quantum state. Its differential evolution corresponds to the infinitesimal updates that depend on the time-continuous mea-

surement of the true quantum state. The new stochastic master equation couples to the two standard stochastic differential equations of time-continuous quantum measurement. We prove that the calculated estimate almost always converges to the true state. We demonstrate this convergence by a numerically simulated evolution of the true and the estimated wave function of a particle in a double-well potential.

Q 41.4 Mi 14:45 5L

Invariance of quantum cellular automata under all lattice symmetries — •Holger Vogts and Reinhard Werner — Institut für Mathematische Physik, TU Braunschweig, www.imaph.tu-bs.de

Quantum cellular automata (QCAs) are local discrete time dynamical evolutions on a lattice of finite dimensional quantum systems, e.g. spin chains. Usually, one requires these operations to be translationally invariant. But in general the underlying lattice provides more symmetries. So it is a natural question to look for QCAs, which commute with these additional symmetry operations, and study the constraints on the local QCA rules. In the one dimensional lattice we consider QCAs, which are invariant under reflection. Nearest neighbor QCAs with this property are up to a cell-wise rotation phase gates. In higher dimensional lattices we also study the invariance under discrete lattice rotations.

Q 41.5 Mi 15:00 5L

Adiabatic quantum algorithms as quantum phase transitions: 1^{st} versus 2^{nd} order — •Gernot Schaller and Ralf Schützhold — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden

In the continuum limit (large number of qubits), adiabatic quantum algorithms display a remarkable similarity to sweeps through quantum phase transitions. We find that transitions of second or higher order are advantageous in comparison to those of first order. With this insight, we propose a novel adiabatic quantum algorithm for the solution of 3-satisfiability (3-SAT) problems (exact cover), which is significantly faster than previous proposals according to numerical simulations (up to 20 qubits). These findings suggest that adiabatic quantum algorithms can solve NP-complete problems such as 3-SAT much faster than the Grover search routine (yielding a quadratic enhancement), possibly even with an exponential speed-up.

Q 41.6 Mi 15:15 5L

Novel schemes and states for measurement-based quantum computation — •David Gross and Jens Eisert — Imperial College London, 58 Prince's Gate, London SW7 2PE, UK

We establish a framework which allows one to systematically construct novel schemes for measurement-based quantum computation. The technique utilizes tools from many-body physics – based on finitely correlated or projected entangled pair states – to go beyond the cluster-state based one-way computer. We identify universal resource states with radically different entanglement properties than the cluster state, and computational models where the randomness is compensated in a different manner. It is shown that there exist universal resource states which are locally arbitrarily close to a pure state. We find that non-vanishing two-point correlation functions are no obstacle to universality. We comment on the possibility of tailoring computational models to specific physical systems as, e.g. in linear optical experiments.

Q 41.7 Mi 15:30 5L

Simulating time evolution with tensor trees — •Robert Hübener — Österreichische Akademie der Wissenschaften, IQOQI, Innsbruck, Austria

A possible extension of the matrix product state (MPS) formalism has recently been proposed by Vidal, Shi, Markov and Duan. Instead of a flat hierarchy of matrices, a tree tensor-network (TTN) is used to describe a state. A major advantage of this approach is the emergence of long-range and large block-wise entanglement, which is known to be suppressed for MPSs.

Our group is implementing this idea in numerical simulations of strongly correlated systems, including 1D systems with long-range couplings and 2D/3D systems. We combine this approach with our recent proposal to use weighted graph states as variational states. Since graph states incorporate long-range and large block-wise entanglement, the idea of the unification of a tree tensor-state with a graph state might improve this aspect of the simulation even further.

Applications of this formalism include the simulation of (imaginary) time evolution and the search for ground states of strongly correlated systems.

Q 41.8 Mi 15:45 5L

Coherent control in a decoherence-free subspace of a collective multi-level system — •Martin Kiffner, Jörg Evers, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Decoherence-free subspaces (DFS) in a system of two dipole-dipole interacting multi-level atoms are investigated theoretically. The ground state of each atom is a S_0 singlet state, and the excited state multiplet is a P_1 triplet which consists of three Zeeman sublevels. Since we consider arbitrary geometrical alignments of the atoms, all Zeeman sublevels of the atomic multiplets have to be taken into account [1]. It is shown that the collective state space of the two dipole-dipole interacting four-level atoms contains a four-dimensional DFS [2]. We describe a method that allows to populate the antisymmetric states of the DFS by means of a laser field, without the need of a field gradient between the two atoms. These antisymmetric states are identified as long-lived entangled states. Further, we show that any single-qubit operation between two states of the DFS can be induced by means of a microwave field. Typical operation times of these qubit rotations can be significantly shorter than for a nuclear spin system.

[1] M. Kiffner, J. Evers, and C. H. Keitel, arXiv:quant-ph/0611071.
[2] M. Kiffner, J. Evers, and C. H. Keitel, arXiv:quant-ph/0611084.

Q 42: Präzisionsmessungen II

Zeit: Mittwoch 14:00–15:45 Raum: 5K

Q 42.1 Mi 14:00 5K

New Payload Architectures for LISA — •Dennis Weise[1], Wolfgang Holota[1], Hans Reiner Schulte[1], Peter Gath[1], Claus Braxmaier[1,2], and Ulrich Johann[1] — [1]EADS Astrium GmbH, Claude-Dornier-Str., 88090 Immenstaad — [2]Fachhochschule Konstanz, Brauneggerstr. 55, 78462 Konstanz

We discuss new concepts for the realization of the LISA metrology system and payload, which have been developed in the context of the LISA Mission Formulation Study currently led by EADS Astrium under ESA contract. Main characteristic is the use of only a single active gravity reference sensor per spacecraft, which serves both associated interferometer arms. While such payload architectures offer an intrinsic elegance and conceptual simplicity, they pose new challenges for the optical payload design. In particular, new approaches are required for the compensation of constellation dynamics. The seasonal variation of the angle between the interferometer arms of approx. $60 \pm 1°$ can for example be accommodated by a method known as "in-field pointing". Furthermore, newly introduced payload components include an off-axis telescope (Schiefspiegler), and an active optical truss for monitoring of detrimental path length changes within the optical system. Depending on the final realization of the payload architecture, alternative proof mass shapes (spherical or hexagonal) appear advantageous. The overall layout is driven by the requirement to minimize geometrical projection effects in the measurement chain.

Q 42.2 Mi 14:15 5K

Hochsensitives Heterodyninterferometer für einen optisch ausgelesenen Inertialsensor im weltraumgestützten Gravitationwellendetektor LISA — •Martin Gohlke[1,2], Thilo Schuldt[1,2], Dennis Weise[1], Ulrich Johann[1], Claus Braxmaier[1,3] und Achim Peters[2] — [1]EADS Astrium GmbH, Claude-Dornier-Strasse, 88039 Friedrichshafen — [2]Humboldt-Universität zu Berlin, AG Quantenoptik und Metrologie, Hausvogteiplatz 5-7, 10117 Berlin — [3]Fachhochschule Konstanz, Brauneggerstr. 55, 78462 Konstanz

Beim weltraumgestützten Gravitationswellendetektor LISA (Laser Interferometer Space Antenna) soll im momentanen Design zur Bestimmung der Position des Satelliten, relativ zu einer frei fliegenden Testmasse, ein interferometrisches Ausleseverfahren angewendet werden.

Die erforderlichen Empfindlichkeiten liegen für die Translationsmessung bei ∼pm/$\sqrt{\text{Hz}}$ und im Bereich von ∼nrad/$\sqrt{\text{Hz}}$ für die Winkelmessung. EADS Astrium, in Zusammenarbeit mit der Humboldt-Universität zu Berlin und der FH Konstanz, entwickelt hierzu ein symmetrisch aufgebautes Heterodyninterferometer, verbunden mit der Methode der differentiellen Wellenfrontmessung zur Winkelbestimmung. Im Vortrag werden die Ergebnisse des aktuellen Aufbaus vorgestellt sowie dessen Limitierungen angesprochen.

Q 42.3 Mi 14:30 5K

Charakterisierung rauscharmer Spanungsreferenzen für LISA — •Roland Fleddermann, Frank Steier, Michael Tröbs, Gerhard Heinzel und Karsten Danzmann — Albert-Einstein-Institut Hannover, Max-Planck-Institut für Gravitationsphysik und Universität Hannover, Callinstr. 38, D-30167 Hannover

Laser Interferometer Space Antenna (LISA) ist eine gemeinschaftliche Mission der ESA und der NASA mit dem Ziel, Gravitationswellen im Frequenzbereich zwischen 10^{-4} Hz und 0,1 Hz mittels satellitengestützter Interferometrie zu messen. Für LISA sind Spannungsreferenzen mit besonders niedrigem Rauschen in diesem Frequenzbereich von besonderer Bedeutung, da einige Anwendungen wie z.B. die Ansteuerung von Piezo-Aktuatoren sowie die Leistungsstabilisierung der verwendeten Laser hierauf basieren. Kommerziell verfügbare Spannungsreferenzen sind für diesen Frequenzbereich schwer zu charakterisieren, da ihre Ausgangsspannung stark von äußeren Einflüssen wie Umgebungstemperatur, Lastwiderstand und Versorgungsspannungsrauschen abhängt. Eine Reihe von Präzisionsmessungen lieferte ein relatives Spannungsrauschen von etwa $10^{-6}/\sqrt{\text{Hz}}$ bei 0,1 mHz. Wir geben eine kompakte Übersicht über Anwendungen, Rauschquellen und deren Reduzierung.

Q 42.4 Mi 14:45 5K

Datenanalyse LISA Pathfinder — •Anneke Monsky — Albert-Einstein-Institut, Hannover

Zur Ermittlung und Subtraktion verschiedener Rauschquellen an Bord der ESA Satellitenmission LISA Pathfinder (Start 2009), werden Daten von 6 Kanälen ausgewertet, deren Abtastfrequenz 10 Hz beträgt. Hierfür wird ein Softwaretool erstellt, das aus einer Vielzahl für die Auswertung nötiger Algorithmen aufgebaut ist, die von jedem Benutzer individuell zusammengestellt werden können. Dabei bleiben die Ergebnisse der jeweiligen Auswertung zu jeder Zeit reproduzierbar. Es werden der Aufbau der Software im Allgemeinen sowie die verschiedenen Algorithmen im Einzelnen beschrieben.

Q 42.5 Mi 15:00 5K

LISA Pathfinder Interferometry: hardware simulation towards on-orbit operation — •Felipe Guzman Cervantes, Frank Steier, Antonio Garcia Marin, Vinzenz Wand, Gerhard Heinzel, and Karsten Danzmann — Albert-Einstein-Institut Hannover

The Laser Interferometer Space Antenna (LISA) is a joint ESA-NASA mission for the first space-borne gravitational wave detector, operating in the measurement band from 0.1 mHz to 1 Hz. LISA consists of three identical spacecraft separated by 5 million kilometers, flying a total of six proof masses in heliocentric drag-free orbits. The relative changes in the separation between two test masses located in different satellites will be measured by laser interferometry with picometer precision. Due to the challenges LISA yields, the ESA technology demonstration mission LISA Pathfinder is planned to be launched in 2009. LISA Pathfinder aims to test core LISA technologies that cannot be tested on ground such as test mass drag-free control and isolation and spacecraft control. A set of 4 heterodyne Mach-Zehnder interferometers is utilized for the read out of test mass displacement and rotation to better than 10 pm/sqrt(Hz) and 10 nrad/sqrt(Hz)in the frequency range from 3-30 mHz respectively. This talk presents the current status in the development of the LISA Pathfinder interferometer and a series of tests conducted as a hardware simulation of the LISA Pathfinder on-orbit operation.

Q 42.6 Mi 15:15 5K

Interferometrische Positionsbestimung der LISA-Testmassen — •Joachim Kullmann, Antonio Garcia Marin, Felipe Guzman Cervantes, Vinzenz Wand, Gerhard Heinzel und Karsten Danzmann — Institut für Gravitationsphysik der Leibniz Universität Hannover und Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) , Callinstr. 38, 30169 Hannover

LISA (Laser Interferometer Space Antenna) ist eine gemeinsame Weltraummission von ESA und NASA und soll ab 2017 zum direkten experimentellen Nachweis von Gravitationswellen im mHz-Bereich dienen. Dafür sollen die durch Gravitationswellen hervorgerufenen Abstandsänderungen zwischen zwei frei fallenden Testmassen mittels Laserinterferometrie bestimmt werden. Jeweils zwei dieser Testmassen befinden sich innerhalb eines von insgesamt drei Satelliten.

Zur relativen Abstandsmessung Testmasse-Satellit in den nicht sensitiven Achsen ist z.Zt. nur ein kapazitives System vorgesehen.

Der Vortrag beschreibt die Möglichkeit, diese Abstandsänderungen zusätzlich optisch mittels eines phasenmodulierten Homodyn-Interferometers zu bestimmen. Messungen an einem entsprechenden Prototyp eines solchen Interferometers liegen vor.

Ziel ist es, eine Sensitivität von einigen nm /$\sqrt{\text{Hz}}$ zu erreichen.

Q 42.7 Mi 15:30 5K

Alignment Simulation für die Optische Bank von LISA Pathfinder — •Gudrun Diederichs, Frank Steier, Felipe Guzman, Gerhard Heinzel und Karsten Danzmann — Callinstraße 38, 30167 Hannover

LISA Pathfinder ist eine gemeinsame Satellitenmission von ESA und NASA, die als Technologietest für LISA voraussichtlich 2009 starten wird. In der Herstellungsphase der Optischen Bank von LISA Pathfinder werden die optischen Komponenten mit Mikrometergenauigkeit auf eine Zerodur Platte gebondet. Die dabei auftretenden Fehlstellungen beeinflussen die Messsignale auf den Quadrantenphotodioden und sorgen für eine Kreuzkopplung zwischen Testmassenrotation und longitudinaler Phase. Die Größe der Kopplungsfaktoren wurde mit Hilfe einer Monte Carlo Simulation über die Fehlstellungen auf der optischen Bank bestimmt, dabei wurde das Gaußsche Profil der zwei Laserstrahlen des Heterodyninterferometers berücksichtigt. Wir stellen die Simulation sowie deren Ergebnisse vor.

Q 43: Optische Messtechnik

Zeit: Mittwoch 14:00–16:00 Raum: 5E

Q 43.1 Mi 14:00 5E

New design of Long-Path-Telescopes for atmospheric trace gas measurements based one fibre optic — •André Merten, Ulrich Platt, and Jens Tschritter — Institut für Umweltphysik, Im Neuenheimer Feld 229, 69126 Heidelberg

Long-Path-telescopes are commonly used for atmospheric trace gas measurement, especially in combination with the DOAS (Differential Optical Absorption Spectroscopy) analysis technique. Such an instrument combines the emitting and receiving telescope in one device with a double-Newton-style design and has a Xe-high pressure lamp as light source with a typical size from 1..2m. Therefore this instrument requires a high effort in planning and executing of field measurements and has also a limited signal-to-noise ratio. We developed a new setup based on fibre optics, which is easier to handle, more stable in the alignment and also more efficient in the transmission and receiving of light. The use of a fibre coupled light source improves the spectral characteristics especially for light sources with a spatial variation of spectral features like high-pressure arc lamps and LEDs. This new design was tested successfully in field measurements. The construction of smaller generation of Long-Path-telescopes is now possible, which would extend the range of the application for this instrument. Together with new economic light source like the LED this instrument can be used for automatic monitoring of air pollutions.

Q 43.2 Mi 14:15 5E

Simultaneous generation of two spectrally separeted ultrashort pulses for 2-lambda contouring with digital holography — •Thomas Hansel[1], Günter Steinmeyer[1], Rüdiger Grunwald[1], Uwe Griebner[1], Claas Falldorf[2], Jan Müller[2], Christoph von Kopylow[2], and Werner Jüptner[2] — [1]Max-Born-Institut, Max-

Born-Strasse 2a, D-12489 Berlin, Germany — [2]Bremer Institut für angewandte Strahltechnik BIAS, Klagenfurter Str. 2, D-28359 Bremen, Germany

Digital holographic shape measurements using femtosecond laser pulses are reported. To perform contouring of very fast moving objects the simultaneous generation of at least two spectrally separated ultrashort pulses is required. A sub-50 fs Ti:sapphire laser system was modified to emit two pulses with a variable spectral separation around 800 nm. The spectrum of a single fs-pulse of the laser system was altered by a prism line and a variable double slit, resulting in two distinct wavelength peaks. Each pulse had a spectral width of about 13 nm, and the spectral difference could be chosen within the 50 nm bandwidth (FWHM) of the original pulse spectrum. A Michelson-type interferometer was then applied to perform 2-lambda-contouring. The phases of the holograms and the difference phases are calculated numerically. The resulting image contains a fringe pattern that can be interpreted as contour lines of the topology of the object. Results for distinct stationary objects are presented. The possibility to record two holograms at once using two synchronized CCD-cameras is discussed.

Q 43.3 Mi 14:30 5E

Optical frequency measurement in the mid- and far-infrared range — •Peter Gaal[1], Markus Raschke[1,2], Klaus Reimann[1], and Michael Wörner[1] — [1]Max-Born-Institut, Berlin, Germany — [2]Department of Chemistry, University of Washington, Seattle, USA

We present a new method for the direct measurement of optical frequencies in the mid- and far-infrared range, which is analogous to a sampling scope. The electric field of an arbitrary source is measured by electro-optic sampling using 12 fs light pulses as a probe from a Ti:sapphire oscillator. The oscillator pulse length determines the upper bandwidth limit of 40 THz. The sampling rate is given by the oscillator repetition rate of 71 MHz. While measuring the time dependent electric field would require a synchronization of the source to the probe pulses, our method can be applied to an unsynchronized source. As a demonstration we investigate a cw CO_2 laser. Since the laser is not synchronized to the probe pulses, the electro-optic signal has to be recorded for each pulse. While we measured a spectral width of 90 kHz for an accumulation time ΔT of 0.7 s, it was reduced to 600 Hz for $\Delta T = 1$ ms. The fluctuations are caused by the thermal instability of the resonators of the oscillator and of the CO_2 laser.

Q 43.4 Mi 14:45 5E

Aufnahme und Rekonstruktion von Hologrammen unter Verwendung von Spiegeln zur Aperturvergrößerung — •Andreas Zepp[1,2], Sven Hirsch[2], Susanne Frey[2], Andrea Thelen[2], Natalie Ladriere[2], Peter Hering[2,3] und Jens Bongartz[1] — [1]RheinAhrCampus Remagen, Südallee 2, 53424 Remagen — [2]Forschungszentrum caesar, Ludwig-Erhard-Allee 2, 53175 Bonn — [3]Institut für Lasermedizin, Universität Düsseldorf, 40225 Düsseldorf

Mit Hilfe der Holografie ist es möglich, sowohl die Amplitude als auch die Phase einer an einem Objekt gestreuten kohärenten Lichtwelle zu speichern. Diese vollständige dreidimensionale Information kann als reelles Bild rekonstruiert und ausgewertet werden. Die erreichbare Ortsauflösung des reellen Bildes ist jedoch abhängig von der Apertur, unter der das vom Objekt gestreute Licht auf die Hologrammplatte gelangt. Durch Abschattungseffekte kann dabei die Auflösung des reellen Bildes zum Teil deutlich reduziert werden.

Im Vortrag wird ein holographischer Aufbau vorgestellt, bei dem durch die Verwendung von Spiegeln die Apertur des Hologramms erhöht wird und somit Abschattungseffekte kompensiert werden können. Durch die Spiegel werden mehrere verschiedene Ansichten des Objektes gleichzeitig auf der Hologrammplatte gespeichert. Werden die reellen Bilder der einzelnen Ansichten bei der Rekonstruktion wieder überlagert, führt dies zu einer Erhöhung der Auflösung des reellen Bildes.

Q 43.5 Mi 15:00 5E

Imaging of npn diodes by scanning near-field infrared microscopy — •Jean-Sébastien Samson, Götz Wollny, Erik Brundermann, and Martina Havenith — Ruhr-Universität-Bochum, Physikalische Chemie 2, NC 7/72, 44780 Bochum

We report on the scanning near-field infrared microscopy studies of doped silicon. We are able to obtain measurement of the refraction index of the investigated materials with a lateral resolution which is far beyond the diffraction limit. The results show that the the index of refraction depend on the doping of the material. This can be use to image and characterize the surface structure. The measurement were carried out on implanted Phosphore Galliu, and Copper nanostructure. The methode as a high potential for imaging and characterization of the space charge zone

Q 43.6 Mi 15:15 5E

Polarization effect in the transmission through a single nanoscopic aperture — •Jochen Müller, Peter Banzer, Susanne Quabis, and Gerd Leuchs — Max Planck Research Group, Institute of Optics, Information and Photonics, University Erlangen-Nuremberg, Guenther-Scharowsky-Str. 1 / Bau 24, 91058 Erlangen

In the recent years the investigation of transmission through sub wavelength holes in thin metal films has intensified in order to gain a better understanding at a fundamental level. Much work has been published studying arrays of holes. In contrast, we experimentally study the transmission of a single aperture and compare our results to rigorous numerical calculation based on FDTD algorithm.

We concentrate on investigating the influence of polarization distributions which are non-homogeneous on a scale of less than one wavelength. For this purpose we generate radially and azimuthally polarized beams at wavelengths of 775 nm and 532 nm which are focussed by a high numerical aperture microscope objective onto each aperture. As a sample we use a silver covered glass substrate which is structured with apertures of different types and sizes.

For holes as well as for annular rings with diameters smaller than the wavelength we find a strong polarization effect on the transmitted power. In this talk, we will apply the concept of cylindrically symmetric waveguide Eigenmodes to our results. Furthermore, the FDTD model calculation reveals the excitation of surface plasmons to play an important role.

Q 43.7 Mi 15:30 5E

Untersuchung des Lichtabklingverhaltens von Flüssigszintillatoren — •Ronald Lauck und Volker Dangendorf — Physikalisch-Technische Bundesanstalt; Braunschweig

Für Radiografieexperimente an einem Hochintensitätslaser benötigen wir einen Flüssigszintillator mit schnellem Lichtabklingverhalten insbesondere der langsamen Komponente, um einzelne aus dem Laserplasma emittierte Neutronen ab ca. 50 ns nach einem um Größenordnungen intensiveren γ-Blitz nachzuweisen.

Zu diesem Zweck untersuchten wir verschiedene mit Sauerstoff gequenchte Kombinationen aus Fluor (PPO, POPOP, bis-MSB) und Lösungsmittel (p-Xylene, hochbrechendes 1-Methylnaphtalen). Die zeitabhängige Lichtintensität der Flüssigszintillatoren wurde über mehrere Größenordnungen mittels Zeitkorrelierter-Einzelphotonen-Zählung bestimmt. Dabei bestrahlten wir den zu untersuchenden Szintillator sowie einen Referenzdetektor mit koinzidenten γ-Quanten aus einer Na22-Quelle. Das Licht aus dem Flüssigszintillator wurde durch eine Blende derart reduziert, daß im Durchschnitt weniger als ein Photon den anschließenden Lichtverstärker erreichte. Das Einzel-Photon-Signal als auch das Referenzsignal wurden über das zu messende Zeitintervall von einigen μs in einem Acqiris-System mit 2 GS/s digital abgetastet und zwischengespeichert. Durch die Vorgabe geeigneter Zählbedingungen bei der Analyse der Einzel-Photonen-Pulse ließ sich der Einfluß der Ionenrückkopplung im Lichtverstärker auf die gemessenen zeit- und pulshöhenabhängigen Einzel-Photon-Spektren darstellen und minimieren.

Q 43.8 Mi 15:45 5E

Aufbau eines optischen Rasternahfeldmikroskops (SNOM) zur Untersuchung evaneszenter Felder — •Frank Fecher, Julia Hahn, Jürgen Petter und Theo Tschudi — TU Darmstadt, Institut für Angewandte Physik, Hochschulstr. 6, 64289 Darmstadt

Optische Rasternahfeldmikroskope (SNOM) sind eine etablierte Methode, um berührungslose Untersuchungen von Proben unterhalb der Abbeschen Auflösungsgrenze durchzuführen. Insbesondere können mit dem System nahfeldoptische Eigenschaften der Proben untersucht werden, wie deren evaneszente Felder, die nur wenige 10 nm Ausdehnung haben.

Das SNOM wird in ein bereits vorhandenes, im Institut entwickeltes Rasterkraftmikroskop (AFM) implementiert, über das auch die Ansteuerung der drei Raumrichtungen erfolgt. Durch Auswerten des Resonanzverhaltens eines kommerziellen Uhrenquarzes kann eine präzise Detektion des Abstands zur Probe vorgenommen werden. Das optische Signal wird durch eine Glasfaser aufgenommen, deren Spitze einen Aperturdurchmesser unterhalb der zu messenden Lichtwellenlänge hat,

und zu einem Photomultiplier geleitet.

Im Rahmen eines Projekts zur Grenzflächenuntersuchung von Zellmembranen wird das SNOM dazu dienen, die evaneszenten Felder von Wellenleiterstrukturen zu charakterisieren, um Angaben über deren Güte und Eigenschaften machen zu können.

Q 44: Ultrakalte Atome (Manipulation und Detektion)

Zeit: Mittwoch 14:00–16:00 Raum: 5D

Q 44.1 Mi 14:00 5D

Using Ultra-Thin Optical Fibers for Cold Atom Physics — •Guillem Sagué[1,2], Eugen Vetsch[1,2], Wolfgang Alt[1], Dieter Meschede[1], and Arno Rauschenbeutel[1,2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz

The strong evanescent field around ultra-thin optical fibers bears a high potential for detecting, trapping, and manipulating cold atoms. Combining such a fiber with a magneto-optical trap, we investigate the interaction of a small number of cold Caesium atoms with the fiber's guided modes and its surface. High resolution spectroscopy reveals that light-induced dipole forces and the van der Waals interaction play a significant role in the dynamics of the atoms. Furthermore, a significant enhancement of the spontaneous emission rate of the atoms is observed. The latter can be assigned to the modification of the vacuum mode density, due to the presence of the fiber.

We acknowledge financial support by the DFG research unit 557.

Q 44.2 Mi 14:15 5D

Microwave near-fields on atom chips — •Pascal Böhi[1], Johannes Hoffrogge[1], Theodor Hänsch[1], Jakob Reichel[2], and Philipp Treutlein[1] — [1]Max-Planck-Institut für Quantenoptik and Ludwig-Maximilians-Universität, München, Germany — [2]Laboratoire Kastler Brossel de l'E.N.S, Paris, France

We present the status of our experiment with microwave near-fields on atom chips. Microwave near-fields are a key ingredient for atom chip applications such as quantum information processing, entanglement of Bose-Einstein condensates, atom interferometry, and chip-based atomic clocks [1,2].

We have integrated miniaturized microwave guiding structures on our atom chip, using a newly developed lithographic fabrication process for chips with multiple layers of metallization. The micrometer-sized structures allow to generate microwave near-fields with unusually strong gradients. Through microwave dressing of hyperfine states, state-selective double-well potentials can be created, which are the basic building block for a collisional quantum phase gate on the atom chip [2].

[1] P. Treutlein *et al.*, Phys. Rev. Lett. **92**, 203005 (2004).
[2] P. Treutlein *et al.*, Phys. Rev. A **74**, 022312 (2006).

Q 44.3 Mi 14:30 5D

Resonant quantum tunneling via vacuum-multiparticle interactions — •Mihai Macovei — Max-Planck Institute for Nuclear Physics, Heidelberg.

The tunneling of matter wave packets through different types of traps and barriers attracted a lot of attention due to a possible design of an atomic soliton laser or a velocity selector for ultracold particles.

Here, we demonstrate that a slow-velocity excited particle tunnels freely through a vacuum electromagnetic field cavity mode filled with N-1 ground state atoms [1]. The reason for this is the trapping of the moving atom into its upper state due to multiparticle influences and the corresponding decoupling from the interaction with the environment such that the quantum state of the emitter is frozen when it passes through the vacuum-induced potentials.

[1] Mihai A. Macovei, submitted; quant-ph/0610126.

Q 44.4 Mi 14:45 5D

Continuous loading of Cr atoms into a magnetic guide — •jimmy sebastian, alexander greiner, anoush aghajanitalesh, paul rehme, axel griesmaier, and tilman pfau — Universität Stuttgart, 5. Physikalisches Institut, Pfaffenwaldring 57, 70550, Stuttgart

A continuous source of cold atoms is the most crucial prerequisite for realizing continuous atom lasers. The high magnetic moment of Chromium (Cr) makes it an ideal candidate to be guided by a magnetic guide. The special electronic structure of Cr allows for a continuous loading scheme of ultracold atoms in to a magnetic trap [1], as well as into a magnetic guide. In this talk we report on our recent experiments on continuous loading of atoms into a 1m long magnetic guide. We achieved a launch velocity of atoms between 0m/s to 3m/s by the moving molasses scheme .The possible applications in atom lithography will also be discussed.

[1] P.O.Schmidt, S.Hensler, J.Werner, T.Binhammer, A.Görlitz and T.Pfau: J. Opt. B: Quantum Semiclass. Opt. 5,170 (2003)

Q 44.5 Mi 15:00 5D

Preparation of ultracold atomic velocities by transforming bound states into tunneling resonances — •Andreas Ruschhaupt — Institut für Mathematische Physik, TU Braunschweig, Mendelssohnstr. 3, D-38106 Braunschweig

A procedure is proposed to prepare the average and width of the velocity distribution of ultra-cold atoms. The atoms are set initially in the ground state of an optical trap formed by an inner red-detuned-laser well and an outer blue-detuned-laser barrier. Then the well and barrier parameters are changed until the ground state becomes a Breit-Wigner tunneling resonance. An optimal time dependence of the switching process, between the sudden and adiabatic limits, adjusts the final translational energies of the leaking atoms to the Lorentzian distribution of the resonance state.

[1] F. Delgado, J. G. Muga, and A. Ruschhaupt, Phys. Rev. A 74 (2006)

Q 44.6 Mi 15:15 5D

Electron Microscopy With Ultracold Quantum Gases — •Tatjana Gericke, Peter Würtz, Daniel Reitz, Nils Hommerstad, and Herwig Ott — Institut für Physik, Universtität Mainz; 55099 Mainz, Germany

Since the first observation of Bose-Einstein condensation, ultracold atoms have proven to be an interesting system to study fundamental quantum effects in many-body systems. Most of the experiments use absorption imaging to extract information from the system and are therefore restricted to the fundamental limitation of this technique: the best spatial resolution that can be achieved is comparable to the wavelength of the absorption laser. Since the average atomic distance in quantum gases is between $100\,nm$ and $500\,nm$ a better spatial resolution is highly desirable. In order to achieve this we are developing a new imaging technique based on scanning electron microscopy: atoms inside the atomic cloud are ionized by the focussed electron beam and subsequently detected with high efficiency on an ion detector. Our electron microscope is fully UHV compatible and has a resolution of better than $50\,nm$. The ^{87}Rb atoms are cooled with a six-beam 3D-MOT which is loaded from a 2D-MOT. Subsequently, the atoms are transferred in a CO_2-dipole trap. The current state of the experiment is presented.

Q 44.7 Mi 15:30 5D

BEC unter Schwerelosigkeit — •Tim van Zoest[1], Ernst Maria Rasel[1], Wolfgang Ertmer[1], Hans Jörg Dittus[2], Kai Bongs[3], Achim Peters[4], Jakob Reichel[5], Reinhold Walser[6] und Wolfgang Schleich[6] — [1]Institut f. Quantenoptik, Leibniz Universität Hannover — [2]ZARM, Univ. Bremen — [3]Inst. f. Laserphysik, Univ. Hamburg — [4]Alexander v. Humboldt Univ. Berlin — [5]ENS Paris — [6]Abt. f. Quantenphysik, Univ. Ulm

Der ausgedehnte freie Fall bietet neue Möglichkeiten, um die nichtklassische Natur kondensierter Quantensysteme zu untersuchen. Die Schwerelosigkeit sollte den Weg zu tieferen Temperaturen dank der Möglichkeit der vollständigen adiabatischen Expansion eröffnen. Außerdem erlaubt dies eine kohärente Entwicklung des Kondensats im Sekundenbereich. Das Pilotprojekt Quantus soll die technologische Machbarkeit der Erzeugung quantenentarteter Gase unter dem Einfluss des ausgedehnten freien Falls, wie er im Fallturm Bremen realisisert wer-

den kann, zeigen. Notwendig waren die Entwicklung und Implementation des gesamten Experiments in eine Fallkapsel (0,7m Durchmesser; 2,3m Höhe), sowie die Entwicklung atomoptischer Komponenten für den Einsatz im Fallturm. Neben dem experimentellen Aufbau sowie die sequentielle Ladung der Atome aus dem Hintergrundgas in 2 magneto-optische Fallen sowie 2 verschiedene Ioffe-Pritchard Fallenkonfigurationen auf einem Atomchip werden auch Untersuchungen des atomaren Ensembles in den Ioffe-Pritchard Fallen sowie der letzte Stand des Experimentierzyklus mit dem Ziel eines BECs erläutert. Das Projekt ist finanziert mit den Mitteln der DLR (DLR 50 WM 0346)

Q 44.8 Mi 15:45 5D

Erste Beobachtungen von kalten Quantengasen unter Schwerelosigkeit — •Thorben Könemann[1], Hansjörg Dittus[1], Wojciech Lewoczko-Adamczyk[2], Achim Peters[2], Anika Vogel[3], Greta Johannsen[3], Sven Wildfang[3], Kai Bongs[3], Klaus Sengstock[3], Tim van Zoest[4], Ernst Maria Rasel[4] und Wolfgang Ertmer[4] — [1]ZARM, Universität Bremen — [2]QOM, Humboldt-Universität zu Berlin — [3]Institut für Laserphysik, Universität Hamburg — [4]IQO, Leibniz Universität Hannover

Im Zuge des Pilotprojekts "Katapult-Test des BEC-Lasersystems für das Projekt 'BEC unter Schwerelosigkeit'" wurde ein Experiment zur Demonstration einer magneto-optischen Falle unter Schwerelosigkeit realisiert. Die magneto-optische Falle dient hierbei als Sensor für die im Fallturm anzutreffenden Störungen (z.B. Erdmagnetfeld, magnetische Störfelder, Vibrationen, Temperaturänderungen). An Hand dieses Experimentes werden optische Schlüsselkomponenten und atomoptische Verfahren für die Erzeugung kalter Gase auf ihre Tauglichkeit im Fallturmeinsatz untersucht. Die Ergebnisse fließen in die Realisierung eines BEC-Experimentes "QUANTUS" ein, das sich gegenwärtig im Aufbau befindet. Der Betrieb der magneto-optischen Falle konnte in einer Serie von Abwürfen im Fallturm Bremen demonstriert und untersucht werden. Das Design des Experiments erlaubt den Einsatz im Katapult und dient daher in Zukunft auch als Studienobjekt für weitergehende Untersuchung von kalten Quantengasen im freien Fall von bis zu 9 Sekunden Dauer. Das Pilotprojekt wird mit Mitteln der DLR unter dem Förderkennzeichen 50WM0508 finanziert.

Q 45: Attosekundenphysik (gemeinsam mit A)

Zeit: Mittwoch 14:00–16:00 Raum: 6G

Hauptvortrag Q 45.1 Mi 14:00 6G

Multielectron wave-packet propagation for electron dynamics following ionization: Basics and explicit applications — •Alexander Kuleff and Lorenz Cederbaum — Theoretische Chemie, PCI, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany

An *ab initio* method for multielectron wave-packet propagation is presented [1]. It gives the possibility to describe fully *ab initio* the dynamics of various de-excitation processes taking into account *all* electrons of the system and their correlation. The approach is equally suitable for tracing in real time and space the electron dynamics of both decaying and non-decaying electronic states. As an example for electron dynamics of non-decaying states, the charge migration solely driven by electron correlation and relaxation is studied. The method is also utilized for tracing in time and space the the evolution of the electronic cloud throughout the interatomic Coulombic decay (ICD) process in the rare gas cluster NeAr following Ne2*s* ionization [2].

[1] A. I. Kuleff, J. Breidbach and L. S. Cederbaum, J. Chem. Phys. **123** (2005) 044111.
[2] A. I. Kuleff and L. S. Cederbaum, arXiv:physics/0612061.

Q 45.2 Mi 14:30 6G

Attosecond Pulse Trains with Two Colors — •Marko Swoboda[1], Johan Mauritsson[1], Erik Gustafsson[1], Per Johnsson[1], Thomas Remetter[1], Thierry Ruchon[1], Anne L'Huillier[1], and Kenneth Schafer[2] — [1]Department of Physics, Lund University, P.O. Box 118, 221 00 Lund, Sweden — [2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA

We demonstrate how a sequence of identical attosecond pulses created with a two-color laser field can be used to release electron wave packets exactly once per laser cycle. The released electrons can then be used to steer and measure atomic processes on attosecond time scales. The pulses arriving at the frequency of the probing infrared field allow us to compare this to a stroboscope, each pulse identical to previous pulses and repeatedly performing measurements in the exact same conditions. Using this technique, we study the ionization of He in presence of a strong infrared laser field which shifts the electron momentum distribution depending on the vector potential of the light field. In this experiment, Coulomb-refocusing and other atomic effects can be observed from driving the electron wave packets back to the atomic core.

Q 45.3 Mi 14:45 6G

Vibration and laser dressing in molecular high-harmonic generation — •Ciprian Chirila and Manfred Lein — Universität Kassel, Fachbereich Physik 18, Heinrich-Plett-Str. 40, 34132 Kassel

We study high-harmonic generation in the H2 molecule, and its heavier isotope, D2, exposed to an intense, low-frequency laser pulse. The molecular vibration is taken into account. We investigate the effect of laser dressing of the two lowest-laying Born-Oppenheimer potentials in the molecular ion formed upon ionizaton. Conclusions are drown about the laser-frequency range and the range of molecular orientations where the dressing becomes relevant to the process.

Q 45.4 Mi 15:00 6G

Attosecond scattering of particles from quantum correlated condensed systems — •Chariton Aris C.-Dreismann — Institut für Chemie, TU Berlin, Sekr. C2, 10623 Berlin

Nuclei and electrons in condensed matter are usually entangled, due to the electromagnetic interaction. However, strong couplings with the "environment"cause an ultrafast decoherence, thus making entaglement effects not accessible to experiments. Recently, neutron [1a] and electron [1b,2] Compton scattering experiments from protons (H-atoms) in several condensed systems at room temperature demonstrated a striking effect, i.e. an "anomalous"decrease of scattering intensity. Due to the large energy (several eV) and momentum (20- 200 $\AA^{-1}$) transfers of these experiments, is the collisional (or scattering) time between the probe particle and the proton $100-1000$ as. The considered effect, which has no interpretation within conventional neutron scattering theory, is caused by the non-unitary quantum dynamics (due to decoherence) during the ultrashort, but finite, time-window of the scattering process. Examples of experimental results will be shown, and a theoretical outline "from first principles"[3] will be presented.

[1] C. A. C.-Dreismann et al., (a) Phys. Rev. Lett. 79, 2839 (1997); (b) Phys. Rev. Lett. 91, 057403 (2003). [2] Physics Today, p. 9,(Sept. 2003). [3] C. A. C.-Dreismann and S. Stenholm, in preparation.

Q 45.5 Mi 15:15 6G

Sub-cycle dynamics in the laser ionization of molecules — •Xinhua Xie, Marlene Wickenhauser, and Armin Scrinzi — TU Wien, Institut f. Photonik

During a single optical cycle of a strong laser pulse, electrons are driven out of a molecule, accelerated, and directed back onto their parent molecule, where they scatter or recombine. We present a precise definition of "emission time" and initial momentum distribution in the framework of the time-dependent Schrödinger equation (TDSE). Solving the TDSE numerically for two-dimensional model molecules, we find that electron emission from and re-collision with the molecule can develop pronounced time-structures that strongly depend on the molecular species, molecular orientation, and on laser intensity. The peak of emission can shift through a significant fraction of laser cycle. The structures are produced by laser-induced intra-molecular electron dynamics. The importance of these findings for high harmonic generation and molecular tomography will be discussed.

Q 45.6 Mi 15:30 6G

Heterodyne control of attosecond pulse generation — •Thomas Pfeifer[1,2], Lukas Gallmann[1,2], Mark J. Abel[1,2],

Phillip M. Nagel[1,2], Aurélie Jullien[1,2], Daniel M. Neumark[1,2], and Stephen R. Leone[1,2] — [1]Departments of Chemistry and Physics, University of California, Berkeley, CA 94720, USA — [2]Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Adding a weak laser field at a different color to the fundamental in high-order harmonic generation results in a new type of heterodyne mixing in the kinetic energy term of the active electron. Analytical calculations and quantum simulations show that the effect of the weak field is amplified by the strong fundamental laser field that acts as the local oscillator [1]. The photon energies of different attosecond pulses within the produced pulse trains can thus be significantly modified. Two important applications for this phenomenon are the generation of isolated attosecond pulses with multi-cycle driving fields and the shaping of attosecond pulse trains.

Ref.: [1] T. Pfeifer et al., Phys. Rev. Lett. **97**, 163901 (2006)

Q 45.7 Mi 15:45 6G

High Harmonic Generation for attosecond pump-probe experiments — •Helga Rietz, Konstantin Simeonidis und Joachim Ullrich — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

The generation of high harmonic (HHG) radiation in rare gases using ultrashort infrared laser pulses is a well proven method to provide an efficient way to produce attosecond light pulses, thus opening the door to direct investigation of dynamics on attosecond timescales, such as the electronic motion in atoms.

Here we report on the construction of the first stage of a new experiment that will combine attosecond light pulses from HHG with a so called "reaction microscope" to perform pump-probe measurements with attosecond resolution on atoms and molecules. An innovative, versatile vacuum chamber housing all necessary optics, a gas target for HHG and a spectrometer setup for XUV-characterisation have been designed and successfully put into operation. The harmonics are generated using 800nm Ti:Sapphire laser pulses produced by a commercially available Ti:Sa-amplifier system at a pulse repetiton frequency of 10 kHz, with a single pulse energy of 0.7 mJ and duration of approximately 25 fs. A further compression to 6 fs is planned. Particularly, the high repetition rate of the system is expected to increase experimental sensitivity. First examinations of the harmonics produced in Argon and Neon exhibit a promising yield of coherent soft-X-ray radiation and confirm our setup.

Q 46: Quantengase (Wechselwirkungseffekte)

Zeit: Mittwoch 16:30–18:45 Raum: 6J

Q 46.1 Mi 16:30 6J

Properties of Canonical Ensembles for Weakly Interacting Dipolar Gases — •Konstantin Glaum[1], Hagen Kleinert[1], Axel Pelster[2], and Lance Labun[3] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany — [3]Dartmouth College, 03755 Hanover, NH, USA

We set up a recursion relation for the partition function of a finite number of harmonically confined dipolar bosons, and derive analytic expressions for free energy, specific heat, and ground-state occupancy. Due to the diluteness of the gas, both the isotropic contact interaction and the anisotropic dipole-dipole interaction are treated perturbatively. A subsequent renormalization of physical parameters yields a self-consistent improvement of the perturbative results. Due to the anisotropy of the dipole-dipole interaction, the thermodynamic quantities of interest depend on the trap configuration. In a cylindrical symmetric trap, there are two extremal configurations, where the symmetry axes of the trap and the dipole-dipole interaction are parallel or perpendicular to each other. By considering the difference between those two configurations we derive observable results which are sensitive to the small anisotropic dipole-dipole interaction.

Q 46.2 Mi 16:45 6J

Large ensembles of ultracold atoms in an ultrahigh-finesse optical cavity — •Stephan Ritter, Tobias Donner, Ferdinand Brennecke, Anton Öttl, Thomas Bourdel, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik, ETH Zürich, 8093 Zürich, Schweiz

The presence of very large numbers of atoms inside an ultrahigh-finesse optical cavity leads to an extremely strong coupling between light and matter. Therefore unprecedentedly large vacuum Rabi splittings can be observed in such systems. The properties of the coupled atom-cavity system drastically differ from those of its bare constituents and allow to study the collective behavior of the atom sample.

In our setup, we produce a Bose-Einstein condensate of ^{87}Rb atoms in a magnetic trap 36 mm above an ultrahigh-finesse optical cavity [1]. We vertically transport more than 10^5 atoms from the magnetic trap into the cavity mode using a red-detuned standing wave. Inside the cavity, various beam geometries allow for the trapping and manipulation of the atom cloud. We study the transmission properties of the cavity in the presence of large atom numbers. Alternatively, the atoms are pumped from the side and the light scattered into the cavity mode is analyzed. Properties and capabilities of the coupled system of an ultrahigh-finesse optical cavity and a large ensembles of atoms are described and the current status of the experiment is reviewed.

[1] A. Öttl, S. Ritter, M. Köhl, and T. Esslinger,Rev. Sci. Instrum. **77**, 063118 (2006).

Q 46.3 Mi 17:00 6J

Scattering of two-dimensional solitons in dipolar Bose-Einstein condensates — •Rejish Nath[1], Paolo Pedri[2], and Luis Santos[1] — [1]Institut fuer theoretische Physik, Leibniz-Universitaet Hannover, Appelstr. 2, D-30167 Hannover — [2]Laboratoire de Physique Theorique et Modeles Statistique, Universite Paris Sud, 91405 Orsay Cedex, Frankreich

We analyze the scattering of bright solitons in dipolar Bose-Einstein condensates placed in unconnected layers. Whereas for short-range interactions unconnected layers are independent, a remarkable consequence of the dipole interaction is the appearance of novel nonlocal interlayer effects. In particular, we show that the interlayer interaction leads to an effective molecular potential between disconnected solitons, inducing a complex scattering physics between them, which includes inelastic fusion into soliton-molecules, and strong symmetric and asymmetric inelastic resonances. In addition, a fundamentally new 2D scattering scenario in matter-wave solitons is possible, in which inelastic spiraling occurs, resembling phenomena in photorrefractive materials. Finally, we consider the scattering of unconnected 1D solitons and discuss the feasibility in current on going experiments.

Q 46.4 Mi 17:15 6J

Strongly correlated dipolar gases in optical lattices — •Giovanni Mazzarella, Arturo Argüelles, and Luis Santos — Insitiut für Theoretische Physik, Leibniz Universität Hannover

We analyze the physics of strongly correlated dipolar gases in optical lattices. We first discuss the case of spatially unconnected neighboring 1D systems, which are however interacting non-locally due to the dipolar interactions. We show, that the nonlocal interactions lead to a Mott-insulator-to-pair-superfluid transition that induces a significant modification of the Mott-insulator phases for low filling factors. We discuss the effects that this distortion may have on the spatial extension of the Mott-insulator plateaux in experiments with an harmonic confinement overimposed to the lattice potential, showing that anti-intuitively the Mott-insulator plateaux may become broader for increasing tunneling. We extend our analysis to nonlocally coupled 2D lattices by means of the corresponding mean-field calculations. In a second part, we study the conditions to achieve a significant collisionally-induced tunneling assisted by the dipole-dipole interaction. The effect of this new term in the Bose-Hubbard Hamiltonian, which resembles (but is not equivalent to) the so-called correlated-hopping in frustrated quantum magnets, are analyzed by means of a mean-field approach.

Q 46.5 Mi 17:30 6J

Investigation of a chromium BEC in the vicinity of a Feshbach resonance — •Thierry Lahaye, Tobias Koch, Marco Fattori, Bernd Fröhlich, Axel Griesmaier, and Tilman Pfau —

5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

Due to its large magnetic moment (6 Bohr magnetons), tuning the scattering length of chromium atoms by using a magnetic Feshbach resonance is a promising way to the realization of a purely dipolar quantum gas. We have modified our BEC apparatus, with which we have already measured dipolar effects on the expansion dynamics of a BEC [Phys. Rev. A **74**, 013621 (2006)], to investigate the BEC near a resonance at 590 G. This resonance has an expected width of 1.7 G. Using fast switching magnetic fields and a high field imaging system we are now able to condense above this resonance and investigate the BEC in its vicinity. We report on the recent experimental progress.

Q 46.6 Mi 17:45 6J

Detecting correlated quantum phases in ultracold atoms — •Michael Köhl[1], Corinna Kollath[2], and Thierry Giamarchi[2] — [1]Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge CB3 0HE, United Kingdom — [2]DPMC-MaNEP, University of Geneva, 24 Quai Ernest-Ansermet, 1211 Geneva, Switzerland

Cold atomic systems provide a unique setup to explore the properties of strongly correlated quantum particles. However, despite the high degree of tunability and control offered by these systems, they are difficult to probe, making the identification of the exotic quantum phases extremely involved. Here we propose a novel experimental probe, using the coherent coupling of a single particle to the system.

Q 46.7 Mi 18:00 6J

BEC with $1/r$ Interatomic Interaction — •Moritz Schütte[1] and Axel Pelster[2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We consider the thermodynamic properties of a Bose-Einstein condensate with laser induced attractive $1/r$ interatomic interaction. Such a system is self-stabilizing and serves as a test laboratory for simulating gravitating objects with huge masses [1]. Using the functional integral approach, we derive a Hartree-Fock mean-field theory and investigate as two special cases the region around absolute zero and around the critical temperature. At first, we obtain an analytic solution of the Gross-Pitaevskii equation in Thomas-Fermi approximation and use a time-dependent variational approach in order to investigate the collective excitations. Then we determine the leading shift of the critical temperature which is due to the $1/r$ interaction and discuss its dependence upon the geometry of an additional harmonic confining potential.

[1] D. O'Dell, S. Giovanazzi, G. Kurizki, and V. M. Akulin Phys. Rev. Lett. 84, 5687 (2000)

Q 46.8 Mi 18:15 6J

Bose-Einstein condensates with attractive $1/r$ interaction: The case of self-trapping — •Ioannis Papadopoulos and Günter Wunner — Institut für theoretische Physik 1, Universität Stuttgart, D-70550 Stuttgart

Amplifying on a proposal by O'Dell *et al.* for the experimental realization of Bose-Einstein condensates of neutral atoms with attractive $1/r$ interaction, we point out that the instances of self-trapping of the condensate, without external trap potential, are physically best understood by introducing appropriate "atomic" units. This reveals a remarkable scaling property: The physics of self-trapping depends only on the parameter N^2a/a_u, where N is the particle number, a the scattering length, and a_u the appropriate "Bohr" radius. We calculate accurate numerical results for self-trapping wave functions and potentials, for energies, sizes and peak densities, and compare with previous variational results.

Q 46.9 Mi 18:30 6J

Excited states of Bose-Einstein condensates with attractive $1/r$ interaction — •Patrick Wagner and Günter Wunner — Institut für Theoretische Physik 1, Universität Stuttgart, D-70550 Stuttgart

We study excited states of Bose-Einstein condensates which consist of bosons interacting via the ususal contact potential plus an additional electromagnetically induced gravity-like $1/r$-potential. The dependence of energies, wave functions and potentials on the distribution of the particles on different orbitals, as well as the choice of the different orbitals, determined in a self-consistent way, will be discussed.

Q 47: Quanteninformation (Quantenkommunikation)

Zeit: Mittwoch 16:30–18:45 Raum: 5L

Q 47.1 Mi 16:30 5L

Towards the Solution of NP Problem: Indistinguished controllable single photons from independent atomic ensembles — •Yu-Ao Chen[1], Shuai Chen[1], Markus Koch[1], Thorsten Strassel[1], Zhen-Sheng Yuan[1], Jörg Schmiedmayer[2], and Jian-Wei Pan[1] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, D-69120 Heidelberg, Germany — [2]Atominstitut der Österreichischen Universitäten, TU-Wien, A-1020 Vienna, Austria

Quantum repeater hold the promise for revolutionary advances to solve the NP problem from the losses and decoherence in the communication channel by a distribution of quantum resources over remote locations and quantum memory.

We use collective spin excitation of atoms as a media for quantum memory. Here we present an implementation of feed forward control of two atomic memories. We use independent "write" laser sources to map the quantum states to the collective spin excitation and again we use independent "read" lasers to retrieve the quantum states from the two atomic memories respectively. We will show that, by using a feed forward circuit, the probability of simultaneously obtaining a pair of single photons will be increased by orders of magnitude. As an application, we show the indistinguishability of independently generated single photons by the observation of destructive interference of their wave packets. Our results demonstrate experimentally a basic principle for enabling scalable quantum communication networks and linear optical quantum computation.

Q 47.2 Mi 16:45 5L

Secret key rates for quantum key distribution scenarios with finite number of signals — •Tim Meyer, Hermann Kampermann, Matthias Kleinmann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, D-40225 Düsseldorf, Germany

We analyze the success of privacy amplification [1] (in terms of secret key rates) in the six-state protocol subjected to a symmetric, collective eavesdropping attack, for any finite number of signals [2]. Starting from a simple entanglement-based scheme, we can include multiphoton pulses into our model, and study its applicability for a realistic prepare-and-measure version.

[1] R. Renner, N. Gisin, and B. Kraus, Phys. Rev. A **72**, 012332 (2005).

[2] T. Meyer, H. Kampermann, M. Kleinmann, and D. Bruß, Phys. Rev. A **74**, 042340 (2006).

Q 47.3 Mi 17:00 5L

The role of memory errors in quantum repeaters — •Lorenz Hartmann[1], Barbara Kraus[1], Hans Briegel[1,2], and Wolfgang Dür[1,2] — [1]Institut für Theoretische Physik, Universität Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Österreich

We investigate the influence of memory errors in the quantum repeater scheme for long-range quantum communication. We show that the communication distance is limited in standard operation mode due to memory errors resulting from unavoidable waiting times for classical signals. We show how to overcome these limitations by (i) improving local memory, and (ii) introducing two new operational modes of the quantum repeater. In both operational modes, the repeater is run blindly, i.e. without waiting for classical signals to arrive. In the first scheme, entanglement purification protocols based on one-way classical communication are used allowing to communicate over arbitrary distances. However, the error thresholds for noise in local control operations are very stringent. The second scheme makes use of entan-

glement purification protocols with two-way classical communication and inherits the favorable error thresholds of the repeater run in standard mode. One can increase the possible communication distance by an order of magnitude with reasonable overhead in physical resources. We outline the architecture of a quantum repeater that can possibly ensure intercontinental quantum communication.

Q 47.4 Mi 17:15 5L

Private States, Privacy Amplification, and the Uncertainty Principle in Quantum Cryptography — •Joseph Renes[1] and Jean-Christian Boileau[2,3] — [1]Institut für Angewandte Physik, TU Darmstadt, Darmstadt, Germany — [2]Institute for Quantum Computation, University of Waterloo, Waterloo, Canada — [3]Perimeter Institute for Theoretical Physics, Waterloo, Canada

Quantum cryptography has typically dealt with the problem of extracting a secret key from a partially private string in one of three ways, corresponding to different treatment of the parties to the cryptographic protocol. Use of two-universal hash functions, termed classical privacy amplification, comes from considering the eavesdropper's quantum state. Alternatively, focusing on the state held by the honest parties can be done either concretely in private state distillation or abstractly as in the approach based on the uncertainty principle. We show that these three are equivalent and interchangeable, unifying the corresponding security proofs of quantum key distribution. By adapting the security proof based on the uncertainty principle, we construct a new protocol for private state distillation which we then prove is identical to classical privacy amplification. Underlying this approach is a new characterization of private states, quantum states capable of generating a secret key, whose relation to their standard formulation is again understood as an instance of the uncertainty principle: A key corresponding to measurement of a given observable is private when the honest parties have full knowledge of the conjugate observable.

Q 47.5 Mi 17:30 5L

Photon Number Statistics of Waveguided Parametric Downconversion — •Malte Avenhaus, Andreas Eckstein, and Christine Silberhorn — Max-Planck-Nachwuchsgruppe für Integrierte Quantenoptik, Erlangen, Germany

Quantum cryptography requires precise knowledge about the quantum states which are communicated over a quantum channel. Especially, the photon number distribution of the quantum light source characterizes the security and performance of practical systems. By detecting impinging photons on highly efficient APDs in Geiger mode, one can only gain binary information, but no resolution regarding actual photon numbers. In our experiment, we use a time multiplexing device distributing photons randomly over several temporal slots. For reconstruction of the actual photon statistics, one needs to take into account losses and the possibilities of n photons being observed in m temporal slots.

We investigate the properties of photon number statistics from a Type-II parametric downconversion (PDC) processes at different pump powers. The resulting statistics from different experimental configurations are compared against correlated thermal and Poissonian distributions, which can be expected for PDC sources.

Q 47.6 Mi 17:45 5L

Quantum key distribution over 144 km — •Martin Fürst[1], Henning Weier[1], Tobias Schmitt-Manderbach[2], Sebastian Schreiner[1], Christian Kurtsiefer[3], and Harald Weinfurter[1,2] — [1]LMU München, Schellingstr 4/III, 80799 München — [2]Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [3]National University of Singapore, 2, Science Drive 3, Singapore 117542

Quantum mechanics ensures the possibility of secure exchange of information between two parties. Several implementations of free space quantum key distribution (QKD) systems exist achieving distances on the order of ten kilometres. QKD on a global scale could be accomplished by free space systems connecting satellites and ground stations. As first steps towards this goal we performed an experiment over a distance of 144 km on the Canary Islands. The transmitter unit including a 15 cm diameter telescope was located on mount Roque de los Muchachos on La Palma. On Tenerife the Optical Ground Station (OGS), developed for optical communication to and from satellites, was used as the receiving telescope. Thanks to an actively controlled bidirectional tracking system the transmission loss of the link was stable with an attenuation between 25 dB and 35 dB over the whole night. We implemented the decoy state QKD protocol to establish a secure key at a rate of 40 bits/s. As this attenuation is also expected for downlinks from low earth orbit (LEO) satellites to ground stations, our experiment thus demonstrates the feasibility for space-based secure communication across the globe.

Q 47.7 Mi 18:00 5L

Quantum Key Distribution: Closing the Gap to Perfect Sources — •Wolfgang Mauerer and Christine Silberhorn — University Erlangen-Nuremberg, Max-Planck Research Group IOIP, Integrated Quantum Optics Group

Quantum key distribution (QKD) allows two parties to communicate securely even in the presence of an arbitrarily powerful eavesdropper. A multitude of protocols have been suggested in the last decades. They were shown to be secure in the presence of

the bit rates over which secure communications can be guaranteed are strongly constricted by experimental imperfections. Decoy-state QKD improves the situation, but achieves only about (70%) of the maximal secure distance imposed by fundamental physics with conventional implementations.

In this talk, we show how we can close the gap between practical QKD implemented with state-of-the-art devices and idealized QKD assuming perfect single-photon signals. A parametric downconversion (PDC) source in conjunction with a photon number resolving detector is utilized to implement a decoy-like QKD scheme. It allows to improve the effectively sent signal statistics. Strict photon-number correlations between the two PDC outputs allow to infer the complete statistical information about one of them by measuring the photon number distribution of the other. For all practical purposes, our protocol accomplishes up to few percent the power of a single photon source in terms of distance, while the key generation rate is on par with the best available schemes.

Q 47.8 Mi 18:15 5L

Experimental realisation of a quantum communication protocol using entangled photons — •Nino Walenta and Martin Ostermeyer — Universität Potsdam, Institut für Physik, 14469 Potsdam

Quantum cryptography protocols using entangled qubit pairs can increase the rate and security of information exchange. The ping pong coding scheme based on entangled photons allows asymptotically secure key distribution and, theoretically, quasi secure direct communication, too [1]. In this presentation we show the experimental realisation of this communication protocol.

Polarisation-entangled photon pairs are generated by parametric down conversion with ps laser pulses. Two out of 4 Bell states are used in order to represent two bits of information. The information is encoded by switching between these two states via the unitary transformation of a Pockels cell applied to one of the photons. The two Bell states are distinguished by a modified Bell state analysis evaluating the arrival time and also the polarisation of the photons. The detection time of every photon is analysed using time-correlated single photon counting (TCSPC) modules in time-tag mode for every detector.

[1] K. Boström, T. Felbinger, Phys. Rev. Lett. 89, 187902 (2002)

Q 47.9 Mi 18:30 5L

Quantum teleportation between light and matter — •Hanna Krauter[1], Jacob Sherson[1], Rasmus Olsson[1], Brian Julsgaard[1], Klemens Hammerer[2], Ignacio Cirac[2], and Eugene Polzik[1] — [1]Niels Bohr Institute, Blegdamsvej 17, Copenhagen, Denmark — [2]Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, Garching, Germany

In this talk the first experimental demonstration of interspecies teleportation between an atomic and a photonic object will be discussed.

The state of a mesoscopic light pulse containing up to a few hundred photons is transferred onto the collective state of an atomic ensemble of 10^12 Cesium atoms over a distance of 0.5m. This is an important step towards e.g. distributed quantum networks.

The general principles of disembodied transfer via teleportation will be introduced and our physical implementation presented in greater detail. Furthermore the possibility to improve the protocol by including higher order temporal modes and the use of a squeezed light beam will be discussed.

Q 48: Photonik I

Zeit: Mittwoch 16:30–18:30 Raum: 5J

Q 48.1 Mi 16:30 5J

Optical self-imaging of gratings fabricated using colloidal crystals and soft-lithography — •Manuel Gonçalves, Ralf Ameling, André Siegel, and Othmar Marti — University of Ulm - Inst. Experimental Physics, Albert-Einstein-Allee 11, D-89069 Ulm, Germany

Since the observation of the Talbot effect in cold atoms by Chapman et al. [1], the self-imaging of classical and matter waves regained attention, both in applications and in the investigation of the interaction of periodic light fields with atom molasses. However, the interpretation of the Talbot effect relies on the Fresnel diffraction approximation. This is adequate for arrays of diffraction where the period is large the wavelength. When the size of the diffraction object of the order of the wavelength the approximation fails.

We show that two-dimensional arrays of microscopic polystyrene spheres and other structures, fabricated using these crystals, behave as arrays of sharp light sources and present self-imaging at distances different of those predicted by the classical Talbot effect.

Theoretical models based on scalar and on the vector diffraction theory, without the Fresnel approximation, were investigated. The Talbot lengths obtained are close to the experimental results, but different from those obtained with the classical formulation.

The periodic structures fabricated using colloidal crystals and soft-lithography techniques may be used to generated complex light fields to manipulate atom molasses.

[1] M. S. Chapman et al., PRA 51(1) R14, 1995.

Q 48.2 Mi 16:45 5J

Dielectric Components for Surface Plasmon Polaritons — •Sven Passinger, Roman Kiyan, Carsten Reinhardt, Andrey Stepanov, and Boris Chichkov — Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

We study applications of two-photon polymerization (2PP) technique for the fabrication of dielectric SPP-structures on metal films, which can be used for excitation, guiding, and manipulation of SPPs. Dielectric SPP components, e.g. waveguides, bends, splitters, and focusing units are demonstrated. Excitation and propagation of SPPs is studied by leackage radiation microscopy.

[1] C. Reinhardt et al., Optics Letters 31, pp. 1307, (2006)

Q 48.3 Mi 17:00 5J

Kontrollierbare negative Brechung ohne Absorption durch elektromagnetisch induzierte Chiralität — •Jürgen Kästel[1], Michael Fleischhauer[1], Susanne F. Yelin[2,3] und Ronald L. Walsworth[2,4] — [1]Technische Universität Kaiserslautern, Germany — [2]ITAMP, Cambridge, Ma, USA — [3]University of Connecticut, Storrs, CT, USA — [4]Harvard University, Cambridge, MA, USA

Die Erzeugung negativer Brechung von Licht stellt derzeit eines der aktivsten Forschungsgebiete der modernen Photonik dar. Trotz beeindruckender Fortschritte, vor allem im Bereich sogenannter Metamaterialien und photonischer Kristalle, ist das zentrale Problem für technologische Anwendungen die hohe Absorption dieser Materialien. Zur Lösung schlagen wir einen Ansatz basierend auf Quanteninterferenzeffekten ähnlich der elektromagnetisch induzierten Transparenz vor. Das führt auf resonant überhöhte Chiralität und negative Brechung bei gleichzeitiger Unterdrückung der Absorption. Als Folge können Brechungs-Absorptions-Verhältnisse von $\mathrm{Re}[|n|]/\mathrm{Im}[n] \propto 10^2$ erzielt werden. Zusätzlich kann der Wert des Brechungsindex durch externe Laserfelder genau kontrolliert werden, was essentiell für praktische Anwendungen wie z.B. die perfekte Linse ist.

Q 48.4 Mi 17:15 5J

Untersuchung von lichtinduziertem Materialtransport in Photopolymeren mittels Röntgenbeugung und optischer Spektroskopie — •Oliver Henneberg, Christian Spitz und Alexander Betke — Institut für Physik, Universität Potsdam, Am Neuen Palais 10, 14469 Potsdam

Reversible E-Z-Isomerisation durch Absorption von Licht kann auch in Festkörpern zu einer induzierten Bewegung führen. Dadurch lassen sich ursprünglich isotrope, feste Filme in einer materialschonenenden Art mit einer Struktur versehen, ohne dass Material verdampft wird oder dass mit Lösungsmitteln gearbeitet werden muss. Durch die Absorption von Licht kommt es zur komplexen Wechselwirkung der Photopolymere mit dem elektrischen Feld des Lichts. Während der Isomerisation z. B. des Azobenzenes ändert sich die relative Lage eines Phenylringes um wenige Nanometer. Es kann aber in der festen Phase ein Molekültransport über etliche 100 Nanometer beobachtet werden. Die verwendete Energiedichte ist jedoch zu gering, um das Polymer zu erweichen oder gar verflüssigen.

Röntgenstrahlung kann genutzt werden, um die Anfänge der Gitterbildung bei wenigen nm Gitterhöhe zu beobachten. Die dabei verwendete GISAX Geometrie ermöglicht in Verbindung mit einer CCD-Kamera die gleichzeitige Beobachtung vieler Beugungsordnungen. Mit Hilfe der Pump-Probe Laser-Spektroskopie lassen sich einzelne Molekülbewegungen bestimmten Übergängen zwischen Energieniveaus zuordnen.

Q 48.5 Mi 17:30 5J

Anisotropic self-focussing in two-dimensional photonic lattices — •Patrick Rose[1], Bernd Terhalle[1], Tobias Richter[2], Anton Desyatnikov[3], Christoph Bersch[1], Jörg Imbrock[1], Friedemann Kaiser[2], Yuri Kivshar[3], and Cornelia Denz[1] — [1]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany — [2]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [3]Nonlinear Physics Center, Research School of Physical Sciences and Engineering, Australian National University, ACT 0200 Canberra, Australia

Wave propagation in periodic nonlinear structures is associated with many exciting novel phenomena that do not have counterparts in either homogeneous nonlinear media or periodic but linear systems. One of the well known examples is the formation of discrete self-localised states known as discrete solitons in one- and two-dimensional photonic lattices. The lattices of different symmetries can be induced optically in photorefractive crystals using periodic light patterns that propagate without a change of their profile. However, due to the electrooptic anisotropy of photorefractive materials the induced refractive index change strongly depends on orientation as well as polarization of the lattice wave.

We study the effect of anisotropy of photonic lattices on the symmetries of discrete solitons, generate experimentally two-dimensional discrete solitons in different lattice types and corroborate the experimental results by numerical simulations.

Q 48.6 Mi 17:45 5J

Holographische Phasenkonjugation von Licht durch Sub-Lambda-Öffnungen* — •Felix Kalkum, Thorsten Hoffmann, Dirk Apitz und Karsten Buse — Physikalisches Institut, Universität Bonn, Wegelerstr. 8, 53115 Bonn

Die Fokussierung von Licht kann nicht nur durch Linsen erfolgen. Eine Alternative ist die holographische Phasenkonjugation: Das Interferenzmuster zweier kohärenter Wellen wird dabei in einem photosensitiven Material aufgezeichnet. Der Signalstrahl tritt zuvor durch eine Öffnung in einem Metallfilm, die kleiner als die Wellenlänge des Lichts ist. Die Referenzwelle ist eine ebene Welle. Wird das Material nun mit der phasenkonjugierten Referenzwelle beleuchtet, also einer ebenen, aus entgegengesetzter Richtung kommenden Welle, so wird die phasenkonjugierten Signalwelle rekonstruiert. Wurde die Signalwelle beugungsbedingt hinter der kleinen Apertur aufgefächert, so findet nun eine Fokussierung statt. In ersten Experimenten konnte eine Fokussierung von Licht mit dieser Methode gezeigt werden werden.

*Wir danken für finanzielle Unterstützung der Deutsche Telekom AG und der Deutsche Telekom Stiftung.

Q 48.7 Mi 18:00 5J

Untersuchung der Phasenmodulationseigenschaften von Flüssigkristallmikrodisplays mit Hilfe von adressierten Beugungsgittern — •S. Quiram[1], F. Kallmeyer[1], H. J. Eichler[1], A. Hermerschmidt[2] und S. Osten[2] — [1]TU Berlin - Institut für Optik und Atomare Physik; Straße des 17. Juni 135; 10623 Berlin — [2]Holoeye Photonics AG; Albert-Einstein-Str. 14; 12489 Berlin

Flüssigkristallmikrodisplays werden in vielen Bereichen der Optik angewendet. Einige Anwendungen, zum Beispiel als schaltbare diffraktive Elemente oder zur holographischen Projektion, bedingen eine ge-

naue Kenntnis der Phasenmodulation als Funktion des adressierten Grauwertes. Die untersuchten ECB-Displays ("electrically controlled birefringence") sind polarisationserhaltend und können als "schaltbare Verzögerungsplatte" zur reinen Phasenmodulation verwendet werden. Um diese Phasenmodulationseigenschaften der ECB-Displays zu charakterisieren, bedienen wir uns der Beugungseigenschaften binärer Gitter. Es werden Binärgitter auf dem Display adressiert. Während der Steg konstant auf einem Grauwert bleibt, wird der Graben in 256 Graustufen von "schwarz" bis "weiß" variiert. Durch Steg und Graben gehendes Licht erfährt verschiedene Verzögerungen. Die erhaltenen Ergebnisse stimmen für Binärgitter großer Gitterkonstante, gut mit den als Referenz gemessenen Ergebnissen aus der Zweistrahlinterferenz überein. Für Binärgitter kleinerer Gitterkonstante, weichen die Ergebnisse stärker ab. Die Abweichungen zeigen, daß die adressierten Binärgitter für große Raumfrequenzen durch Randeffekte an den Pixelübergängen nicht korrekt vom Display dargestellt werden.

Q 48.8 Mi 18:15 5J

A Tunable Whispering-Gallery-Mode Bottle Resonator — •Michael Pöllinger[1,2], Florian Warken[1], Wolfgang Alt[1], Dieter Meschede[1], and Arno Rauschenbeutel[1,2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz

Bottle resonators, i.e., highly prolate-shaped whispering gallery mode microresonators, have a number of advantageous properties [1]. They exhibit two spatially well-separated regions with enhanced field strength and the field per photon on the resonator surface is significantly higher than, e.g., for equatorial whispering-gallery-modes in microsphere resonators with a comparable mode volume. At the same time, the frequency spacing of these modes is much more favorable.

We experimentally realize and spectroscopically investigate such bottle resonators. In agreement with the theoretical predictions, the mode spectrum exhibits a free spectral range one order of magnitude smaller than in comparable microsphere resonators. By applying mechanical strain with a low-voltage piezoelectric actuator, we were therefore able to tune the resonance frequencies over more than one free spectral range, making tuning to any arbitrary resonance frequency possible.

We acknowledge financial support by the DFG research unit 557.

[1] Y. Louyer, D. Meschede, and A. Rauschenbeutel, Phys. Rev. A **72**, 031801(R) (2005).

Q 49: Informationsspeicherung und -verarbeitung

Zeit: Mittwoch 16:30–17:45 Raum: 5E

Q 49.1 Mi 16:30 5E

Mikroholographische Datenspeicherung 1: Schreiben und Lesen am optischen Auflösungslimit — •Henning Markötter, Enrico Dietz, Sven Frohmann, Christian Müller und Susanna Orlic — Optisches Institut der TU-Berlin

Aufbauend auf der CD/DVD Technologie wird ein optisches System entwickelt, das digitale Daten in ein photoempfindliches Polymermaterial schreibt. Hierbei wird ein Bit durch ein lokalisiertes holographisches Reflexionsgitter gespeichert. Die Erzeugung dieser Mikrogitter geschieht durch Überlagerung zweier gegenläufiger Laserstrahlen, die mit hochgeöffneten Objektiven beugungsbegrenzt fokussiert werden. Dies hat eine Brechungsindexänderung entsprechend dem Interferenzmuster im Material zur Folge. Diese wird mit dem Laserstrahl als Variation der Reflexion detektiert. Die Abmessungen der Mikrogitter sind dabei vergleichbar mit der Wellenlänge des Laserlichtes. Es wird ein System vorgestellt, bei dem die Bits nicht nur in der Diskebene, sondern auch in mehreren Ebenen innerhalb des Photopolymers übereinander geschrieben werden, um die Kapazität zu erhöhen.

Q 49.2 Mi 16:45 5E

Mikroholographische Datenspeicherung 2: Spektrale Untersuchungen von Mikrogittern in Photopolymeren — •Timo Feid, Dennis Plüschke, Enrico Dietz, Sven Frohmann, Christian Müller und Susanna Orlic — Optisches Institut der TU-Berlin

Um Photopolymere auf ihre Eignung für den Einsatz in optischen mikroholographischen Datenspeichern haben wir die Entwicklung eines Medientesters abgeschlossen. Es handelt sich um einen Aufbau der vergleichende Charakterisierung verschiedener Polymere mit hoher Stabilität ermöglicht. Zur spektralen Untersuchung wurde ein hochauflösendes Spektrometer integriert. Damit wird es möglich die zeitliche Entwicklung der spektralen Empfindlichkeit von Mikrogittern aufzunehmen. Aus diesen Beobachtungen lassen sich dann Rückschlüsse über die etwaige Schrumpfung eines Photopolymers ziehen. Da die Wellenlängenverschiebung des Gitters direkt beobachtet werden kann, ist es nun außerdem möglich die Variation der Beugungseffizienz über einen längeren Zeitraum zu observieren. Für die Machbarkeit von Wellenlängenmultiplexing, als effiziente Methode zur Erhöhung der Kapazität, ist es notwendig die spektrale Breite der Mikrogitter zu bestimmen, so dass sich dann die minimalen Abstände zwischen zwei Wellenlängen festlegen lassen, mit denen in der vorgegebenen Konstellation noch Wellenlängenmultiplexing möglich ist.

Q 49.3 Mi 17:00 5E

Microholographische Datenspeicherung 3: Charakterisierung und Anwendung blauer Laserdioden zur holographischen Datenspeicherung — •Alan Günther, Bruno Heimke, Enrico Dietz, Sven Frohmann, Christinan Müller und Susanna Orlic — Optisches Institut der TU-Berlin

Die Entwicklung von GaN-Laserdioden hat die Einführung eines neuen Formats in der optischen Disktechnologie ermöglicht. Solche Laser sind auch für ein mikroholographisches Speichersystem attraktive Strahlquellen. Die wichtigsten Vorteile anderen Lasern gegenüber sind eine kurze Wellenlänge um 405nm für kleine Datenstrukturen und damit hohe Datendichte, viele mögliche Wellenlängen für Multiplexing, kleine Größe für höchste Kompaktheit und einfaches Design und damit geringe Herstellungskosten. Zwei verschiedene Laser auf GaN-Basis sind untersucht worden: Eine freilaufende Diode und ein External Cavity Diodenlaser. Die Charakterisierung dieser Laserdiodensysteme erfolgt mittels hochauflösendem Gitter und Fabri-Perot Interferometer wobei alle für die Anwendung zur holographischen Datenspeicherung interessanten Parameter wie Modenbreite, -Zahl, -Abstand, sowie die spektrale Verschiebung bei Veränderung der Betriebsparameter gemessen werden. Des Weiteren wurde die Kohärenzlänge untersucht, da diese den entscheidenden Punkt für die holographische Datenspeicherung darstellt.

Q 49.4 Mi 17:15 5E

Mikroholographische Datenspeicherung 4: Dynamisch induzierte Mikrogitter — •Jonas Gortner, Enrico Dietz, Sven Frohmann, Christian Müller und Susanna Orlic — Optisches Institut der TU-Berlin

Die Verwendung von Mikrogittern in der holographischen Datenspeicherung bietet einen Ansatz die bisherige Limitierung optischer Speicherkonzepte auf zwei Dimensionen zu überwinden. Es wurde bereits demonstriert, dass die minimale Strukturgröße der Mikrogitter denen herkömmlicher Pit-Land Strukturen, wie sie zum Beispiel in CD und DVD verwendet werden, entspricht. Allerdings wurden an der optischen Auflösungsgrenze bisher nur statisch erzeugte Mikrogitter generiert. Für die Datenspeicherung müssen die Mikrogitter hingegen dynamisch geschrieben werden. Um die Eigenschaften solcher dynamisch generierten Mikrogitter zu untersuchen wurden Messreihen durchgeführt, die die minimale Modulationsperiode zwischen zwei Gittern bestimmen halfen. Weiterhin wurde das maximale Auflösungsvermögen des mikroholographischen Setups bestimmt. Aus diesen beiden Parametern lassen sich erste Rückschlüsse über die Leistungsfähigkeit, d.h. über die Speicherdichte ziehen. Die erzielten Ergebnisse zeigen, dass mit dem mikroholographischen Speicherprinzip die gleiche Datendichte wie mit herkömmlichen optischen Datenspeichern (DVD) erreichbar ist ohne jedoch auf nur zwei Datenlayer eingeschränkt zu sein.

Q 49.5 Mi 17:30 5E

Mikroholographische Datenspeicherung 5: Interferometrische Untersuchungen zur Systementwicklung — •Jens Rehanek, Enrico Dietz, Sven Frohmann, Christian Müller und Susanna Or-

LIC — Optisches Institut der TU-Berlin

Die Bereitstellung von kompletten Schreib-/Lesesystemen ist ein wichtiger Schritt auf dem Wege zur nächsten Generation der optischen Datenspeicherung. Im Zuge der Entwicklung des mikroholographischen Systems wurde ein Aufbau erarbeitet, der es erlaubt, Mikrogitter dynamisch auf einer rotierenden Disk zu schreiben. Dieses Vorhaben setzt ein hohes Maß an Präzision des Aufbaus voraus. Es stellt hohe Anforderungen sowohl an das Material, wie auch an alle Systemkomponenten. So wurde eine Methode entwickelt, mit deren Hilfe die Laufgenauigkeit der verwendeten Laufwerkmotoren untersucht werden kann. Diese Methode basiert auf einem Michelson-Interferometer, welches in modifizierter Form zur Anwendung kommt um die Rotationsstabilität hinsichtlich der vorgegebenen Systemtoleranzen zu untersuchen.

Q 50: Ultrakalte Atome (Einzelne Teilchen und Ionenfallen)

Zeit: Mittwoch 16:30–18:30 Raum: 5D

Q 50.1 Mi 16:30 5D

Deterministic strong coupling of a well-controlled number of trapped atoms to the mode of a high-finesse optical resonator — •Mkrtych Khudaverdyan, Wolfgang Alt, Igor Dotsenko, Mkrtych Khudaverdyan, Dieter Meschede, Dieter Meschede, Sebastian Reick, and Arno Rauschenbeutel — Institut für Angewandte Physik, Wegelerstr. 8, D-53115 Bonn

To realize quantum information processing with neutral atoms, controlled coherent interaction between them is a fundamental requirement. One approach relies on deterministic coupling of two or more atoms to the mode of a high-finesse optical resonator in the strong coupling regime. An essential prerequisite for all known entanglement schemes is the stability of the atom-photon coupling strength.

We present our latest results on the deterministic placement of a few atoms down to a single atom inside the mode of a high-finesse resonator. This is achieved by combing our number-triggered loading technique with the ability to place atoms at a predetermined position along our conveyor belt with sub-micrometer precision. The presence of atoms inside the resonator is detected by monitoring the modification of the transmission of a probe laser beam. Long observation times up to several seconds are achieved by choosing appropriate settings of cavity and probe laser beam parameters. In addition, we discuss the quantification, stabilization and optimization of the atom-photon coupling strength.

Q 50.2 Mi 16:45 5D

Koinzidenz-Kalibrierung eines Einzelatomdetektors für Atomchips — •Alexander Stibor[1], Sebastian Kraft[1], Andreas Günther[1], Tom Campey[2], David Komma[1], József Fortágh[1], Chris Vale[2], Halina Rubinsztein-Dunlop[2] und Claus Zimmermann[1] — [1]Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen — [2]School of Physical Sciences, The University of Queensland, St Lucia 4072, Australia

Die Möglichkeit eine kleine Anzahl von Atomen auf einem Mikrochip zu fangen und zu manipulieren eröffnet eine Vielzahl interessanter Experimente zur Physik der ultrakalten Quantengase. Dafür wird jedoch eine neue Detektionsmethode für einzelne Atome benötigt. Wir präsentieren ein solches Detektionsschema für kalte Atome in einer magnetischen Mikrofalle auf einem Atomchip. Dabei werden Rubidium-Atome direkt auf dem Chip durch Laserionisation nachgewiesen. In einem Testaufbau wird der Detektor durch Elektronen-Ionen Koinzidenzen kalibriert. Außerdem wird die Möglichkeit diskutiert, mit der gemessenen Detektionseffizienz von über 50%, ein Atomensemble mit sub-Poissonscher Genauigkeit zu zählen.

Q 50.3 Mi 17:00 5D

Sub-micro second, state selective detection of a single 87Rb atom in an optical dipole trap — •Florian Henkel[1], Michael Krug[1], Fredrik Hocke[1], Wenjamin Rosenfeld[1], Jürgen Volz[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, Schellingstraße 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Fast and efficient, state selective detection of internal atomic states are a vital ingredient towards the realisation of long-distance atom-atom entanglement and for a future loophole-free test of Bell's inequality [1].

Starting from two highly entangled atom-photon pairs [2] as two space-separated sources for the Bell experiment, ordinary flourescence techniques (typically a few 0.1 ms) prove to be far too slow as an atomic state detection tool. In order to keep the distance between the two local, simultaneous atomic state measurements on a reasonable, experimental level, sub-micro second detection of single 87Rb atoms has to be realised.

Here, we propose to combine an efficient, hyperfine-state selective, laser-induced ionisation process [3] with an already implemented adiabatic population transfer, which should allow us to perform projective atomic spin measurements within some 220 ns.

[1] C. Simon and WTM Irvine, Phys. Rev. Lett. 91, 110405 (2003)
[2] Volz et al., Phys. Rev. Lett. 96, 030404 (2006)
[3] E. S. Fry and T. Walther and S. Li, Phys. Rev. A, 52, (1995)

Q 50.4 Mi 17:15 5D

Trapping and observing single atoms in the dark. — •T. Puppe, I. Schuster, A. Grothe, A. Kubanek, K. Murr, P.W.H. Pinkse, and G. Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

A single atom strongly coupled to a high-finesse cavity constitutes a fundamental quantum system of matter-light interaction. In experiments with couplings largely exceeding the decay rates, i.e. small mode volume, optical access from the side is difficult. Therefore, atoms are mostly stored in dipole traps based on a cavity mode. So far only red-detuned dipole traps have been realized [1].

We prepare a strongly coupled atom-cavity system by two-dimensional guiding and three-dimensional confinement of single atoms in *blue*-detuned cavity modes. The prominent characteristics of a blue-detuned dipole trap is, that at the trap center the free-space properties of the atom are preserved. In particular, the vanishing Stark shift is an advantage for the study of fundamental quantum effects as well as applications in quantum information processing. Strong coupling and the absence of a light shift is directly observed in the normal-mode spectrum of the system. With the help of the blue trap, we explore the possibility to detect the presence of the atom while scattering less than one spontaneous photon from the atom.

[1] J. Ye, et al. PRL **83**, 4987 (1999). P. Maunz, et al. *Nature* **428**, 50-52 (2004).

Q 50.5 Mi 17:30 5D

Realisierung einer transparenten Mikrochip-Ionenfalle — •Markus Debatin[1], Michael Kröner[2], Jochen Mikosch[1], Sebastian Trippel[1], Nathan Morrison[1], Markus Reetz-Lamour[1], Peter Woias[2], Roland Wester[1] und Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Freiburg — [2]Institut für Mikrosystemtechnik, Universität Freiburg

Für die Untersuchung von Wechselwirkungen zwischen Molekülionen und ultrakalten Atomen in einer magnetooptischen Falle (MOT) haben wir eine Radiofrequenz Mikrochip Ionenfalle mit gutem optischen Zugang entwickelt. Wir verwenden eine planare Multipolfalle [1] mit 16 kammartig angeordneten Elektroden pro Chip, die ein großes feldfreies Speichervolumen und eine geringe Heizrate verspricht. Die Verfahren der Mikrosystemtechnik erlauben dazu eine schnelle und präzise Herstellung.

In ersten Experimenten konnte die Speicherung von N_2^+ und O_2^+ Ionen demonstriert und Lebensdauern von 0,5 s realisiert werden. Wir werden Photodetachment negativer Ionen [2] zur Charakterisierung der räumlichen Verteilung in der Falle verwenden. In einer weiteren Falle sollen spezielle Materialien erprobt werden, die eine hohe Transmission auch durch die Elektroden erlauben, wie dies für die Kombination mit einer MOT erforderlich ist.

[1] D. Gerlich, Adv. Chem. Phys. 82, 1 (1992)
[2] S. Trippel *et al.*, Phys. Rev. Lett. 97, 193003 (2006)

Q 50.6 Mi 17:45 5D

Wiring up trapped ions — •Tony Lee[1], Rob Clark[2], and Hartmut Häffner[1] — [1]Institut für Quantenoptik und Quanteninforma-

tion, Innsbruck, Austria — [2]Massachusetts Institute of Technology, Boston, USA

We are setting up an experiment to couple ions in different Paul traps with a wire. A trapped ion induces oscillating charges in the trap electrodes. By sending these charges over a wire to an electrode of another trap, the motional states of the ions in the two traps are coupled. The applications include scalable quantum computing, sympathetic cooling, and precision measurements.

We plan to trap Calcium–40 ions in a segemented surface trap with multiple trapping regions. To obtain a reasonable coupling strength (∼1 kHz), the capacitance of the coupling wire must be small. This means the wire must be electrically floating. In addition, the wire must be close (<50 microns) to the ions. Thus, we first seek to reliably position an ion close to a wire at floating potential and to study the wire's influence on the trap potential and motional heating.

Q 50.7 Mi 18:00 5D

Kalte Ionenkristalle in einer segmentierten Falle zur deterministischen Implantation einzelner Ionen in Festkörper — •W. Schnitzler, T. Deuschle, G. Huber, J. Eble, N. M. Linke, F. Schmidt-Kaler und K. Singer — Universität Ulm, Inst. für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm

Im Zuge der voranschreitenden Miniaturisierung von Halbleiterbauelementen stellt die statistische Fluktuation der Dotierungskonzentration ein Problem dar. Durch die deterministische Implantation einzelner Dotierungsionen können hingegen die elektrischen Eigenschaften verbessert werden [1]. Wir stellen ein neuartiges Verfahren vor, bei dem eine Ionenfalle als deterministische Punktquelle dient [2]. Dazu haben wir eine segmentierte lineare Paulfalle aufgebaut, in der wir kalte $^{40}Ca^{+}$-Ionenkristalle fangen. Das Auftrennen und Verschieben der Ionenkette zwischen den 15 Segmenten der Falle sowie das Laden gemischter Kristalle mit N^{+} bzw. anderen Dotierungsionen stellen die wesentlichen Schritte für die Realisierung unseres Einzelionen-Implanters dar. Wir stellen Messungen zur Charakterisierung der Falle vor. Die durch unser Verfahren gegebene nm-genaue deterministische Implantation wird neue Realisierungsmöglichkeiten eines skalierbaren Festkörper-Quantencomputers eröffnen, basierend auf Phosphorstörstellen in Silizium [3] oder Farbzentren in Diamant [4] .

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

Q 50.8 Mi 18:15 5D

Experimentelle Demonstration einer skalierten planaren Oberflächenfalle — •S. Schulz, J. Sigler und F. Schmidt-Kaler — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm

Segmentierte planare Oberflächenfallen zur Speicherung und Manipulation von Qubit-Systemen auf der Basis von Ionenkristallen können ein wertvoller Baustein auf dem Weg zum Quantencomputer sein. Die rein zweidimensionale Geometrie dieser Paulfalle ermöglicht den optischen Zugang im gesamten Halbraum und eine hohe Skalierbarkeit.

Wir berichten über eine segmentierte Oberflächenfalle, in der wir das Trennen, Zusammenführen und Verschieben von linearen Kristallen realisieren. Um die Skalierbarkeit unserer Geometrie in Lade-, Speicher- und Prozessorregion zu demonstrieren, transportieren wir über Fallenverzweigungen [1]. Zur Verwendung kommt eine Falle mit 180 Elektroden in hexagonaler Symmetrie bestehend aus Elementarzellen von jeweils 30 einzeln ansteuerbaren Elektrodensegmenten. Experimente in diesem Modellsystem bzw. Messungen der charakterischen Falleneigenschaften für Mikroteilchen werden vorgestellt. Die Erweiterung auf reale Qubit-Systeme und planare Oberflächenfallen für atomare Ionen wird diskutiert.

[1] C. E. Pearson, et al., arXiv:quant-ph/0511018 (2006)

Q 51: Hertha-Sponer Preisträgervortrag

Zeit: Donnerstag 11:30–12:00 Raum: 5L

Preisträgervortrag Q 51.1 Do 11:30 5L

Quantum communication based on photon counting and integrated optics — •Christine Silberhorn — Max Planck Forschungsgruppe IOIP, Günther Scharowskystr 1 / Bau 24, 91058 Erlangen

Conventional quantum communication systems are typically either based on single photon protocols or on so-called continuous variable states with Gaussian phase space representations. The characterisation of multi-photon states of most experimental work in the field is based on homodyne detection where photon numbers cannot be distinguished. A recent development employs conditioning single-photon detection to generate highly non-classical non-Gaussian states from Gaussian single-mode squeezed states. Photon number resolved detection can be accomplished in cost-effective linear fibre networks and provides a new promising tool for conditioning state preparation and applications in quantum communication. In this talk we present a new method to measure directly the photon statistics of non-classical light. We exploit a priori information of the state generation process to obtain loss-tolerant photonic state characterization, which is crucial for the observation of many quantum characteristics. For the generation of non-classical light we employ highly efficient wave guided parametric down conversion sources. In conjunction with number resolved photon counting these sources can be utilized to implement effective quantum key distribution.

Q 52: Quantengase (Tunneln II)

Zeit: Donnerstag 12:00–13:00 Raum: 6J

Q 52.1 Do 12:00 6J

Collective and Quantum Dynamics in 0-π Josephson Junctions — •Oliver Crasser, Reinhold Walser, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, 89069 Ulm

A fluxon is the quantized magnetic flux in a single one-dimensional superconducting junction. By subdividing this junction into a 0 and a π domain, we obtain a 0-π junction. Now, semifluxons are localized phase jumps at the 0-π interface and are an intensively investigated subject of superconductivity [1,2].

In this presentation, we will examine an analogous system, implemented with cold bosonic quantum gases (BEC), using a double well potential as well as a phase dependent Rabi coupling, which leads to a four-mode model. We will shortly discuss the semi-classical equilibrium configuration which is doubly degenerated. Within the four-dimensional Fock space we study various quantum mechanical features such as macroscopic tunneling.

[1] W. Buckel and R. Kleiner, Superconductivity: Fundamentals and applications, Wiley-VCH, Berlin (2004)
[2] E. Goldobin et al., Phys. Rev. B 72, 054527 (2005)

Q 52.2 Do 12:15 6J

Coherently controlled entanglement generation in a binary Bose-Einstein condensate — •Christoph Weiss[1] and Niklas Teichmann[2] — [1]Groupe Atomes Froids, Laboratoire Kastler Brossel, Ecole Normale Superieure, 24 rue Lhomond, F-75231 Paris, Frankreich — [2]Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg

Considering a two-component Bose-Einstein condensate in a double-well potential, a method to generate a Bell state consisting of two spacially seperated condensates is suggested. For repulsive interactions, the required tunnelling control is achieved numerically by varying the amplitude of a sinusoidal potential difference between the wells. Both

numerical and analytical calculations reveal the emergence of a highly entangled mesoscopic state.

Q 52.3 Do 12:30 6J

Quantum and thermal phase fluctuations of two Bose Einstein Condensates coupled through a tunneling barrier

— •Alexej Schelle[1], Andrey Kolovsky[1,2], Ming-Chiang Chung[1], and Andreas Buchleitner[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Strasse 38, 01187 Dresden, Germany — [2]L. V. Kirensky Institute of Physics, 660036 Krasnoyarsk, Russia

We study the coherence properties of two Josephson-coupled Bose Einstein Condensates loaded into the local minima of a double-well potential, at finite and at zero temperature. The quantum mechanical phase distributions are derived in the angular momentum representation of the two-mode Hamiltonian. Within our treatment we explain thermally and quantum mechanically induced decoherence effects recently observed in experiments [1]. In particluar, we analyse the behavior in the Fock, Josephson, and Rabi regime. [1] Oberthaler et al., cond-mat/0606281

Q 52.4 Do 12:45 6J

Many-body Landau-Zener tunnelling — Andrea Tomadin[1], Riccardo Mannella[1], and •Sandro Wimberger[2] — [1]Dipartimento di Fisica, Università degli Studi di Pisa, Largo Pontecorvo 3, I-56127 Pisa — [2]Dipartimento di Fisica, Politecnico di Torino, Corso Duca degli Abruzzi 24, I-10129 Torino

A perturbative treatment of the Landau-Zener decay out of the ground-state band of a Bose-Hubbard model is presented. The decay channels are derived from a full two-band model in the presence of an additional linear Stark force. The dynamics of the ground-state band can be switched from a regular to a chaotic regime. The choice of the dynamical regime strongly influences the nature of the many-body Landau-Zener decay, which is mediated by the atom-atom interaction and the Stark force simultaneously.

Q 53: Quanteninformation (Quantencomputer I)

Zeit: Donnerstag 12:00–13:00 Raum: 5L

Q 53.1 Do 12:00 5L

Transport of Atoms in Arrays of Dipole Traps — •Andre Lengwenus, Jens Kruse, Manuel Scherer, Markus Wagner, and Gerhard Birkl — Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany

For the experimental realization of quantum information processing it is essential to perform one- and two-qubit operations in a controlled fashion. In our approach, qubits are inscribed in the hyperfine states of rubidium atoms. The atoms are trapped in a two-dimensional array of well separated optical micro-potentials created by micro-fabricated lens arrays. We already demonstrated single-qubit operations by the coherent coupling of the hyperfine ground states of ^{85}Rb by stimulated Raman transitions.

We plan the realization of two-qubit gates by the use of ultracold collisions. For this, atoms have to be transported from one trap position to another. We demonstrate the transfer of atoms in microtraps using steering methods which are based on the variation of the incident angle of the laser beam illuminating the array of microlenses.

With this technique we achieved the transfer of atoms over a distance of more than half of the trap-to-trap separation. This is enough to move two initially well separated arrays on top of each other. Trap losses and temperature evolution during transfer are determined. Furthermore we present first data on an atomic shift register based on two independently switchable micro-trap arrays.

Q 53.2 Do 12:15 5L

Quantenzustandsmanipulation in segmentierten Paulfallen:Anwendungsmöglichkeiten der Optimal Control Theory — •Ulrich Poschinger, Kilian Singer und Ferdinand Schmidt-Kaler — Universität Ulm, AbteilungQuanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069Ulm

Lasergekühlte Ionen in Paulfallen stellen zur Zeit das beste System für Quantenzustandsmanipulationen dar. In konventionellen Paulfallen besteht das derzeitige Limit in der deterministischen Verschränkung von acht Ionen[1]. Um deutlich mehr Ionen kohärent manipulieren zu können, wurden segmentierte Paulfallen vorgeschlagen. Hier sollen die Ionen in kleinen Gruppen durch Laser manipuliert und zwischen den verschiedenen Fallensegmenten bewegt werden. Wir präsentieren numerische Untersuchungen, inwiefern Optimal Control Theory (OCT) als Werkzeug verwendet werden kann, um die benötigten Prozessschritte schneller und mit höherer Genauigkeit auszuführen. Dies sind das Grundzustandskühlen der Ionen[2], die verschiedenen Verschiebeoperationen[3] und optische Quantengatter zwischen zwei Ionen[4]. Erste Resultate bestätigen, das OCT ein vielseitiges Werkzeug darstellt, um an die experimentellen Bedingungen angepasste Lösungen für die auftretenden Kontrollprobleme zu finden. [1] H. Häffner et al., Nature 438, 643 (2005) [2] S. Sklarz et al., quant-ph/0402143v1 [3] S. Schulz et al., Fortschr. Phys. 54, 648 (2006) [4] C. Rangan et al., PRL 92, 113004 (2004)

Q 53.3 Do 12:30 5L

Experimental investigation of $^{43}Ca^+$ as a new qubit candidate — •Jan Benhelm[1], Gerhard Kirchmair[1], Timo Koerber[1], Christian Roos[2], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften

We have assembled a new ion trap apparatus capable of trapping strings of $^{43}Ca^+$ ions to investigate this ion species' applicability for quantum information processing. The major motivation is the existence of the clock states (F=4, m_F=0 and F=3, m_F=0) in the ground state manifold, which allows a qubit encoding that is insensitive to phase decoherence due to laser frequency and magnetic-field noise to first order. For sideband cooling and state initialization we want to make use of a narrow bandwidth laser on the quadrupole transition. In order to gain control over the complex level structure, the S-D quadrupole transition has been measured precisely. This enabled us to improve on the determination of the hypefine structure coefficients and the isotope shift of the $D_{5/2}$ state by more than two orders of magnitude. Furthermore we found a number of transitions starting from the stretched states that are first order magnetic-field independent for low magnetic fields ($< 10\ G$). These could also be used as qubits or in order to build an optical clock.

Q 53.4 Do 12:45 5L

Photoassociation phasegate for ultracold atoms in an optical lattice — •Christian Schwenke[1], Tommaso Calarco[2,3], and Christiane Koch[1] — [1]Institut fuer Theoretische Physik, Freie Universitaet Berlin, Arnimallee 14, 14195 Berlin — [2]CNR-INFM BEC Center, I-38050 Povo (TN), Italy; ECT*, I-38050 Villazzano (TN), Italy — [3]ITAMP, Harvard Smithsonian Center for Astrophysics, and Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

Ultracold neutral atoms in optical lattice have been proposed as possible realization of a quantum computer [1]. In general, the most difficult part is to find the implementation of a two qubit gate. Here, the possibility to perform a phasegate using short shaped laser pulses inducing transitions between the ground and first electronically excited state will be studied. The qubits are encoded in the electronic spin states of an alkali atom such as Rb87. The gate operation corresponds then to achieving a relative phase between singlet and triplet states of the two-atom system. Optimal control theory [2] is employed to find suitable laser pulses.

[1] H.-J. Briegel, T. Calarco, D. Jaksch, J. I. Cirac, P. Zoller, J. Mod. Opt. Journal of Modern Optics 47, 415 (2000). [2] J. P. Palao, R. Kosloff, Phys. Rev. Lett. 89, 18 (2002)

Q 54: Teilchenoptik

Zeit: Donnerstag 12:00–13:00 Raum: 5K

Q 54.1 Do 12:00 5K

Atom Interferometry in Gravity — •Endre Kajari, Gerrit Nandi, Reinhold Walser, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, 89069 Ulm, Germany

In the seminal atomic fountain experiment A. Peters, K. Y. Chung and S. Chu [1,2] measured the gravitational acceleration with very high accuracy. Since this time many activities for gravitational, rotational and inertial sensing with matter waves have been initiated, e. g. MAGIA, CASI and HYPER. This talk introduces an efficient theoretical description of such matter wave interferometric devices. In particular, we analyze the dependence of the phase difference on several experimental parameters, such as the time delay between the laser pulses or changes of the laser frequencies to compensate for Doppler shifts.

[1] M. Kasevich and S. Chu, Appl. Phys. B **54**, 321 (1992).
[2] A. Peters, K. Y. Chung, and S. Chu, Nature **400**, 849 (1999).

Q 54.2 Do 12:15 5K

A Kapitza-Dirac interferometer for massive molecules — •Lucia Hackermueller[1], Sarayut Deachapunya[2], Stefan Gerlich[2], Klaus Hornberger[3], Alexander Stibor[4], Hendrik Ulbricht[2], and Markus Arndt[2] — [1]Institut f. Physik, Johannes-Gutenberg-Universität Mainz, Staudingerweg 7, 55090 Mainz — [2]Fakultät für Physik, Universität Wien, Boltzmanng. 5, A-1090 Wien — [3]Arnold-Sommerfeld-Center, Ludwig-Maximilians-Universität, Theresienstrasse 37, 80333 München — [4]Physikalisches Institut, Universität Tübingen, Auf der Morgenstelle 14 , 72076 Tübingen

The development of new interferometers and molecular sources is essential for future tests of de Broglie physics with molecules of increasing mass and complexity. A Talbot-Lau interferometer has favourable scaling properties and allows high count rates because it accepts uncollimated beams. Using a standing light wave as diffracting object further increases the particle flux and avoids influences by van-der-Waals interactions. We present the successful realization of a new interferometer - the Kapitza-Dirac-Talbot-Lau interferometer - that paves the way for matter wave physics with particles in the 10k Dalton range. Especially promising candidates for interferomery are perfluorinated molecules. These species with masses between 3000 - 7000 amu can still be evaporated with a slow thermal velocity of 30-50 m/s. Due to their high mass they can even be additionally retarded in the gravitational field. For slow particles with a mass of 7000 amu a distance of 1m is already sufficient to stop them.

Q 54.3 Do 12:30 5K

Emission-time entanglement of massive particles — •Clemens Gneiting and Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München

We propose a scheme for the demonstration of macroscopic entanglement of two massive particles, employing the concept of emission-time entanglement. Given two initially bound particles, emission-time entanglement occurs, when the state of the system at later time is described by a coherent superposition corresponding to various separation times. So far, this type of entanglement has only been realized in the case of photons. We discuss whether the verification of entanglement by coincidence-interference remains possible when accounting for dispersive matter waves and investigate whether an implementation of the scheme by the controlled dissociation and subsequent atom-optical manipulation of ultracold molecules is realistic with current experimental technology. Such an experiment would test so far unconfirmed predictions of QM, such as the entanglement of massive, macroscopically separate particles in their spatial degrees of freedom.

Q 54.4 Do 12:45 5K

Hochauflösende Sagnac-Interferometrie mit kalten Atomen — •Michael Gilowski, Thijs Wendrich, Tobias Müller, Christian Schubert, Waldemar Herr, Ernst Maria Rasel und Wolfgang Ertmer — Institut für Quantenoptik - Leibniz Universität Hannover

Die Materiewelleninterferometrie hat ihr hohes Potential in der präzisen Messung von Inertialkräften bewiesen und ist daher zu einem wichtigen Werkzeug der fundamentalen Physik und Metrologie geworden. Im Rahmen des Projekts CASI (Cold Atom Sagnac Interferometer) wird ein Materiewelleninterferometer zur Messung von Rotationen und Beschleunigungen realisiert, um die Fähigkeiten und Limitierungen von Atomsensoren auszuloten [1]. Um zwischen den genannten Inertialkräften unterscheiden zu können, wird das Interferometer in einer gegenläufigen, dualen Interferometeranordnung betrieben. Die Verwendung kalter Rubidiumatome, die mit optischen Raman-Übergängen kohärent aufgeteilt und rekombiniert werden, erlaubt einen kompakten und transportablen Aufbau ohne Einbußen bei der erzielbaren Auflösung.
Im derzeitigen Aufbau reduzierter Auflösung werden die kritischen Komponenten des Interferometers optimiert und der Einfluss systematischer Effekte analysiert. Das Ziel ist der Ausbau des Experiments, um die volle Sensitivität von $2 * 10^{-9}$ rad/s/$\sqrt{Hz}$ für $1 * 10^8$ Atome/s bei einer Geschwindigkeit von 3m/s zu erreichen.[1] C. Jentsch, T. Müller, E.M. Rasel, and W. Ertmer, Gen. Rel. Grav. 36(10), 2197(2004)

Q 55: Quanteneffekte (Lichtstreuung I)

Zeit: Donnerstag 12:00–13:00 Raum: 5E

Q 55.1 Do 12:00 5E

Localization of atomic ensembles via superfluorescence — •Jörg Evers[1], Mihai Macovei[1], M. Suhail Zubairy[1,2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institute for Quantum Studies and Dept. of Physics, Texas A&M University, College Station, Texas 77843, USA

The sub-wavelength localization of an ensemble of atoms concentrated to a small volume in space is studied [1]. For this, we discuss the light scattered in the interaction of the atoms with a standing wave laser field [2]. The fluorescence light can be described by an intensity profile, which depends on the standing wave field parameters, the ensemble properties, and which is modified due to collective effects in the ensemble of nearby particles. We demonstrate that the intensity profile can be tailored to suit different localization setups, and discuss two localization schemes. First, we show how to localize an ensemble fixed at a certain position in the standing wave field. Second, we discuss localization of an ensemble passing through the standing wave field.
[1] M. Macovei, J. Evers, C. H. Keitel, and M. S. Zubairy, quant-ph/0611148.
[2] J.-T. Chang, J. Evers, M. O. Scully and M. S. Zubairy, Phys. Rev. A 73, 031803(R) (2006).

Q 55.2 Do 12:15 5E

Single-Photon emission from Silicon-Vacancy centers in diamond — •Juliane Bahe[1], Chunlang Wang[1], Harald Weinfurter[1], Vladimir Chernychev[1,2], and Jan Meijer[2] — [1]Sektion Physik, Ludwig-Maximilians-Universität München, D-80779 München, Germany — [2]Experimantalphysik III, Ruhr-Universität-Bochum, D-44780 Bochum, Germany

We report on single photon emission from SiV (silicon-vacancy) centers in bulk diamond and diamond nanocrystals. The investigated SiV centers are highly photostable and emit single photons with a narrow zero phonon line (FWHM 5nm) centered at 738nm and very weak vibronic sidebands at room temperature. The short luminescence lifetime (1.2ns) should enable efficient single photon generation. Therefore the SiV center in diamond may be a promising candidate for the practical applications in quantum cryptography.
Possibly due to the existence of a non-fluorescent neutral charge state, the actually observed quantum efficiency is very low[1]. Here we investigate the effects of additional nitrogen doping which should allow to stabilize the negatively charged, radiating SiV center in order to

significantly increase single photon emission.
[1] C. Wang, C. Kurtsiefer, H. Weinfurter and B. Burchard, J. Phys. B: At. Mol. Opt Phys. 39 (2006) 37-41

Q 55.3 Do 12:30 5E

Measurement-induced spatial modulation of spontaneous decay and photon arrival times — •Joachim von Zanthier[1], Thierry Bastin[2], and Girish S. Agarwal[3] — [1]Institut für Optik, Information und Photonik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège au Sart Tilman, Liège, Belgium — [3]Department of Physics, Oklahoma State University, Stillwater, OK, USA

We report on the manipulation of the spontaneous emission process leading to a spatial modulation of spontaneous decay [1]. The effect is observed in case of coherently driven atoms separated by less than a transition wavelength. It is quantified by Glauber's photon-photon second order correlation function. We show that the photon arrival time, usually regarded as an entirely random process, depends not only on where a photon is detected but also on where a former photon had been recorded previously. Our results shed light on the unexpected consequences of state reduction and entanglement for the fundamental process of spontaneous emission.

[1] J. von Zanthier, T. Bastin, G. S. Agarwal, accepted for publication in Phys. Rev. A (Rapid Comm.)

Q 55.4 Do 12:45 5E

The Spectrum of non-Markovian resonance fluorescence — •Geesche Boedecker and Carsten Henkel — Universität Potsdam, Institut für Physik, Am Neuen Palais 10, 14469 Potsdam

We study the resonance fluorescence from a driven two-level atom coupled to a structured reservoir, as it can be realized in a photonic crystal near a band edge. Due to the singular mode density of the vacuum field, the time evolution of both atom and field shows nontrivial memory effects and is highly non-Markovian. We investigate the dynamics of the atomic Bloch vector and identify algebraic tails in the long-time limit. Similarly, the dipole correlation function $\langle\sigma^\dagger(t_1)\sigma(t_2)\rangle$ depends on both times t_1, t_2 which makes the notion of a spectrum problematic. We give a critical discussion of different methods to approach this problem.

Q 56: Quantengase (Fermionen und Gemische)

Zeit: Donnerstag 14:00–15:45 Raum: 6J

Q 56.1 Do 14:00 6J

Bose-Fermi-Hubbard-Modell im Grenzfall leichter Fermionen: eine effektive Theorie — •Alexander Mering und Michael Fleischhauer — Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern

Wir stellen Rechnungen zum Bose-Fermi-Hubbard-Modell im Limes großen fermionischen Hoppings vor. Unter Verwendung der Born-Oppenheimer- und Markoff-Näherung ergibt sich ein effektiver Hamiltonoperator für die Bosonen. Dieser beschreibt ein erweitertes Bose-Hubbard-Modell mit unendlicher Reichweite, wobei die Dichte-Dichte-Kopplungskonstanten oszillieren und stark von der Fermionendichte sowie dem Abstand abhängen. Das resultierende Phasendiagramm beinhaltet mehrere unterschiedliche Phasen, welche numerisch diskutiert und durch eine exakte Diagonalisierung und mit DMRG-Methoden untersucht werden.

Q 56.2 Do 14:15 6J

Bloch oscillations of Fermi atoms in a 1D optical lattice — •Alexey Ponomarev[1], Andrey Kolovsky[1,2], Ming-Chiang Chung[1], and Andreas Buchleitner[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden — [2]Kirensky Institute of Physics, Ru-660036 Krasnoyarsk

We discuss the time dependent response of cold, non-polarized, fermionic atoms loaded in a 1D optical lattice to a static linear potential. Using Floquet-Bloch theory complemented by a perturbative analysis, we explain the dynamical properties of the fermions through the spectral characteristics of the Floquet-Bloch operator. A variety of unexplored dynamical regimes, such as periodic modulations of Bloch oscillations and the doubling of the Bloch frequency are described.

Q 56.3 Do 14:30 6J

Mixture of bosons and spin-polarized fermions in optical lattices — •Corinna Kollath[1], Lode Pollet[2], Ulrich Schollwöck[3], and Matthias Troyer[2] — [1]University of Geneva, Switzerland — [2]ETH Zürich, Switzerland — [3]RWTH- Aachen, Deutschland

The physics in a mixture of bosonic and fermionic atoms confined to an optical lattice is very rich. Recently, two experimental groups succeeded in loading a mixture of bosonic and fermionic atoms into an optical lattice. The presence of a trapping potential makes the interpretation of the results difficult and controversial. We focus on the interplay of strong interparticle interactions, a trap, and finite temperature which leads to physics quite different from the homogeneous case. To name one example, we find a non-monotonous dependence of the visibility of the matter wave interference pattern after releasing the bosons from the optical lattice versus the lattice depth. This is in contrast to the experimental results and the difference can be resolved when taking into account heating while ramping up the lattice.

Q 56.4 Do 14:45 6J

Interacting Fermions in a 3D Optical Lattice — •Niels Strohmaier[1], Kenneth Günter[1], Yosuke Takasu[1], Henning Moritz[1], Michael Köhl[1,2], and Tilman Esslinger[1] — [1]Institute of Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland — [2]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

The Fermi-Hubbard model, which is an important element of modern condensed matter theory, can be experimentally explored with fermionic atoms in optical lattices. A particularly appealing feature is the capability to change smoothly from non-interacting to attractive or repulsive interactions by accessing a Feshbach scattering resonance. In the strongly repulsive case, one expects the formation of a fermionic Mott insulator state with reduced number fluctuations on each site. For attractive interactions superfluidity is predicted.

In our experiment, we prepare a spin mixture of ultracold fermions in a three-dimensional optical lattice at various filling factors. Recent results concerning the behaviour of the system for attractive as well as repulsive interactions will be presented.

Q 56.5 Do 15:00 6J

Energy spectrum of two interacting particles with unequal trapping frequencies at an optical lattice site — •Frank Deuretzbacher[1], Kim Plassmeier[1], Daniela Pfannkuche[1], Christian Ospelkaus[2], Silke Ospelkaus[2], Klaus Sengstock[2], and Kai Bongs[2] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We study fermionic ^{40}K atoms interacting with bosonic ^{87}Rb atoms at a single optical lattice site at a heteronuclear atomic Feshbach resonance [1] both experimentally and theoretically. We treat the interaction in terms of a regularized δ-function pseudopotential and consider the general case of particles with different trap frequencies, where the usual approach [2] of separating center-of-mass motion and relative motion fails. We numerically obtain the energy spectrum and the eigenfunctions from an exact diagonalization of the Hamiltonian. We find significant corrections to the energy not only due to the anharmonicity of the lattice site but also due to the different trap frequencies. Furthermore we calculate the transfer efficiency of the rf association and the lifetime of the molecules and compare our results with the experimental data. Finally we extend our study to other mixtures, such as ^{6}Li and ^{133}Cs, where the effect is even larger.
[1] C. Ospelkaus *et al.*, Phys. Rev. Lett. **97**, 120402 (2006).
[2] Th. Busch, B. G. Englert, K. Rzazewski, M. Wilkens, Found. Phys. **28**, 549 (1998).

Q 56.6 Do 15:15 6J

Heteronukleare Feshbach-Resonanzen in einer ultrakalten Bose-Fermi-Mischung — •Carsten Klempt, Thorsten Henninger, Oliver Topic, Johannes Will, Wolfgang Ertmer und Jan Arlt — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover

In den letzten Jahren wurden sowohl bosonische als auch fermionische Ensembles quantenentarteter Atome eingehend untersucht. Unser Experiment bietet die faszinierende Möglichkeit zum Studium gemischter Gase. In Zukunft sollen mit Hilfe einer heteronuklearen Feshbach-Resonanz aus dem atomaren Gasgemisch KRb-Moleküle gebildet werden.

Eine magneto-optische Falle wird mit bosonischem ˆ{87}Rb und fermionischem ˆ{40}K geladen. Ein bewegliches Spulenpaar transportiert die Atome in eine Magnetfalle, in der mittels Radiofrequenz-Evaporation eine quantenentartete Borse-Fermi-Mischung erzeugt werden kann. Das Ensemble kann in eine Dipolfalle umgeladen werden, um über ein starkes, homogenes Magnetfeld die heteronuklearen Feshbach-Resonanzen nachzuweisen. Die Position der Resonanzen wird mit aktuellen Ergebnissen anderer Gruppen und theoretischen Vorhersagen verglichen. Eine präzise Vermessung der Resonanzen trägt zum Verständnis des KRb-Molekülpotenzials bei. Eine genaue Kenntnis des Potentials und der zugehörigen Molekülzustände wird es in Zukunft ermöglichen, schwach gebundene Feshbach-Moleküle über ein oder mehrere Molekülniveaus in stark gebundene Moleküle im absoluten Grundzustand zu überführen.

Q 56.7 Do 15:30 6J

Bose-Fermi Mixtures in a Three-Dimensional Optical Lattice — •Kenneth Günter, Thilo Stöferle, Henning Moritz, Michael Köhl, and Tilman Esslinger — Institute of Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland

Optical lattices allow to enter the strongly correlated regime of ultracold bosons or fermions. A mixture of both species interconnects two systems of fundamentally different quantum statistics, and interesting phenomena such as the existence of polarons or a phase transition to a supersolid phase are expected.

We have studied mixtures of fermionic ^{40}K and bosonic ^{87}Rb quantum gases in a three-dimensional optical lattice. We observe that an increasing admixture of the fermionic species diminishes the phase coherence of the bosonic atoms as measured by studying both the visibility of the matter wave interference pattern and the coherence length of the bosons. Moreover, we find that the attractive interactions between bosons and fermions lead to an increase of the boson density in the lattice which we measure by studying three-body recombination in the lattice.

Q 57: Quanteninformation (Quantencomputer II)

Zeit: Donnerstag 14:00–16:15 Raum: 5L

Gruppenbericht Q 57.1 Do 14:00 5L

Theoretical and experimental challenges for the trapped electron quantum computer — •Irene Marzoli[1], Pavel Bushev[8], Adam Buczek[6], Michael Hellwig[8], Carsten Henkel[5], Igor Jex[7], Wojtek Koczorowski[6], Vojtěch Koštár[7], Gerrit Marx[2], Riccardo Natali[1], Ferdinand Schmidt-Kaler[8], Ewa Stachowska[6], Stefan Stahl[4], Gustaw Szawioła[6], Adrian Walaszyk[6], Paolo Tombesi[1], and Günter Werth[3] — [1]University of Camerino, Italy — [2]Universität Greifswald — [3]Universität Mainz — [4]Stahl Electronics, Mettenheim — [5]Universität Potsdam — [6]Poznan University of Technology, Poland — [7]Czech Technical University, Prague — [8]Universität Ulm

One of the possible candidates for a quantum computer is an array of trapped electrons [1]. The traps can be realized with segmented ring electrodes deposited on a planar substrate, combined with a homogeneous magnetic field (Penning traps). Since the first proposal [2], quite a number of additional investigations and studies of this scalable scheme have been performed. Currently some of the elements of this scheme are entering the experimental stage. On the theoretical side, we comment on single qubit coherence, coupling qubits with wires, implementation of Heisenberg spin chains, and quantum networks. Relevant experimental implications are outlined.

[1] G Ciaramicoli & al, Phys Rev Lett **91** (2003) 017901
[2] S Stahl & al, Eur Phys J D **32** (2005) 139

Q 57.2 Do 14:30 5L

Efficient algorithm for multi-qudit twirling for ensemble quantum computation — •Geza Toth[1] and Juan Jose Garcia-Ripoll[2] — [1]Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary — [2]Max Planck Institute for Quantum Optics, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany

We present an efficient algorithm for twirling a multi-qudit quantum state. The algorithm can be used for approximating the twirling operation in an ensemble of physical systems in which the systems cannot be individually accessed. It can also be used for computing the twirled density matrix on a classical computer. The method is based on a simple non-unitary operation involving a random unitary. When applying this basic building block iteratively, the mean squared error of the approximation decays exponentially. In contrast, when averaging over random unitary matrices the error decreases only algebraically. We present evidence that the unitaries in our algorithm can come from a very imperfect random source or can even be chosen deterministically from a set of cyclically alternating matrices. Based on these ideas we present a quantum circuit realizing twirling efficiently.

Q 57.3 Do 14:45 5L

Experimental realization of quantum search algorithm using hyper-entanglement — •Kai Chen[1], Cheming Li[1], Qiang Zhang[1], Alois Mair[1], Yu-Ao Chen[1], Alexander Goebel[1], Shuai Chen[1], Joerg Schmiedmayer[1], and Jian-Wei Pan[1,2] — [1]Physikalisches Institut der Universitaet Heidelberg, Philosophenweg 12, Heidelberg 69120, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

We present the first experimental demonstration of an one-way implementation of Grover search algorithm by exploiting optical hyper-entangled cluster states. This is realized by developing a bright two photon hyper-entangled source with both polarizing and spacial degrees of freedom, which achieves the fastest quantum search utilizing measurement-based quantum computation in currently available optical setups. The two qubit algorithm is succeeded within one single step, in wonderful agreement with theoretical predictions. This highlights ultra-fastness and simplicity of one-way quantum computing using optical hyper-entangled cluster states.

Q 57.4 Do 15:00 5L

Quantum processing photonic states in optical lattices — •Christine Muschik, Ines de Vega, Diego Porras, and Ignacio Cirac — Max Planck Institute for Quantumoptics, Garching, Germany

The mapping of photonic states to collective excitations of atomic ensembles is a powerful tool which finds a useful application in the realization of quantum memories and quantum repeaters. In this work we show that cold atoms in optical lattices can be used to perform an entangling unitary operation on the transferred atomic excitations. After the release of the quantum atomic state, our protocol results in a deterministic two qubit gate for photons. The proposed scheme is feasible with current experimental techniques and robust against the dominant sources of noise.

Q 57.5 Do 15:15 5L

High-speed linear optics quantum computing using active feed-forward — •Robert Prevedel[1], Philip Walther[1,2], Felix Tiefenbacher[1,3], Pascal Böhi[1], Rainer Kaltenbaek[1], Thomas Jennewein[3], and Anton Zeilinger[1,3] — [1]Institute for Experimental Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria — [2]Physics Department, Harvard University, Cambridge, Massachusetts 02138, USA — [3]Institute for Quantum Optics and Quantum Information (IQOQI), Austrian Academy of Sciences, Boltzmanngasse 3, A-1090 Vienna, Austria

Quantum computers promise to be more efficient and powerful than their classical counterparts. In the one-way quantum computer model, a sequence of measurements processes qubits, which are initially prepared in a highly entangled cluster state. The key advantage of this scheme over the standard network approach of quantum computing is that inherent, randomly induced measurement errors can classically be fed-forward and corrected by adapting the basis of subsequent measurements. Active feed-forward is therefore crucial to achieve deterministic quantum computing once a cluster state is prepared. We have experimentally realized such a feed-forward one-way quantum computation scheme by employing up to three active-switching Electro-Optical Modulators (EOM) in a four-qubit cluster state encoded into the polarization state of four photons. Using these switches we demonstrate one- and two-qubit gate operations as well as Grover's quantum search algorithm. With present technology this feed-forward step can be performed in less than 150 nanoseconds.

Q 57.6 Do 15:30 5L

"Entanglement Swapping" mit gespeicherten Ionen — •T. Monz[1], M. Riebe[1], P. Schindler[1], M. Chwalla[1], K. Kim[1], P. O. Schmidt[1], W. Hänsel[1], H. Häffner[2], C. F. Roos[2] und R. Blatt[1,2] — [1]Institut für Experimentalphysik, Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria

Einzeln adressierbare Ionen, gefangen in einer Paul-Falle, stellen einen vielversprechenden Kandidaten für die Realisierung eines Quantencomputers dar. Ein wichtiger Baustein ist ein verschränkendes 2-Qubit-Gatter, in unserem Fall ein Cirac-Zoller controlled NOT-Gatter. Mit Hilfe dieses Gatters konnten wir bereits die Teleportation des elektronischen Zustandes eines Ionenqubits auf ein anderes Ion implementieren. "Entanglement Swapping" stellt eine verallgemeinerte Form dieser Teleportation dar, bei der ein verschränktes Qubit teleportiert wird. Im Vortrag wird auf die apparativen Verbesserungen eingegangen welche die Implementierung solcher fortgeschrittenen Algorithmen erlauben. Erste Messungen zur Realisierung von "Entanglement Swapping" werden präsentiert.

Q 57.7 Do 15:45 5L

Percolation, renormalization, and quantum computing with non-deterministic gates — •Konrad Kieling[1,2], Terry Rudolph[1,2], and Jens Eisert[1,2] — [1]QOLS, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2BW, UK — [2]Institute for Mathematical Sciences, Imperial College London, Prince's Gate, London SW7 2PE, UK

We apply a notion of static renormalization to the preparation of cluster states for quantum computing, exploiting ideas from percolation theory. Such a strategy yields a novel way to cope with the randomness of non-deterministic quantum gates. This is most relevant in the context of linear optical architectures, where probabilistic gates are inevitable. We demonstrate how to efficiently construct cluster states without the need for rerouting, thereby avoiding a massive amount of feed-forward and conditional dynamics, and furthermore show that except for a single layer of fusion measurements during the preparation, all further measurements can be shifted to the final adapted single qubit measurements. Remarkably, the cluster state preparation is achieved using essentially the same scaling in resources as if deterministic gates were available. Further, techniques to reduce the size of the required resource states will be presented.

Q 57.8 Do 16:00 5L

Quantum gates for optical transition qubits in ion trap — •Kihwan Kim[1], Mark Riebe[1], Michael Chwalla[1], Thomas Monz[1], Philipp Schindler[1], Hartmut Häffner[2], Christian Roos[2], Wolfgang Hänsel[1], Timo Körber[2], Piet Schmidt[1], and Rainer Blatt[1,2] — [1]Institute für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Austria

Qubits in ion trap quantum computation have been implemented at the long lived atomic states of either micro wave transitions or optical transitions. To realize a controlled-NOT gate, quantum gate operations have been studied theoretically and experimentally that use spin-dependent forces on hyperfine qubits. For qubits encoded in optical transitions, however, only controlled-NOT gates of Cirac-Zoller have been investigated so far [1,2]. Here, we show that similar forces to spin dependent one can also be employed for qubits on optical transitions. In contrast to hyperfine qubits, we find that the forces on optical quadrupole transitions have the following interesting properties: (1) Spontaneous photon scattering rates are low, (2) σ_z spin dependent forces can be be applied to magnetic-field insensitive states, (3) maximum coupling strength is achieved in a pair of co-propagating laser beams, which makes the gate robust against phase errors from optical path length fluctuations. We discuss the physics behind the gate operation and discuss its sensistivity against experimental imperfections.

[1] F. Schmidt-Kaler, *et al.*, Nature **422**, 408 (2003).
[2] M. Riebe, *et al.*, Phys. Rev. Lett. **97**, 220407 (2006).

Q 58: Photonik II

Zeit: Donnerstag 14:00–15:45 Raum: 5J

Q 58.1 Do 14:00 5J

Solitonenmoleküle in dispersionsalternierenden Glasfasern: Phasensensitive Charakterisierung — •Alexander Hause, Haldor Hartwig, Michael Böhm und Fedor Mitschke — Universität Rostock, Fachbereich Physik, Universitätsplatz 3, 18051 Rostock

Wie kürzlich von uns gezeigt wurde [1], existieren in Glasfaserstrecken mit periodisch wechselnder Dispersion stabile Verbundzustände aus Solitonen, so genannte Solitonenmoleküle. Deren Stabilität ist stark an das Vorhandensein eines Phasensprunges von π rad in der Mitte geknüpft.

Während in der Simulation die komplexwertige Einhüllende direkt zugänglich ist, lieferten bisherige Messungen lediglich das Spektrum und eine zeitliche Autokorrelation der Impulsform. Fortgeschrittenere Methoden zur vollständigen Impulscharakterisierung wie z.B. SHG-FROG versagten bei Vorhandensein von Nullstellen und Phasensprüngen.

Jetzt ist es jedoch mit Hilfe eines speziellen Blind-FROG-Aufbaus und eines neuartigen Rekonstruktionsalgorithmus VAMPIRE [2,3] gelungen, im interessierenden Parameterbereich die komplexwertige Einhüllende bei jeder Messung vollständig und eindeutig zu rekonstruieren. Dies erlaubt zusammen mit den durchgeführten Simulationen Rückschlüsse auf den Bindungsmechanismus im Solitonenmolekül.

[1] M. Stratmann et al., PRL **95**, 143902 (2005)
[2] B. Seifert et al., JOSA B **21**, 1089 (2004)
[3] B. Seifert et al., Opt. Lett. (submitted)

Q 58.2 Do 14:15 5J

Bestimmung des Solitonengehaltes von Lichtimpulsen in verlustbehafteten Glasfasern — •Michael Böhm und Fedor Mitschke — Institut für Physik, Universitätsplatz 3, 18055 Rostock

Optische Solitonen spielen u.a. in der Datenübertragung eine wichtige Rolle. Eine analytische Beschreibung gelingt mit der Inversen Streutheorie [1], die aber auf integrable Systeme beschränkt ist. Für reale Systeme kann man also wegen der stets vorhandenen Verluste keine analytische Aussagen treffen. Zwar kann man die Impulsausbreitung immer numerisch simulieren, erhält dadurch jedoch keine Aussage über den Solitonenanteil eines Lichtimpulses. Wir benutzen hier die kürzlich eingeführte „soliton-radiation beat analysis"[2], um den Solitonengehalt von Lichtimpulsen in verlustbehafteten Glasfasern zu untersuchen, und diskutieren den schließlichen Zerfall des Solitons.

[1] V. E. Zakharov and A. B. Shabat, *Exact theory of two-dimensional self-focusing and one-dimensional self-modulation of waves in nonlinear media*, Soviet Phy. JETP, **34** 1, (1972) 62-69
[2] M. Böhm und F. Mitschke, *Soliton-radiation beat analysis*, Phys. Rev. E **73** 066615, (2006)

Q 58.3 Do 14:30 5J

Nichtlinearitäten 3. Ordnung in Photonischen Kristallen im mittleren Infrarot-Bereich — •Kerstin Mitzschke[1], Andreas Langner[2], Frank Müller[2], Ulrich Goesele[2] und Heinrich Graener[1] — [1]Martin-Luther-Universität, Institut für Physik, 06099 Halle — [2]MPI für Mikrostrukturphysik, Weinbergweg 2, 06120 Halle

Die Erzeugung der Dritten Harmonischen (THG) ist eine relativ ein-

fache Methode der nichtlinearen Spektroskopie zur optischen Untersuchung von Metamaterialien wie Photonischen Kristallen (PC) aus Silizium. Die THG im mittleren IR-Bereich erlaubt Experimente im hoch interessanten Frequenzbereich der photonischen Bandlücken.

Die untersuchten 2D- und 3D-PC wurden auf einen Si-Wafer durch einen photoelektrochemischen Ätzprozess erzeugt. Das für das Experiment benutzte Lasersystem lieferte durchstimmbare Impulse in einem Bereich von 2500-4000 cm-1.

Kontrollexperimente an Bulk-Si zeigen die theoretisch zu erwartenden Ergebnisse, eine 4-bzw- 8-zählige Winkelbahängigkeit, deren Ursache in der Struktur des $\chi(3)$-Tensors liegt.

Bei Photonischen Kristallen mit hexagonaler Struktur zeigt sich jedoch ein völlig anderes Ergebnis, über das berichtet werden soll.

Q 58.4 Do 14:45 5J

Brillouin scattering in hollow core photonic bandgap fibers — •Erik Benkler and Harald R. Telle — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Stimulated Brillouin scattering limits the high power transmission capability of narrowband cw and quasi-cw signals in optical fibers. Recently developed hollow core photonic bandgap (HC-PBG) fibers, however, promise a much lower Brillouin scattering cross section than conventional fibers due to strongly reduced overlapping between light field and guiding structure.

We have measured the Brillouin gain spectrum of commercially available HC-PBG fibers employing a novel highly sensitive scheme. Two frequency modulated DFB laser diodes are used as pump and Stokes sources. The resulting AM component of the Brillouin signal is lock-in detected at the difference of the two modulation frequencies.

Using excitation wavelengths in the telecommunication band, we found spectra at Brillouin shifts around 7.5 GHz which are substantially more complex and at least 4 orders of magnitude smaller than those of standard telecom fibers.

Q 58.5 Do 15:00 5J

Collective Photon Modes in Coupled-Resonator Optical Waveguides — •Björn M. Möller[1], Mikhail V. Artemyev[2], and Ulrike Woggon[1] — [1]Fachbereich Physik, Universität Dortmund, 44227 Dortmund — [2]Institute for Physico-Chemical Problems, Belarussian State University

Waveguides composed of coherently coupled microcavities — so-called coupled-resonator optical waveguides (CROWs) [1-3] — represent promising microstructures for slowing down the group velocity of light.

In this contribution, we apply spatially and spectrally resolved Bloch-mode mapping to study collective photon modes in chains of coherently coupled polymeric microspheres. An efficient excitation of optical Bloch modes inside the coupled-resonator chains is demonstrated in the visible spectral range utilizing nanocrystals as dopants. The experimental results are explained with an analytical coupled-harmonic oscillator model. Experimentally, a slowing-factor $S = 31$ for the group velocity of light has been determined at the Bloch band center as a lower bound.

We discuss the impact of size variations in a coupled-resonator chain. The modification of the coupled cavity fields and the respective changes of the dispersion relation are evaluated for several types of cavity size variations.

[1] A. Yariv, *et al.*, Opt. Lett. **24**, 711 (1999)
[2] B. M. Möller, *et al.*, Opt. Lett. **30** (16), 2116 (2005)
[3] B. M. Möller, *et al.*, J. Opt. A **8**, S113 (2006)

Q 58.6 Do 15:15 5J

Selectively infiltrated hollow core photonic crystal fibers for fluorescence sensing — •Stephan Smolka, Michael Barth, and Oliver Benson — Nano Optics, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin

We investigate the potential of hollow core photonic crystal fibers (HCPCFs) for ultra-sensitive fluorescence detection in the visible. For this purpose the central hole of a HCPCF is selectively infiltrated with fluorophores using a fusion splicer technique. Depending on the infiltration procedure, the central hole is either coated with fluorophores or completely filled with dye-doped fluids, which allows us to study the sensing properties of HCPCFs operating in the band gap guiding regime and in the index guiding regime, respectively. The influence of reabsorption and intermolecular interactions are determined experimentally for both cases. We demonstrate that both configurations are suitable to detect dyes with concentrations down to 100 pM using only nanoliter sample volumes.

Our results show that depending on the employed coating/filling technique, HCPCFs can thus be applied for various sensing tasks. Coated fibers may be used in gas sensing devices where the fluorescence signal is affected by the concentration of several gases. By functionalization of the core walls and infiltration of biochemical samples, various chemical or biological processes might be monitored. Due to the small sample volumes an integration in optoelectronic devices could be managed.

Q 58.7 Do 15:30 5J

Reduction of Guided Acoustic Wave Brillouin Scattering in Photonic Crystal Fibers — •Dominique Elser[1], Ulrik Andersen[1,2], Oliver Glöckl[1], Stefan Lorenz[1], Christoph Marquardt[1], and Gerd Leuchs[1] — [1]Institut für Optik, Information und Photonik (Max-Planck-Forschungsgruppe), Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1, Bau 24, 91058 Erlangen — [2]Department of Physics, Technical University of Denmark, Building 309, 2800 Kgs. Lyngby, Denmark

Guided Acoustic Wave Brillouin Scattering (GAWBS) leads to phase and polarization noise of light propagating in glass fibers. This excess noise is a major limitation for fiber-based squeezing sources as well as for the transmission of quantum information through fibers. In order to achieve quantum states of high quality it is therefore important to reduce the harmful effect of GAWBS.

In Photonic Crystal Fibres (PCFs), light is guided by a photonic crystal structure simultaneously acting as a phononic crystal which modifies the acoustic noise spectrum. By measurements and simulations we have demonstrated a GAWBS-noise reduction in commercially available PCFs. This gives rise to the prospect of fiber squeezers exhibiting less excess noise, resulting in higher quantum state purity. Further improvement can be achieved by tailoring the photonic microstructure such that a reduction of phonons 'by design' is achieved.

Q 59: Quanteneffekte (Lichtstreuung II)

Zeit: Donnerstag 14:00–16:00 Raum: 5E

Q 59.1 Do 14:00 5E

Generating EPR-entangled radiation with a beam of atoms — •SUSANNE PIELAWA[1,2], GIOVANNA MORIGI[1], DAVID VITALI[3], and LUIZ DAVIDOVICH[4] — [1]Dept. de Fisica, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Spain — [2]ICFO-Institute of Photonic Sciences, E-08860 Castelldefels (Barcelona), Spain — [3]Dipt. di Fisica, Universita' di Camerino, I-62032 Camerino, Italy — [4]Inst. de Fisica, Universidade Federal do Rio de Janeiro, Brasil

We propose a scheme for generating two-mode squeezing in resonators using a beam of atoms with statistical arrival times. A classical field drives the atoms inside the cavity transversally, saturating the dipole transition and thereby setting it on resonance with two non-degenerate cavity modes. By suitably preparing the atoms initial state, the stationary state after a sufficient atomic statistics is a two-mode squeezed state, whose degree of entanglement is controlled by the external parameters of atomic beam and pumping field. The scheme can be realized in the parameter regimes of present experiments with microwave resonators [1,2]. In the outlook we discuss possible extensions to the optical regime. [1]J. M. Raimond, M. Brune, and S. Haroche, Rev. Mod. Phys. 73, 565-582 (2001). [2]H. Walther, B.T.H. Varcoe, B.-G. Englert and T. Becker, Rep. Prog. Phys. 69, 1325-1382 (2006).

Q 59.2 Do 14:15 5E

Light propagation beyond the multiphoton resonance condition — •Jörg Evers[1] and Mohammad Mahmoudi[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Physics Department, Zanjan University, P. O. Box 45195-313, Zanjan, Iran

The light propagation of a probe field pulse is studied in atomic media where the applied laser fields form a closed interaction loop [1]. Such systems have interesting properties, but only admit a time-independent analysis if the laser field detunings satisfy the so-called multiphoton resonance condition. This condition, however, is violated in light propagation in particular for short pulses with a large frequency width. To overcome this limitation, we solve the time dependent problem using a Floquet decomposition of the equations of motion, and identify the processes contributing to the medium response. We then show that our four-level double-Λ type model system allows for sub- and superluminal light propagation with small absorption or even gain, controlled by one of the coupling field Rabi frequencies.

[1] M. Mahmoudi and J. Evers, Phys. Rev. A. in print (quant-ph/0609206)

Q 59.3 Do 14:30 5E

Towards coupling of two distant emitters — •Robert Lettow[1], Stephan Götzinger[1], Ville Ahtee[2], Erkki Ikonen[2], and Vahid Sandoghdar[1] — [1]Laboratory of Physical Chemistry, ETH Zürich, CH-8093 Zürich — [2]Metrology Research Institute, Helsinki University of Technology, Finland

We report on experiments where two organic dye molecules are coupled over a long distance. Although both coherent and incoherent coupling of emitters have been demonstrated in the near field via the dipole-dipole interaction, coupling of two quantum optical systems separated by more than a wavelength remains a challenge due to several experimental difficulties. In the gas phase the detection and excitation efficiencies are very low while in the solid state usually the spectral inhomogeneity, the coupling to phonons and a low absorption cross section pose problems. In our laboratory, we have set up an experiment where single molecules in two different samples are detected simultaneously at liquid helium temperature. By using microscope objectives of high numerical aperture, we achieve very efficient excitation of the molecules and collection of their emitted photons. Furthermore, by applying local electric fields, we tune the Fourier limited zero-phonon lines of the two molecules to make them spectrally indistinguishable. We present the current status of this experiment and discuss future plans.

Q 59.4 Do 14:45 5E

Amplification of Terahertz pulses in thin gases — •Gerhard Schwaab, Konstanze Schröck, and Martina Havenith — Physikalische Chemie II, Ruhr-Universität Bochum, D-44780 Bochum

We have carried out Terahertz Time-Domain Spectroscopy in a plasma at low pressure and observed a simultaneous absorption and amplification process within each single rotational transition. We were able to model the observation and could show that it is a direct consequence of the short interaction time of the pulsed THz radiation with the plasma. The interaction time is shorter than the average collision time between the molecules. Thus, during measurement time the molecular and photonic states may be considered entangled.

The solution of the time dependent Schrödinger equation yields a linear term that may usually be neglected for long observation times, large frequencies, or non-entangled states. We determine the restrictions for the observation of this effect and calculate the spectrum for a simple diatomic molecule.

We predict an absorption/amplification process that shows a quadratic instead of the typical exponential behaviour. Using this model we are able to explain the spectral features showing a change from emission to absorption as observed previously.

The observed effect should be a general phenomenon for any quantum mechanical system with entangled states when a) the time scale for disturbances exceeds the typical interaction time of the light pulse with the sample and b) the population difference is small.

Q 59.5 Do 15:00 5E

The coherent backscattering spectrum of two atoms — •Vyacheslav Shatokhin[1], Thomas Wellens[2], Benoit Gremaud[3], and Andreas Buchleitner[4] — [1]B.I. Stepanov Institute of Physics, National Academy of Sciences, Nazavisimosti Avenue 68, 220072 Minsk, Belarus — [2]Institut für Theoretische Physik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany — [3]Laboratoire Kastler Brossel, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cedex 05, France — [4]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

We present a detailed analytical and numerical analysis of the inelastic coherent backscattering spectrum of laser light incident on cold atoms. We identify frequency domains where the interference contribution can be positive or negative, or exhibit dispersive features. These distinctive features are explained by reciprocity arguments and dressed state two-photon scattering amplitudes.

Q 59.6 Do 15:15 5E

Multiple photon scattering in resonant atomic media — •Tobias Kerscher and Cord Müller — Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth

We investigate multiple photon scattering in a dense cloud of resonant atoms by means of a self-consistent perturbation theory. The atoms are assumed to be identical two-level systems. In this medium the self-energy Σ determines the photonic dispersion relation.

We present a diagrammatic calculation of Σ to leading order in atomic density and compare it to a coherent potential approximation (CPA). The dressed propagation of light in turn influences the natural line width Γ of the atomic resonance. The near-resonance behaviour of Γ will be discussed.

Q 59.7 Do 15:30 5E

Coherence of light scattered by two coupled atoms — Stefan Rist[1], Giovanna Morigi[1], •Markus Hennrich[2], and Jürgen Eschner[2] — [1]Dept. de Fisica, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Spain — [2]ICFO-The Institute of Photonic Sciences, E-08860 Castelldefels (Barcelona), Spain

We investigate theoretically the properties of the light scattered by two atoms which are imaged onto each other by a lens and a mirror. In a recent experiment using that configuration [1], interference between the light scattered by one atom and the mirror image of the second one was observed as a function of the difference between the optical paths of the light reaching the detector. Here we develop a theoretical model for the experimental situation, which extends the work of Ref. [2] describing the dynamics of a single atom in front of a mirror. The emission spectra of the two atoms are evaluated by taking into account multiple scattering of photons at all orders, thereby determining the corrections to the Wigner-Weisskopf approximation for the atomic linewidth. Novel features in the first order interference spectrum are identified which arise from the interaction between the two atoms, and which could be revealed in the setup of Ref. [1].

[1] J. Eschner, C. Raab, F. Schmidt-Kaler, and R. Blatt, Nature 413, 495 (2001).

[2] U. Dorner and P. Zoller, Phys. Rev. A 66, 023816 (2002)

Q 59.8 Do 15:45 5E

Radiation pressure cooling of a micro-mirror — •Simon Gröblacher[1,2], Sylvain Gigan[2], Hannes Böhm[1,2], Florian Blaser[2], Katharina Gugler[2], Anton Zeilinger[1,2], and Markus Aspelmeyer[1,2] — [1]Institut für Experimentalphysik, Universität Wien, Boltzmanngasse 5, 1090 Wien, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Boltzmanngasse 3, 1090 Wien, Österreich

I will present recent results on radiation pressure induced cooling of a massive micro-mirror. This is of relevance for future quantum experiments involving macroscopic physical systems, e.g. entangled states of micro-mirrors.

Q 60: Fallen und Kühlung (gemeinsam mit A)

Zeit: Donnerstag 14:00–16:00 Raum: 5D

Q 60.1 Do 14:00 5D

Time-Averaged Adiabatic Potentials: Novel traps and waveguides for ultracold quantum gases — •Wolf von Klitzing and Igor Lesanovsky — Institute of Electronic Structure and Laser, Foundation for Research and Technology -Hellas, P.O.Box1527, GR-71110 Heraklion, Greece

We demonstrate a novel class of trapping potentials, time-averaged adiabatic potentials (TAAP) which allows the generation of a large variety of traps and waveguides for ultracold atoms. Multiple traps can be coupled through controllable tunneling barriers or merged altogether. We present analytical expressions for pancake-, cigar-, and ring- shaped traps. The ring-geometry is of particular interest for guided matter-wave interferometry as it provides a perfectly smooth waveguide of controllable diameter, and thus a tunable sensitivity of the interferometer.

[1] I. Lesanovsky and W. von Klitzing, preprint: cond-mat/0612213 (2006)

Q 60.2 Do 14:15 5D

Ultra-cold strontium atoms for optical frequency metrology — •Joseph Sundar Raaj Vellore Winfred, Thomas Legero, Fritz Riehle, and Uwe Sterr — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Precise measurement of time is of paramount importance in technological and scientific endeavors. Recent advancement in optical frequency metrology promises to measure time with a fractional accuracy of 10^{-17}. Strontium is an attractive candidate for such an optical clock because of its narrow line transition with a linewidth of about 1 mHz and the existence of a magic wavelength for the clock transition in the NIR region. Here we report preliminary results of cooling and trapping of strontium atoms. The strontium atoms are cooled down to ultra-cold temperature regime($2\,\mu$K) in a two-stage cooling process. An overview of our experimental set up, characterization of a 1-D optical dipole trap with respect to different trap parameters and its relevance to frequency measurement will be presented.

Q 60.3 Do 14:30 5D

Auf dem Weg zu wenigen fermionischen Atomen in einer Mikrofalle — •Friedhelm Serwane[1], Timo Ottenstein[1] und Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Fakultät für Physik und Astronomie, Universität Heidelberg

Wir berichten über die Planungen für ein Experiment zur Präparation eines Systems bestehend aus einer deterministischen Anzahl von fermionischen ^{6}Li-Atomen im Grundzustand einer optischen Mikrofalle. Mittels einer Feshbachresonanz kann die Wechselwirkung zwischen Teilchen in unterschiedlichen Spinzuständen frei eingestellt werden. Auf diese Weise kann die Physik weniger wechselwirkender Fermionen untersucht werden, die auch die Eigenschaften von Kernen und Atomen entscheidend bestimmt. Besonders interessant erscheint dabei auch die Möglichkeit, exotische Konfigurationen nach Belieben zu präparieren, wie sie zum Beispiel als Halokerne in der Kernphysik studiert werden. Ausgangspunkt für diese Experimente wird ein molekulares Bose-Einstein-Kondensat von $^6Li_2$-Molekülen sein, mit dem eine ausreichend niedrige Temperatur erreicht werden kann, bevor dann die meisten Teilchen durch kontrolliertes Absenken des Fallenpotentials entfernt werden.

Q 60.4 Do 14:45 5D

Noise reduction in a cold atomic trapped sample — •Jerome Esteve, Andreas Weller, Jens Appmeier, Christian Gross, Rudolf Gati, and Markus Oberthaler — Kirchhoff Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg

In typical cold atom experiments, the fluctuations of the total atom number in the trap are dominated by technical fluctuations and are usually bigger than shot-noise. Reducing these fluctuations as much as possible is of great interest for numerous experiments. In particular, it is a prerequisite to the generation of entangled states in Bose-Einstein condensates since many entanglement schemes rely on the knowledge of the absolute atom number. In this presentation, we will show experimental results where the total atom number fluctuations in an optical dipole trap are strongly reduced down to approximately the shot-noise level by introducing three body losses in the sample. We will discuss the minimal noise that can be achieved by this method and show that sub-shot-noise fluctuations should indeed be observable.

Q 60.5 Do 15:00 5D

Laser Cooling of Barium — •Subhadeep De, Umakanth Dammalapati, Klaus Jungmann, and Lorenz Willmann — 1KVI, University of Groningen, 9747 AA Groningen, The Netherlands

Heavy alkaline earth elements like radium offer unique possibilities to test fundamental symmetries in nature. This has triggered the interest in laser cooling and trapping of such isotopes. We have developed strategies for laser cooling with barium, which exhibits a very similar level scheme. These isotopes suffer from large losses from the strong 1S0-1P1 cooling transition to metastable D-states. The branching ratio to the 1D2, 3D2, 3D1-states is 330:1 for barium and similar for radium. We have performed the first laser spectroscopy of the 1D2, 3D2, 3D1 to 1P1 repumping transitions in barium. With the repumpers (1108nm, 1130nm, 1500nm) we were able to demonstate the first laser cooling of barium, where we reduced the loss to the metastable state to less than 1 in 10000. This allow to slow an atom by more than 100m/s. In addition, we are investigating other schemes for repumping in barium. We plan to apply these results to laser cooling of radium.

Q 60.6 Do 15:15 5D

Atomfalle im Internet — •Anika Vogel, Greta Johannsen, Kai Bongs und Klaus Sengstock — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Die Physik kalter atomarer Gase findet weltweit größtes Interesse in Grundlagenforschung und Anwendung und wurde 1997 mit dem Nobelpreis gewürdigt. Um dieses Gebiet für Studenten (und potentiell Schüler) aller Welt zugänglich und aktiv erfahrbar zu machen, erstellen wir derzeit ein reales Experiment zur magnetooptischen Speicherung von Rubidium-87-Atomen, das wir in einem Internetportal mit interaktiv steuerbaren experimentellen Parametern zugänglich machen wollen. Lernmodule sollen ein Verständnis der Laserkühlung mit detaillierten Texten zu den theoretischen Grundlagen sowie mit Animationen und Simulationen zum Thema ermöglichen. In diesem Vortrag wird der experimentelle Aufbau und der aktuelle Stand der Arbeiten vorgestellt. Das Projekt wird vom Multimediakontor Hamburg gefördert.

Q 60.7 Do 15:30 5D

Electric trapping of Rb atoms — •Thomas Rieger, Pepijn Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Here we report on all-electric trapping of Rb atoms. Electric trapping of neutral atoms in time-varying electric fields was already proposed in the early nineties [1]. Recently, Katori and co-workers demonstrated first electric trapping in a micro trap [2]. We have shown two-dimensional trapping (guiding) of neutral molecules in time-varying electric fields [3] with a similar technique. The perspective of sympathetic cooling of molecules with atoms led us to set up an experiment for trapping neutral atoms in time-varying electric fields. In contrast to the one in Ref. [2], our electric trap is of millimeter size, allowing good optical access.

Based on simulations predicting a trap depth of $30\,\mu$K, a magneto-optical trap has been setup. The laser-cooled atoms are magnetically trapped and transferred to the electric trap by mechanically moving the trap coils. After turning on the alternating electric fields, the atoms are electrically trapped for a few hundred milliseconds. The experimental results will be discussed in detail.

[1] F. Shimizu and M. Morinaga, Jpn. J. Appl. Phys., **31**, L1721 (1992)
[2] H. Katori et al., AIP Conf. Proc. **770**, 112 (2005)
[3] T. Junglen et al., Phys. Rev. Lett., **92**, 223001 (2004)

Q 60.8 Do 15:45 5D

Optical Storage Ring for Cold Atoms — •Andre Lengwenus[1], Jens Kruse[1], Michael Volk[1], Wolfgang Ertmer[2], Matthias Gruber[3], Jürgen Jahns[3], and Gerhard Birkl[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Institut für Quantenoptik, Universität Hannover, 30167 Hannover, Germany — [3]Lehrgebiet Optische Nachrichtentechnik, FernUniversität Hagen, 58084 Hagen, Germany

Most applications for atom interferometers, e.g. sensors for rotation

or acceleration, benefit from long interaction times and large enclosed areas. Both can be achieved, using guided interferometer structures for cold atoms. We experimentally demonstrate a new interferometer-type guiding structure for laser cooled neutral atoms based on a ring-shaped dipole potential. The dipole potential is created by focusing a far red-detuned laser beam by a specially designed micro-fabricated optical structure.

We can load atoms into this miniaturized storage ring and can observe how atoms move along the ring-shaped potential minimum. Illuminating only part of the ring lens with a moveable asymmetrical gaussian laser beam gives us the possibility to create a double well potential with variable barrier height. This enables us to move the atoms around the ring as well as dividing and recombining the atom cloud as required for a guided-atom interferometer.

Q 61: Poster Quanteneffekte

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 61.1 Do 16:30 Poster C

Kohärenter Besetzungstransfer zwischen atomaren Niveaus: Erzeugung und Vermessung von Überlagerungszuständen — •Frank Vewinger[1,2], Manfred Heinz[1], Christian Barthel[1,3], Ulrich Schneider[1,4] und Klaas Bergmann[1] — [1]Fachbereich Physik der Universität, Kaiserslautern — [2]Institut für angewandte Physik, Universität Bonn — [3]Department of Physics, Harvard University, USA — [4]Institut für Physik, Johannes Gutenberg-Universität Mainz

In den letzten Jahren wurden laser-basierte Techniken für die Manipulation von atomaren und molekularen Zuständen in grosser Vielfalt entwickelt. Wir präsentieren Arbeiten zur kontrollierten Erzeugung von Überlagerungszuständen entarteter Niveaus durch Erweiterungen der stimulierten Raman-Streuung mit adiabatischer Passage (STIRAP). Metastabile Neonatome werden durchgeeignete Laserfelder vom Anfangszustand $(2s53p)^3P_0$ in eine Superposition der entarteten Zeemanzustände des Niveaus $(2s53p)^3P_2$ transferiert, wobei sowohl die relativen Phasen der Zustände als auch die Amplitudenverteilung kontrolliert wird[1]. Zusätzlich präsentieren wir ein Verfahren zum "schalten" der relativen Phase einer Superposition mittels der Frequenz der beteiligten Laserfelder[2]. Die experimentelle Charakterisierung der erzeugten Überlagerungszustände geschieht mittels phase-to-population mapping, welches die vollständige Tomographie der erzeugten Superpositionszustände erlaubt [3].

[1] F. Vewinger et al., Phys. Rev. Lett., **91**, 213001 (2003)
[2] M. Heinz et al., Opt. Comm. **264**, 247 (2006)
[3] P. Ivanov et al., Opt. Comm. **264**, 368 (2006)

Q 61.2 Do 16:30 Poster C

Adiabatic frequency conversion of quantum optical information in atomic vapor — •Frank Vewinger[1,2], Eden Figueroa[2], Jürgen Appel[2], and Alexander Lvovsky[2] — [1]Institut für angewandte Physik, Universität Bonn — [2]Institute for Quantum Information Science, University of Calgary, Canada

We experimentally demonstrate a quantum communication protocol that enables frequency conversion and routing of quantum optical information in an adiabatic and thus robust way. The protocol, termed "Raman adiabatic trabsfer of optical states (RATOS)" [1] is based on electromagnetically induced transparency in systems with multiple excited levels: transfer and/or distribution of optical states between different signal modes is implemented by adiabatically changing the control fields. The proof-of-principle experiment is performed using the hyperfine levels of the rubidium D1 line [2].

[1] J. Appel et al., Phys. Rev. A **73**, 013804 (2006)
[2] F. Vewinger et al, quant-ph/0611181 (2006)

Q 61.3 Do 16:30 Poster C

Optimal truncation of Gauss sums for integer factorization — •Martin Štefaňák[1,2], Wolfgang Merkel[2], Wolfgang P. Schleich[2], Daniel Haase[3], and Helmut Maier[3] — [1]Department of Physics, FJFI CTU in Prague, Czech Republic — [2]Institut für Quantenphysik, Universität Ulm, Germany — [3]Institut für Zahlentheorie und Wahrscheinlichkeitstheorie, Universität Ulm, Germany

We analyze truncated Gauss sums in the context of integer factorization. The absolute value of the Gauss sum is a useful tool to discriminate factors from non-factors. Recently, an experimental realization in physical systems demonstrated the ability to factorize numbers with Gauss sums. Experimental limitations directly translate into a truncation of the summation range. However, this constraint results in less contrast between factors and non-factors. We derive an upper bound on the truncation parameter which allows to suppress all non-factors below a threshold value. Moreover, we show that if we tolerate a limited number of errors we can reduce the truncation even further.

Q 61.4 Do 16:30 Poster C

Towards Quantum Optics with Surface Plasmons — •Vasily V. Temnov[1], Yuri Fedutik[1], Marco Allione[1], Oliver Schöps[1], Vitaly Anikeyev[1], Mikhail V. Artemyev[1,2], Jose Dintinger[3], Eloise Devaux[3], Thomas W. Ebbesen[3], and Ulrike Woggon[1] — [1]Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — [2]Institute of Physico-Chemical Problems of Belorussian State University, Leningradskaya Str. 14, 220080 Minsk, Belorussia — [3]Laboratoire des Nanostructures, ISIS, Universite Louis Pasteur, 8 allee Monge, BP 70028, 67083 Strasbourg, France

Excitation and propagation of electromagnetic surface waves (surface plasmons) at optical frequencies in different types of metallic nanostructures, i.e. slit-groove nanostuctures in noble metal films manufactured by a focused ion beam or chemically grown silver nanowires, are investigated by optical spectroscopy. Distinct Fabry-Perot-type periodic modulations in transmission spectra of these nanostructures can be attributed to excitation of surface plasmons and form the eigenmodes in plasmonic nanocavities. Using microphotoluminescence spectroscopy we demonstrate the excitation of plasmonic cavity modes via photoluminescence emission of semiconductor nanocrystals positioned ∼20 nm above the metal surface. Picosecond time-resolved photoluminescence measurements demonstrate the increase in SP-mediated spontaneous emission rate (Purcell effect). The possibilities to observe further quantum-optical effects with surface plasmons are discussed.

Q 61.5 Do 16:30 Poster C

Casimir Forces and nano-crafted surfaces — Lodewijk Arntzen, Maarten DeKieviet, Felix Laux, and •Ulrich Warring — Physikalisches Institut der Universität, Philosophenweg 12, D-69120 Heidelberg

In the Heidelberger Atomic Beam Spin Echo (ABSE) spectrometer, we have recently succeeded to detect Quantum Reflection (QR) of ^{3}He atoms from plain and well-characterized surfaces. For semi-conductors, we find that QR takes place at the transition from the van der Waals dominated part of the interaction potential to the Casimir-Polder part. In order to investigate the topological aspects of the Casimir-Polder force, we studied QR from different gratings. Depending on the shape and the orientation of these nano-structures, changes in the reflected intensity and the angular-distribution were observed. Quantitatively, the data are explained by vertical and lateral Casimir-Polder forces.

Q 61.6 Do 16:30 Poster C

Photon correlations in broadband down-converted light — •Benjamin Freyer, Axel Heuer, and Ral Menzel — Institute of Physics, Chair of Photonics, University of Potsdam, Am Neuen Palais 10, D-14469 Potsdam

Parametric down conversion (PDC), is frequently used for the generation of correlated photon pairs in several quantum optic applications like quantum cryptography or quantum imaging. In this process the two photons of the pair are generated via the spontaneous decay of one pump photon. Both photons, signal and idler, are strongly correlated because of conservation of energy and momentum regarding their wavelength and propagation direction. The spectrum of the down-converted light, only limited by the phase matching conditions, could spread over several hundreds of nanometres.

We investigated pulsed PDC in Beta Barium Borat (BBO) crystals. The crystals are cut for type I phase matching. Type I phase matching results in emission cones of the signal and idler photons, which are centred around the propagation direction of the pump photon. The aperture angle of the cone is a function of the wavelength of signal and idler photons as well as of the angle of incidence of the pump pho-

ton. We measured the rate of coincidence for different cone angles and wavelengths. In these measurements the pump geometry and crystal length was varied. As a result we get the normalized coincidence rate as a function of the PDC spectrum and of the cone radius.

Q 61.7 Do 16:30 Poster C

Two photon interference of multimode waveguided parametric downconversion. — •Andreas Eckstein and Christine Silberhorn — Max-Planck-Nachwuchsgruppe Integrierte Quantenoptik, Erlangen, Deutschland

A typical bosonic property of light is two-photon bunching, i. e. the probability of two single photons taking the same path at a beamsplitter is higher than can be classically explained. This is known as HOM interference. To generate the required single photons, PDC is typically employed. Surprisingly, by superposition of different spectral modes, the reverse behavior can be induced: The photons are more likely to split up than classically predicted. We present the observation of the interaction of two spatial modes of an optical waveguide used for PDC in a HOM interference experiment leading to two-photon anti-bunching. We develop a theoretical model for this interaction and explore the feasibility of this tool to study the dispersion properties of the waveguide.

Q 61.8 Do 16:30 Poster C

Wignerfunktion zur Beschreibung der Riemann-Zeta-Funktion — •Cornelia Feiler, Rüdiger Mack und Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm

Das Wellenpaket mit dem Anfangszustand $|\psi\rangle = \sum_{n=1}^{\infty} \frac{1}{n^\sigma}|n\rangle$ befindet sich in einem Potential mit logarithmisch verteilten Eigenwerten zu den Eigenzuständen $|n\rangle$. Seine Zeitentwicklung wird durch eine der Wignerfunktion ähnliche Darstellung in Winkel- und Wirkungsvariablen beschrieben. Solche Wellenpakete können verwendet werden, um durch Autokorrelationsmessungen die Riemann-Zeta-Funktion zu beschreiben.

Q 61.9 Do 16:30 Poster C

Non-linear processes in pulse propagation through closed-loop systems — •Robert Fleischhaker and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

We discuss laser-driven atomic systems where the applied fields form a closed interaction loop. In general the properties of such closed-loop systems depend on the relative phase of the driving fields, which allows for a convenient manipulation of the optical properties. But on the other hand, these systems only reach a steady state in the long time limit, if the applied fields fulfill the so-called multiphoton resonance condition. If one of the laser fields is a pulsed probe field, then this condition is necessarily violated due to the finite frequency width of the probe pulse. To overcome this, recently the time-dependent properties of a four-level double-lambda type system have been investigated [1]. The time dependent solution to linear order in the probe field coupling has been found with the help of a Floquet decomposition. Using this formalism, here, we analyze non-linear effects in the probe field pulse propagation through closed-loop media. As an additional advantage of the Floquet decomposition, the various Floquet components can be interpreted as individual contributions to the medium response, thus providing insight into the physical origin of the results.

[1] M. Mahmoudi and J. Evers, Phys. Rev. A. in print (quant-ph/0609206)

Q 61.10 Do 16:30 Poster C

An ultracold gas of Rydberg atoms — •Janne Denskat, Christian Giese, Thomas Amthor, Markus Reetz-Lamour, and Matthias Weidemüller — Physikalisches Institut Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg

We report on the investigation of different interaction and excitation phenomena in ultracold Rydberg gases. With our setup we confine ^{87}Rb atoms in a magneto-optical trap and excite a part of the atomic cloud into Rydberg levels via a two-photon process (780 nm and 480 nm). We present experimental details and results of the latest works. These include coherent Rabi oscillations between ground and Rydberg state [1] and stimulated rapid adiabatic passage, transferring 90% of the gas into Rydberg states [2], ionization induced by van der Waals forces [3], the understanding of the coherent dynamics of resonant energy transfer processes [4] and the dipole blockade in a mesoscopic gas.

[1] M. Reetz-Lamour *et al.*, submitted
[2] J. Deiglmayr *et al.*, Opt. Comm. 264, 293 (2006)
[3] T. Amthor *et al.*, Phys. Rev. Lett., in press
[4] S. Westermann *et al.*, Eur. Phys. J. D 40, 37 (2006)

Q 61.11 Do 16:30 Poster C

Towards negative refraction in the optical frequency domain — •Peter P. Orth, Jörg Evers, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Materials with a negative index of refraction have received increasing interest over the last years [1] and a particular aim is to obtain negative refraction in the optical frequency range. As an alternative approach to metamaterials, recently, it was proposed to use dense atomic ensembles with a level structure that allows both for magnetic and electric response at the same frequency, as required for a negative index of refraction [2,3]. These systems nevertheless suffer from difficulties such as requiring extremely high densities and posing strict constraints on the level scheme. Here, we discuss negative refraction in extended atomic level schemes. Our aim is to gain better control over the medium response, and to relax the stringent conditions on the atomic structure.

[1] S. Linden und M. Wegener, Physik Journal **5**, 29 (2006).
[2] M. Ö. Oktel and Ö. E. Müstecapioglu, Phys. Rev. A **70**, 053806 (2004).
[3] Q. Thommen and P. Mandel, Phys. Rev. Lett. **96**, 053601 (2006).

Q 61.12 Do 16:30 Poster C

Geometry-dependence of dipole-dipole interaction — •Sandra Isabelle Schmid and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

If atoms are nearby on a length scale given by the involved transition wavelength, the collective dynamics is influenced by the dipole-dipole interaction between the atoms. Recently, it was found that in particular the dipole-dipole coupling of transitions with orthogonal dipole moments, which was neglected in most previous works, can crucially influence the system dynamics [1,2]. Here, we discuss the geometrical properties of this dipole-dipole interaction in atomic ensembles of experimental interest by considering various atom pair setups. We find that especially in lower-dimensional samples the dipole-dipole interaction of transitions with orthogonal dipole moments cannot be neglected.

[1] G. S. Agarwal and A. K. Patnaik, Phys. Rev. A 63, 043805 (2001).
[2] J. Evers, M. Kiffner, M. Macovei and C. H. Keitel, Phys. Rev. A 73, 023804 (2006)

Q 61.13 Do 16:30 Poster C

Stern-Gerlach experiment for slow light — •Leon Karpa[1,2] and Martin Weitz[1,2] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

Electromagnetically induced transparency allows for light transmission through dense atomic media by means of quantum interference of absorption amplitudes [1]. Media exhibiting electromagnetically induced transparency have interesting properties, such as very slow group velocities [2]. Associated with the slow light propagation are quasiparticles, so-called dark polaritons, which are mixtures of a photonic and an atomic contribution [3]. In contrast to the properties of a free photon, it can be demonstrated that these excitations behave as particles with a nonzero magnetic moment. We report on ongoing experiments in which circularly polarized light passing through a rubidium gas cell under EIT conditions is deflected by a small magnetic field gradient [4]. The deflection angle is proportional to the propagation time of an optical pulse through the cell. The observed beam deflection can be understood by assuming that dark state polaritons have an effective magnetic moment. Our experiment can be described in terms of a Stern-Gerlach experiment for the dark polaritons.

[1] See e.g.: E. Arimondo, Prog. Opt. **35**, 257 (1996)
[2] See e.g.: L. V. Hau et al. Nature (London) **397**, 594 (1999)
[3] M. Fleischhauer and M. D. Lukin, Phys. Rev. Lett. **84**, 5094 (2000)
[4] L. Karpa and M. Weitz, Nature Physics **2**, 332 (2006)

Q 61.14 Do 16:30 Poster C

Laser assisted dynamics of the electron pair in harmonium: photoexcitation, energy absorption, and transparency. — •Oleg Kidun and Dieter Bauer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

It is known that the dynamics of two (Coulomb-interacting) nonrelativistic electrons confined by a parabolic potential and driven by a classical, intense laser field (in dipole approximation) is exactly soluble. We calculate the time-dependent population of the harmonic oscillator two-electron states and the energy absorbed from the laser. It turns out that the key entity on which all observables sensitively depend is the modulus square of the Fourier-transformed vector potential of the laser field, evaluated at the harmonic oscillator frequency. The system is transparent to laser field configurations for which this entity vanishes. We discuss the Poisson statistics behavior of the transition probabilities and analyze the conditions for the complete survival and full depletion of the initial state.

Q 62: Poster Ultrakalte Atome

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 62.1 Do 16:30 Poster C

Simulations of multi-species ion crystals in an rf ion trap — •Chaobo Zhang, David Offenberg, Bernhard Roth, and Stephan Schiller — Universitätsstr.1, 25.42 01.36, D-40225 Düsseldorf

Molecular dynamics (MD) simulations are a powerful tool to investigate the properties of many-body systems. We have simulated heating and cooling processes for multi-species ion crystals confined in a linear rf ion trap, and have deduced ion numbers, ion temperatures, and crystal shapes. The trap modes of oscillation were studied which is essential to interpret experimental trap mode spectra. Rf micromotion was included in the simulations, and the results were compared to the pseudopotential case. We have shown that, in order to interpret the experimental results, the pseudopotential approach is sufficient. Furthermore, the coupling of the radial micromotion to the axial motion of the ions in an ideal rf trap and the heating rate of an rf phase offset on the middle electrodes were investigated.

Q 62.2 Do 16:30 Poster C

Objektiv großer numerischer Apertur zur Abbildung des Fluoreszenzlichts einzelner Ionen bei 369 nm — •Christian Schneider, Michael Johanning und Christof Wunderlich — Fachbereich Physik, Universität Siegen, 57068 Siegen

Elektrodynamisch gespeicherte $^{171}\mathrm{Yb}^{+}$-Ionen sind gut geeignet zur Verwendung als Frequenzstandard oder für die Quanten-Informationsverarbeitung, wobei zwei Hyperfeinzustände des elektronischen Grundzustands als quantenmechanisches Zwei-Niveau-System (qubit) dienen [1]. Der zustandsselektive Nachweis der Ionen erfolgt durch Streuung von Laserlicht mit einer Wellenlänge von 369,5 nm auf der optischen Resonanz $^2S_{1/2}, F = 1 \leftrightarrow {}^2P_{1/2}, F = 0$. Hierbei limitiert optisches Pumpen in den Zustand $^2S_{1/2}, F = 0$ die Intensität des zum Nachweis zur Verfügung stehenden Fluoreszenzlichts. Um eine hohe Nachweiseffizienz zu erhalten, wird deshalb ein Objektiv mit großer numerischer Apertur benötigt. Da mehrere gespeicherte Ionen typischerweise einen Abstand von wenigen Mikrometern aufweisen, benötigt man für deren individuellen Nachweis außerdem gute Abbildungseigenschaften, auch unter Einbeziehung des Fensters eines Vakuumrezipienten. Die Entwicklung und Charakterisierung eines (nahezu) beugungsbegrenzten Objektivs mit einer numerischen Apertur von 0,4 für den genannten Zweck wird vorgestellt.

[1] Chr. Balzer, A. Braun, T. Hannemann, Chr. Paape, M. Ettler, W. Neuhauser, and Chr. Wunderlich, Phys. Rev. A **73**, 041407 (R) 2006.

Q 62.3 Do 16:30 Poster C

Eine mikrostrukturierte Ionenfalle mit Magnetfeldgradienten von bis 10^3 T/m — •Delia Brüser, Michael Johanning und Christof Wunderlich — Fachbereich Physik, Universität Siegen, 57072 Siegen, Deutschland

Setzt man in einer linearen Falle gespeicherte und lasergekühlte Ionen einem Magnetfeldgradienten aus, ist es möglich, die Ionen im Frequenzraum einzeln zu adressieren [1]. Außerdem wird die Dynamik der internen Zustände der Ionen durch eine langreichweitige Spin-Spin-Kopplung bestimmt, deren Betrag proportional zum Quadrat des Magnetfeldgradienten ist [2]. Unser Ziel ist es, in einer mikrostrukturierten Paul-Falle (Mikrofalle) Gradienten von bis zu 1000 T/m zu erzeugen, um zum Einen eine große Niveauaufspaltung zu erhalten und so eine große Anzahl von Ionen adressieren zu können, und zum Andern große Kopplungskonstanten zu realisieren. Wir haben ein zur Mikrofalle kompatibles Design erarbeitet, welches diesen Gradienten erzeugen soll und vergleichen Ergebnisse der Simulation der magnetostatischen und thermodynamischen Eigenschaften dieses Designs mit Messergebnissen an Prototypen.

[1] F. Mintert, Chr. Wunderlich, Phys. Rev. Lett. **87**, 257904 (2001).
[2] Chr. Wunderlich, in *Laser Physics at the Limit* (Springer, Heidelberg, 2002), p. 261; auch quant-ph/0111158;

Q 62.4 Do 16:30 Poster C

A laser cooled Indium atomic beam for atomic nanofabrication — •Bernhard Klöter, Dietmar Haubrich, and Dieter Meschede — Institut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn

Laser cooled atomic beams are the method of choice for Atomic Nanofabrication (ANF) where high deposition rates are needed. We have realized 1D transverse cooling of a neutral Indium atomic beam with a Λ-type cooling scheme which involves five laser wavelengths at 410 nm and 451 nm. We present our systematic studies of these schemes concerning the role of external magnetic fields, interaction length and laser parameters such as polarisation and intensity.

Q 62.5 Do 16:30 Poster C

Atom guiding in photonic bandgap fibres — •Stefan Vorrath, Mirja Michels, Sören Götze, Kai Bongs, and Klaus Sengstock — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

In our project we investigate a new kind of atomic waveguide based on a 2D photonic band gap fibre providing nearly lossless guiding of light and atoms in the central hole of the fibre. The guiding mechanism is realized by capturing rubidium atoms from a MOT by means of a loading and a guiding red detuned dipole trap. To maximize the number of captured atoms from the MOT we have studied the loading process into the traps intensively. We will present the actual status of our project as well as future plans for experiments like atom cooling and atom interferometry.

Q 62.6 Do 16:30 Poster C

Calcium atoms in a dipole trap — •Chih-Yun Yang, Purbasha Halder, Oliver Appel, Dirk Hansen, and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Alkaline-earth metal atoms are interesting candidates for laser cooling due to their strong principal fluorescence lines. At the same time, narrow intercombination lines can be exploited for refined cooling schemes or in time metrology. Recently, we demonstrated magnetic trapping of metastable Ca atoms in a miniaturized Ioffe trap. However, reaching the quantum degenerate regime by evaporative cooling in this trap was made impossible by the unvavorable ratio between inelastic and elastic collisions [1].

Currently, efforts are under way to prepare an ensemble of cold ground state Ca atoms in an optical dipole trap at 532nm. Here, we present latest developments and the status of the experiment.

[1] Dirk Hansen, Andreas Hemmerich, Phys. Rev. Lett. 96, 073003

Q 62.7 Do 16:30 Poster C

Signalgenerator zur phasenkohärenten Frequenzumschaltung mit 500 MHz Bandbreite — •Cornelius Weiss, Thilo Hannemann und Christof Wunderlich — Fachbereich Physik, Universität Siegen, 57068 Siegen

Viele Experimente im Bereich der Quantenoptik, insbesondere solche im Bereich der Quanten-Informationsverarbeitung, erfordern die Erzeugung elektromagnetischer Signale zur kohärenten Zustandsmanipulation in N Quantensystemen. Zur Erhaltung der Phaseninformation der i. A. unterschiedlichen N Resonanzfrequenzen werden üblicherweise N Oszillatoren über einen Multiplexer *phasenkohärent* geschaltet, wodurch die Skalierbarkeit der Versuchsanordnung eingeschränkt wird. Wir stellen ein Gerät vor, welches mittels digitaldirekter Fre-

quensynthese und Seitenbandmodulation einen Frequenzbereich von 500 MHz durchstimmbar mit phasenkohärenter Frequenzumschaltung zugänglich macht. Hierbei verwenden wir einen FPGA zur Synthetisierung der Signale mit 50 mHz Frequenz- und 16 bit Phasenauflösung in einem Frequenzbereich von 0 bis 150 MHz. Der Einsatz eines *Single-Sideband*-Mixers in Kombination mit einer Frequenzdekade erlaubt die kostengünstige Vervielfachung des Frequenzbereiches.

Q 62.8 Do 16:30 Poster C

Charakterisierung einer segmentierten Ionenfalle mit kalten Ionenkristallen — •T. Deuschle, G. Huber, W. Schnitzler, R. Reichle, K. Singer und F. Schmidt-Kaler — Institut für Quanteninformationsverarbeitung, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm

Segmentierte lineare Paulfallen stellen einen vielversprechenden Kandidaten für skalierbare Quantencomputer mit Ionen dar. Wir stellen eine Paulfalle mit 15 Segmenten vor, deren Struktur sich in einen weiten Lade- und einen engen Speicherbereich unterteilt. Einzelne lasergekühlte $^{40}Ca^{+}$-Ionen und Ionenketten werden gefangen, mit Laserlicht bei 397nm und 866nm gekühlt und über die emittierte Fluoreszenz beobachtet. Durch Veränderung der Spannungen an den Segmenten [1] können die Ionen zwischen verschiedenen Segmenten transportiert werden. Die Messungen der Ionenabstände [2] und Schwingungsfrequenzen [3,4] werden benutzt, um die Fallenpotentiale zu bestimmen. Wir vergleichen experimentell extrahierte Daten mit Simulationen und berichten über den Stand aktueller Experimente.

[1] S. Schulz et al., Fortschr. Physik **54**, 648 (2006)
[2] H. C. Nägerl et al., Appl. Phys. **B 66**, 603 (1998)
[3] H. C. Nägerl et al., Optics Express **3**, 89 (1998)
[4] M. Drewsen et al., Phys. Rev. Lett. **93**, 243201 (2004)

Q 62.9 Do 16:30 Poster C

magnetischer Transport von Rubidiumatomen — •Matthias Wolke, Malik Lindholdt, Julian Klinner und Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Aus einer 3D-MOT werden kalte Rubidiumatome mit Hilfe eines MOT- und eines Transferspulenpaares, welche sich innerhalb der Vakuumkammer befinden, in eine 28mm entfernte QUIC-Falle transportiert. Mit Hilfe numerischer Verfahren wurden Stromwerte so ermittelt, dass sich die resultierende Magnetfallengeometrie während des Transportes minimal ändert. Zusätzlich ist über ein klassisches Modell der Transport numerisch simuliert worden. Ergebnisse dieser Simulation führten zu einer weiteren Optimierung des Transportes und lieferten Einblicke in die Dynamik der Atome während der erzwungenen Bewegung.

Q 62.10 Do 16:30 Poster C

cavity cooling — •Malik Lindholdt, Julian Klinner, Matthias Wolke, and Andreas Hemmerich — Institut für Laserphysik,Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

We presently prepare a new experimental apparatus, which permits to trap a Bose-Einstein Condensate of rubidium atoms inside an optical cavity with 400.000 finesse and a large mode volume. The cavity will display a ratio between the scattering rate into the cavity mode and into all other modes well above 10 and a narrow bandwidth of a few kHz. We plan to explore cavity induced cooling mechanisms in the transition regime between thermal and quantum degenerate atomic dynamics. The poster will present the status of our experiments.

Q 62.11 Do 16:30 Poster C

A combined trap for Rb and Yb atoms — •Sven Kroboth, Nils Nemitz, Florian Baumer, Claudia Höhl, and Axel Görlitz — Institut für Experimentalphysik, Universität Düsseldorf

On this poster, we report on technical aspects of the trap used for our experiments on mixtures of ultracold Ytterbium (Yb) and Rubidium (Rb) atoms.

The different magnetic and electronic properties allow for a combined trap in which the two species can be manipulated independently. The trap consists of a Ioffe-Pritchard-type magnetic trap (MT) for Rb and a bichromatic optical dipole trap (ODT) for Yb employing two copropagating laser beams with wavelengths of 1064 nm and 532 nm and beam waists of 15 μm. By choosing the proper laser power ratio the effect of the light field on Rb can be cancelled to first order. To ensure the spatial overlap of the two ODT trapping beams with the required accuracy better than 1 μm, their positions have to be actively stabilized. To suppress losses during the preparation process the MT and the ODT are initially separated by 700 μm and are loaded consecutively from corresponding MOTs.

With this novel type of combined trap and by means of evaporative and sympathetic cooling, we have successfully prepared a mixture of about 3×10^6 ^{87}Rb and 2×10^5 ^{174}Yb atoms at a temperature of 20 μK.

Q 62.12 Do 16:30 Poster C

Kühlen und Fangen von neutralen Quecksilberatomen — •Patrick Villwock, Mathias Sinther und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schloßgartenstraße 7, 64289 Darmstadt

Die Erzeugung translatorisch oder vibratorisch kalter Moleküle ist bereits möglich. Kalte Quecksilberatome in einer magneto-optischen Falle bieten die Möglichkeit der Erzeugung translatorisch kalter Moleküle durch Photoassoziation, sowie deren Laserkühlung in den vibratorischen Grundzustand. Zusätzlich erlaubt es die Untersuchung eines neuen Zeitstandards. Quecksilber hat stabile bosonische und fermionische Isotope, deren natürliche Häufigkeit im zweistelligen Prozentbereich liegen. In einer UHV-Kammer lässt sich mit einer Einstrahl-MOT ein gekühlter Atomstrahl erzeugen, der durch eine differentielle Pumpstufe hindurch in eine magneto-optische Falle gelangt. Der verwendete Kühlübergang liegt bei einer Wellenlänge von 253,652nm. Um diese Wellenlänge zu erlangen verwenden wir einen Scheibenlaser bei 1014,608nm. Die Frequenzstabilisierung ermöglicht einen modensprungfreien Betrieb bis zu 3 Stunden. Durch zwei Frequenzverdopplungsstufen ist die gewünschte Frequenz erreichbar. Es wird der derzeitige Fortschritt der experimentellen Realisierung einer Atomfalle für Quecksilber vorgestellt.

Q 62.13 Do 16:30 Poster C

Kryogenische planare Penningfallen für einen Quantenprozessor mit Elektronen — •M. Hellwig[1,2], P. Bushev[1,3], G. Marx[2] und F. Schmidt-Kaler[1] — [1]Institut für Quanteninformationsverarbeitung, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm — [2]Institut für Physik, Universität Greifswald, Domstrasse 10a, 17487 Greifswald — [3]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz

Eine zweidimensionale Anordnung untereinander verbundener, kryogenisch gekühlter planarer Penningfallen soll für einen skalierbaren Quantenprozessor genutzt werden [1]. Der Spin einzelner Elektronen dient dabei zum Speichern von Quanteninformation.

Wir stellen das Herzstück des Experiments, die planaren mikrostrukurierten Fallenarrays vor: (i) Eine aus konzentrischen Ringen aufgebaute Einzelelektronenfalle bei der der vertikale Abstand des Elektrons über einer Oberfläche variiert werden kann. (ii) Eine Struktur aus hexagonalen Elektroden bei der unterschiedlichen Fallen-Formen frei realisiert werden können und eine laterale Verschiebung des Elektrons untersucht werden soll. (iii) Ein Array aus bis zu 9 miteinander elektrisch verbundenen Einzelelektronen-Fallen bei dem die Kopplung der Quantenbits untersucht werden soll. Numerische Simulationen der Fallenpotentiale und der Stand des Experiments werden vorgestellt.

[1] S. Stahl et. al., Eur. Phys. J. **D 32**, 139 (2005)

Q 62.14 Do 16:30 Poster C

A Rod in the MOT – Influence of an Ultra-Thin Optical Fiber on a Cold Atom Cloud — •Eugen Vetsch[1,2], Guillem Sagué[1,2], Wolfgang Alt[1], Dieter Meschede[1], and Arno Rauschenbeutel[1,2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz

We inserted a sub-wavelength diameter optical fiber into a standard magneto-optical trap (MOT), in order to couple cold Caesium atoms to the guided mode of this ultra-thin fiber. The atoms are probed with a laser launched through the fiber while temporarily switching off all MOT laser beams. The presence of the fiber has no significant influence on the global shape or size of the MOT. In the immediate vicinity of the fiber surface, the density of the freely expanding cloud of cold atoms is however strongly modified through light-induced dipole forces and the van der Waals force. The predictions of a numerical model taking into account these forces are in excellent agreement with our experimental observations.

We acknowledge financial support by the DFG research unit 557.

Q 62.15 Do 16:30 Poster C

Aufbau einer kompakten Apparatur für Bose-Kondensation — •Kai Könecke, Matthias Ölschläger, Marcus Gildemeister, Georg Wirth und Andreas Hemmerich — Universität Hamburg, ILP, Luruper Chaussee 149, 22761 Hamburg

Wir konstruieren eine kompakte UHV-Apparatur zur Erzeugung eines optisch gut zugänglichen Bose-Kondensats.

Als Quelle für kalte Atome dient eine erste mit Hilfe von Rubidium-Dispensern geladene MOT. Über eine differenzielle Pumpstrecke werden die Atome in eine zweite MOT innerhalb einer Glasküvette befördert. Von hier werden die kalten Atome über mehrere Zentimeter magnetisch in eine miniaturisierte Ioffe-Falle (QUIC-Falle) transportiert, die sich in einem schmalen Appendix der Küvette befindet.

Das kompakte Design ermöglicht hohe Magnetfeldgradienten bei geringer Wärmeentwicklung und gleichzeitig hervorragenden optischen Zugang für zukünftige Experimente. Unser Poster zeigt den derzeitigen Entwicklungsstand sowie erste Zwischenergebnisse.

Q 62.16 Do 16:30 Poster C

Magnetic coupling of a BEC to a nanomechanical resonator — •David Hunger[1,2], Stephan Camerer[1,2], Daniel König[1], Jörg Kotthaus[1], Jakob Reichel[3], Theodor Hänsch[1,2], and Philipp Treutlein[1,2] — [1]LMU, München, Germany — [2]MPQ, Garching, Germany — [3]Laboratoire Kastler-Brossel de l'ENS, Paris, France

The experimental fusion of quantum optics and condensed-matter systems is a new, promising research field. Atomchip experiments seem particularly suitable to match the challenges of this convergence due to their high degree of control over atoms close to surfaces. A first milestone is to show that a designed, controllable interaction between small atom clouds and nano-structured solid state systems can be realized.

We introduce our experiment, which aims at coupling the thermal oscillations of a nanomechanical beam resonator to the spin of a nearby Bose-Einstein condensate via a magnetic interaction. The coupling is mediated by a small island of ferromagnetic material on the cantilever. In this way, the resonator motion causes an oscillating magnetic field that can drive atomic spin-flip transitions. If the eigenfrequency of the beam is resonant with transitions to untrapped magnetic sublevels, observable trap loss occurs. A detailed simulation of the system we are implementing yields a displacement sensitivity of $\sim 5 \cdot 10^{-14}\mathrm{m}/\sqrt{\mathrm{Hz}}$, close to the quantum limit of the oscillator[1] and shows that signatures of coherent coupling dynamics can be observable. As outlook we consider a regime, where the backaction of the atoms on the resonator can lead to significant cooling of the mechanical mode.

[1] M. LaHaye et al, Science 304, 74 (2004)

Q 62.17 Do 16:30 Poster C

A setup for experiments with microwaves on atom chips — Pascal Böhi[1], •Johannes Hoffrogge[1], Theodor Hänsch[1], Jakob Reichel[2], and Philipp Treutlein[1] — [1]Max-Planck-Institut für Quantenoptik and Ludwig-Maximilians-Universität, München, Germany — [2]Laboratoire Kastler Brossel de l'E.N.S, Paris, France

We present our new setup for experiments with microwave near-fields on atom chips. Microwave near-fields are a key ingredient for atom chip applications such as quantum information processing, entanglement of Bose-Einstein condensates, atom interferometry, and chip-based atomic clocks [1,2].

On our atom chip, carefully designed gold structures allow to combine microwave signals and stationary currents in the same wires. We characterize the miniaturized microwave guiding structures on our chip, which were fabricated using a newly developed process for chips with multiple layers of metallization. For the stationary currents, we have developed fast yet very stable current sources. We give an overview over our setup and report the latest progress of our experiment.

[1] P. Treutlein *et al.*, Phys. Rev. Lett. **92**, 203005 (2004).
[2] P. Treutlein *et al.*, Phys. Rev. A **74**, 022312 (2006).

Q 62.18 Do 16:30 Poster C

Deterministic strong coupling of a controlled number of trapped atoms to the mode of a high finesse optical resonator — •Sebastian Reick, Wolfgang Alt, Igor Dotsenko, Mkrtych Khudaverdyan, Dieter Meschede, Ariane Stiebeiner, and Arno Rauschenbeutel — Institut für Angewandte Physik, Wegelerstr. 8, D-53115 Bonn

Cavity QED experiments provide unique possibilities for studying atom-photon interactions at a fundamental level. In our experiment we explore the coupling of a a small number of neutral caesium atoms to the mode of a high-finesse optical cavity in a controlled and deterministic way.

Using a number-triggered loading process we transfer a predetermined number of atoms, ranging from one single atom to several atoms, from a MOT into a standing wave dipole trap. Subsequently, the atoms are transported into the center of the cavity mode with sub-micrometer precision.

The atoms are coupled to the field of a probe laser beam, which is resonant with the empty cavity (finesse $F \approx 10^6$), thereby shifting the cavity out of resonance. The time-dependent transmission of the probe laser light is detected, which allows us to infer information about the dynamics of the atom-cavity system.

A single atom coupled to the cavity mode can be observed for several seconds, indicating cavity-assisted cooling.

Q 62.19 Do 16:30 Poster C

Quantum Transport of Single Neutral Atoms — •Leonid Förster[1], Wolfgang Alt[1], Daniel Döring[1], Arne Härter[1], Michal Karski[1], Arno Rauschenbeutel[2], and Dieter Meschede[1] — [1]Institut für Angewandte Physik, Wegelerstraße 8, 53115 Bonn — [2]Institut für Physik, Staudingerweg 7, 55128 Mainz

The state-dependent (quantum) transport [1] of neutral atoms stored in a one dimensional optical lattice is a promising technique to implement controlled interactions between them using coherent cold collisions [2]. This is required in several schemes of quantum information processing. Here, we focus on the technical implementation of the quantum transport for single Caesium atoms, as well as the manipulation and detection of their internal states.

Multiple quantum transport steps in combination with microwave-operations on the internal state of an atom promise to implement various one dimensional quantum walks [3]. Using the quantum transport with two or more atoms we plan to investigate atom-atom interactions by overlapping their wave-functions within a predetermined lattice site.

We acknowledge financial support from the EC (IP SCALA) and from the DFG (FG 635).

[1] O. Mandel, PRL 91, 010407 (2003) [2] D. Jaksch, PRL 82, 1975 (1999) [3] W. Dür, PRA 66, 052319 (2002)

Q 63: Poster Ultrakalte Moleküle

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 63.1 Do 16:30 Poster C

Forming Ultracold Polar Molecules in the Rovibrational Ground State — •Christian Glück, Jörg Lange, Johannes Deiglmayr, Stephan Kraft, Leif Vogel, Benjamin Müller, Christian Giese, Peter Staanum, Roland Wester, and Matthias Weidemüller — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

Recently, the spontaneous formation of ultracold LiCs molecules in a double MOT was observed for the first time in our group [1]. LiCs possesses the strongest permanent electric dipole moment of all alkali dimers and is therefore a promising candidate to study an ultracold gas with strong externally tunable interactions.

Here we present the formation of ultracold LiCs ground state molecules by active photoassociation, leading to a strongly increased production rate. In order to transfer the molecules in the rovibrational ground state we have developed a Raman-type relaxation scheme using potential curves from new high resolution sprectroscopy of LiCs [2]. Furthermore, we present experimental details which focus on the locking scheme of the photoassociation laser and an enhanced setup for storing the molecules in a crossed dipole trap.

[1] S. D. Kraft *et al.*, J. Phys. B **39**, S 993 (2006)
[2] P. Staanum *et al.*, arXiv/physics/0612031

Q 63.2 Do 16:30 Poster C

Formation of Ground State Strontium Molecules with Optical Feshbach Resonances — •Ruzin Aganoglu[1], Philippe Pellegrini[2], Robin Côté[2], and Christiane Koch[1] — [1]Freie Universität Berlin, Institut für Theoretische Physik, Arnimallee 14, 14195 Berlin — [2]University of Connecticut, Dept. of Physics, 2152 Hillside Road, Storrs, CT 06269-3046, USA

Ultracold earth alkali atoms are attracting interest in both experiment and theory because of the many exciting perspectives they offer from optical frequency clocks and high resolution spectroscopy to the manipulation of ultracold molecules. In the alkali species, magnetic Feshbach resonances proved to be the most efficient way to form molecules in their electronic ground state. Since even isotopes of the earth alkalis possess no hyperfine structure in their ground state, this route to ground state molecules is not available. Photoassociation of e.g. strontium atoms was successfully employed to create short lived excited state molecules.The formation of ultracold ground state earth alkali molecules has not yet been reported.

Optical Feshbach resonances may provide an alternative way to form molecules in their ground state, provided the atoms are kept in a tight trap such as an optical lattice. We study here the formation of Sr2 ground state molecules by employing an optical Feshbach resonance. We investigate the feasibility of this scheme as a function of the experimental control parameters laser intensity, detuning and trap frequency.

Q 63.3 Do 16:30 Poster C

Formation, Control and Spectroscopy of Cesium Feshbach Molecules — •Michael Mark[1], Francesca Ferlaino[1], Steven Knoop[1], Johann Georg Danzl[1], Harald Schöbel[1], Tobias Kraemer[1], Hanns-Christoph Nägerl[1], and Rudi Grimm[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria

We present our work on magnetic control of ultracold Cesium Feshbach molecules in an optical dipole trap. Starting with an ultracold Cs gas at 250 nK we create samples of ultracold trapped d- and g-wave molecules on various Feshbach resonances. After the initial formation we transfer the samples into other dimer states by adiabatically following or nonadiabatically jumping avoided crossings between intersecting molecular states. By this method we have complete control over the quantum state of the sample and we can populate all dimer states with s-, d-, g- and l-wave character up to binding energies of 10 MHz and magnetic fields up to 55 G [1]. In particular we show that molecular states with high relative angular momentum l=8 can be addressed for which direct Feshbach association is not feasible as a result of negligible coupling with the s-wave atomic threshold. To map out the molecular state structure we perform magnetic moment spectroscopy. From the avoided crossing we can determine the coupling strength between the different molecular states. In addition we use precise microwave spectroscopy to investigate the universal character of a weakly bound s-wave state. [1] M. Mark et al, submitted to PRA (2007)

Q 63.4 Do 16:30 Poster C

Coherent optical transfer of Feshbach molecules to a lower vibrational state — Klaus Winkler[1], •Florian Lang[1], Gregor Thalhammer[1], Peter van der Straten[2], Rudolf Grimm[1,3], and Johannes Hecker Denschlag[1] — [1]Institut für Experimentalphysik, Universität Innsbruck, Österreich — [2]Debye Institute, Universiteit Utrecht, Netherlands — [3]Institut für Quantenoptik und Quanteninformation, Innsbruck, Österreich

We have recently[1] demonstrated the realization of an efficient and highly selective transfer scheme, where an ensemble of $^{87}Rb_2$ Feshbach molecules in an optical lattice is coherently converted to a deeper bound molecular state via stimulated Raman adiabatic passage (STIRAP). In this experiment we reach a single transfer efficiency of 87% and a coherence time of 2ms. The experimental data is well described by our theoretical model without free parameters. The presented scheme can be extended in a straight forward manner for the transfer of ultracold molecules into the absolute vibrational ground state.

[1] cond-mat/0611222, accepted for publication in PRL (2007)

Q 63.5 Do 16:30 Poster C

UV photodissociation studies of polyatomic molecular ions at milli-Kelvin temperatures — •David Offenberg, Chaobo Zhang, Bernhard Roth, and Stephan Schiller — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

Photodissociation spectroscopy is a commonly used tool to investigate molecular properties. The spectral resolution can be enhanced by reducing the molecules' thermal energy [1], as recently demonstrated on $diatomic$ molecular ions [2]. Here, we present our initial advances towards photodissociation spectroscopy of $polyatomic$ molecules.

As a first model system we use translationally cooled, singly protonated molecules of Glycyrrhetinic Acid (GA) $-$ a biomolecule of mass 471 amu consisting of 80 atoms. In our apparatus, the molecular ions are generated by an electrospray ionization source, transferred to and stored in a radio-frequency trap together with laser-cooled barium ions. Due to their Coulomb interaction with the atomic coolant, they cool down from ambient temperature to the hundred milli-Kelvin range and can be kept and investigated under these low-temperature and nearly collisionless conditions for more than one hour [3]. We have measured the photodissociation rate of GA ions using a single-frequency cw-laser at 266 nm. In further studies we plan to investigate the feasibility of resonance enhanced two-photon dissociation with additional tunable IR lasers.

[1] O. Boyarkin et al., J. Am. Chem. Soc. 128, 2816 $-$ 2817 (2006)
[2] B. Roth et al., Phys. Rev. A 74, 040501(R) (2006)
[3] A. Ostendorf et al., Phys. Rev. Lett. 97, 243005 (2006)

Q 63.6 Do 16:30 Poster C

Creation of an ultracold heteronuclear mixture of fermionic lithium and potassium — •Andreas Trenkwalder[1,2], Gabriel Kerner[1], Devang Naik[1], Eric Wille[1,2], Frederik Spiegelhalder[1], Clarice Aiello[1,2], Raquel Chulia-Jordan[1], Gerhard Hendl[1], Florian Schreck[1], and Rudolf Grimm[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Institut für Experimentalphysik, Innsbruck, Austria

Studies of ultracold heteronuclear mixtures of fermionic atoms in the BEC-BCS crossover regime will give new insights into many-body physics. Therefore, we have constructed a new experiment to investigate mixtures of the three fermionic species ^{6}Li, ^{40}K and ^{87}Sr. We have already trapped various combinations of fermionic and bosonic isotopes in our multi-species MOT. We have loaded a ^{6}Li-^{40}K mixture into a crossed-beam optical dipole trap realized with a 100 W near-infrared fiber laser. Close to the 834 G Feshbach resonance of ^{6}Li, we have performed evaporative cooling and recently achieved our first $^6Li_2$ molecular BEC. Under the same conditions we observe efficient sympathetic cooling of ^{40}K by ^{6}Li. Currently we are investigating heteronuclear interactions. In this poster we present a brief overview of our experiment and our latest results.

Q 63.7 Do 16:30 Poster C

Femtosecond Pump-Probe Experiments on Ultracold Molecules — •Terence Mullins[1], Wenzel Salzmann[1], Judith Eng[1], Magnus Albert[1], Roland Wester[1], Matthias Weidemüller[1], Andrea Merli[2], Steffan Weber[2], Franziska Sauer[2], Mateusz Plewicki[2], Fabian Weise[2], Ludger Wöste[2], and Albrecht Lindinger[2] — [1]Universität Freiburg, Hermann Herder Str.3, D-79104 Freiburg i. Br., Germany — [2]Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

We present details of femtosecond pump-probe experiments on ultracold Rb atoms. The atoms are trapped in a high density dark magneto-optical trap (MOT) [1] (10^{11}cm^{-3}). MOT light photoassociated ground state molecules and colliding atom pairs are excited to bound molecular states with a femtosecond pump pulse, centered 75cm^{-1} red of the D1 atomic transition. After a defined delay, which may be adjusted with respect to the pump pulse, the molecules are ionized with a femtosecond probe pulse. A quadrupole mass spectrometer selects Rb_2^+ molecular ions. An increased ion signal, along with wavepacket oscillations, is observed when the pump pulse precedes the probe pulse. Propagation timescales suggest a two-photon transition to 5s5d states, consistent with the measured non-linear pump power dependence. The experimental requirements for pump-dump formation of ground state molecules [2,3] is discussed.

[1] C.G. Townsend *et al.*, Phys. Rev. A, **53**, 1702, 1996.
[2] C.P. Koch *et al.*, Phys. Rev. A, **73**, 043409, 2006.
[3] U. Poschinger *et al.*, J. Phys. B, **39**, 1001 2006.

Q 63.8 Do 16:30 Poster C

The Efimov Molecule: Is the Efimov effect really incomprehensible? — •Bettina Berg[1], Misha Ivanov[2], Lev Plimak[1], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany — [2]NRC Canada, 100 Sussex Drive,

Ottawa, Ontario K1A 0R6, Canada

We investigate the so-called Efimov molecule, formed by two heavy and one light particle interacting via short-range potentials between the light particle and the heavy ones. Applying what we call "Quantum Chemistry 101"in the Born-Oppenheimer limit for the square-well model of the "light-heavy"potential, we obtain the molecular term with the characteristic $\sim 1/R^2$ behaviour of the Efimov potential. This derivation is physically straightforward, making the Efimov molecule arguably the simplest possible example of a three-body system exhibitig the Efimov effect. We also present an equation generalising this result to an arbitrary "light-heavy"potential.

Q 64: Poster Quantengase

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 64.1 Do 16:30 Poster C

A BEC Setup for Rydberg Excitation — •Björn Butscher, Rolf Heidemann, Vera Bendkowsky, Ulrich Raitzsch, Helmar Bender, Robert Löw, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut,

We present our versatile experimental setup which allows us to excite Rubidium atoms to Rydberg states in thermal clouds as well as in Bose-Einstein condesates produced in a Ioffe-Pritchard-type magnetic trap. The setup is equipped with additional tools to control the internal and external atomic degrees of freedom in a large parameter space.

For the two photon excitation into Rydberg state we employ a diode laser setup which is stabilized to a combined two photon linewidth below 1.5 MHz. Besides a radio frequency setup to perform evaporative cooling, we use an ultra stable microwave source at 6.8 GHz for cooling purposes as well as to control the atomic density distribution. Additionally, we installed eight electric field-plates inside the vacuum chamber close to the trapped atoms, allowing to apply complex electric field distributions to the atoms. This can be utilized to generate spatially dependent Stark shifts or to field ionize Rydberg atoms state selectively. The emerging ions and electrons can be detected simultaneously by two micro-channel plates.

We also present our experimental results on collective coherent Rydberg excitation in a thermal cloud as well as first measurements on Rydberg excitation in a BEC.

Q 64.2 Do 16:30 Poster C

All roads lead to Rome – even for trapped quasi-1D bosons — •Michael Eckart, Reinhold Walser, and Wolfgang Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

In this contribution we use an extended mean-field theory to calculate the correlation functions up to third order of a homogeneous as well as a trapped quasi-1D gas of bosons at zero and finite temperature. The relevance of our results arises from the fact that experiments in quasi-1D geometries are presently conducted [1, 2, 3] and the theoretical analysis of the transition from the weakly correlated Gross-Pitaevskii regime to the strongly correlated Tonks-Girardeau regime is pursued by many groups [4, 5].

With our results we are also able to study the limits of an extended mean-field theory and give a clear indication where it has to be replaced by a different approach. In addition to this we also present a comparison of our full extended mean-field theory with an exact as well as an approximate solution in the homogeneous case and numerical results for the exact behavior of few-boson systems in a trapped quasi-1D geometry [6].

[1] M. Greiner *et al.*, Nature **415**, 39 (2002)
[2] D. Hellweg *et al.*, Phys. Rev. Lett. **91**, 010406 (2003)
[3] T. Kinoshita *et al.*, Phys. Rev. Lett. **95**, 190406 (2005)
[4] K.V. Kheruntsyan *et al.*, Phys. Rev. A **71**, 053615 (2005)
[5] G.E. Astrakharchik *et al.*, J. Phys. B **39**, S1 (2006)
[6] S. Zöllner *et al.*, Phys. Rev. A **74**, 053612 (2006)

Q 64.3 Do 16:30 Poster C

Nonequilibrium dynamics of an ultracold lattice Bose gas — •Thomas Gasenzer[1] and Kristan Temme[1,2] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]School of Physics & Astronomy, University of Leeds, Leeds LS2 9JT, United Kingdom

The dynamical evolution of a Bose-Einstein condensate trapped in a one-dimensional lattice potential is investigated theoretically in the framework of the Bose-Hubbard model. The emphasis is set on the far-from-equilibrium evolution in a case where the gas is strongly interacting. This is realized by an appropriate choice of the parameters in the Hamiltonian, and by starting with an initial state, where one lattice well contains a Bose-Einstein condensate while all other wells are empty. Oscillations of the condensate as well as non-condensate fractions of the gas between the different sites of the lattice are found to be damped as a consequence of the collisional interactions between the atoms. Functional integral techniques involving self-consistently determined mean fields as well as two-point correlation functions are used to derive the two-particle-irreducible (2PI) effective action. The action is expanded in inverse powers of the number of field components $\mathcal{N}$, and the dynamic equations are derived from it to next-to-leading order in this expansion. This approach reaches considerably beyond the Hartree-Fock-Bogoliubov mean-field theory, and its results are compared to the exact quantum dynamics obtained from the solution of the Schrödinger equation for small atom numbers.

Q 64.4 Do 16:30 Poster C

Measurements of scattering lengths in ultracold lithium rubidium mixtures — •Benjamin Deh, Carsten Marzok, Philippe W. Courteille, and Claus Zimmermann — Physikalisches Institut, Universität Tübingen, Auf der Morgenstelle 14, D-72076

The physics of ultracold mixtures has received enormous interest in recent times. Fascinating experiments, such as simulation of a solid state like system and the formation of ultracold dimers are conceivable. The mixture of lithium and rubidium is especially interesting due to its high mass difference. We cooled both the Fermi–Bose mixture, ^{6}Li and ^{87}Rb, and the bose–bose mixture, ^{7}Li and ^{87}Rb, to ultracold temperatures. Furthermore, we were able to measure the triplet scattering lengths of these systems. The current status of the experiment will be described.

Q 64.5 Do 16:30 Poster C

A Platform for Experiments with Multiple-Species Mixtures of Quantum-Degenerate Gases — •Matthias Taglieber, Arne-Christian Voigt, Wolfgang Wieser, Christoph Eigenwillig, Takatoshi Aoki, Theodor W. Hänsch, and Kai Dieckmann — MPI for Quantum Optics, Hans-Kopfermann-Str. 1, D-85748 Garching and LMU Munich, Schellingstr. 4/III, D-80799 Munich

Spin mixtures of quantum-degenerate fermionic gases exhibit long lifetimes in the strongly-interacting regime near a Feshbach resonance. This has opened the door for numerous key experiments like the creation of Fermi-Fermi molecules, the realization of molecular BEC, and the observation of a pairing gap and of superfluidity in a fermionic gas in the BEC-BCS cross-over region near a Feshbach resonance.

We have set up an apparatus for the generation of a two-species mixture of quantum-degenerate Fermi gases. This additional degree of freedom bears the prospect for the realization of superfluid phases with inhomogeneous order parameter, of long-range pairing due to an induced attractive interaction, and of stable, dipolar Fermi-Fermi molecules. Our production scheme for quantum-degenerate fermionic ^6Li and ^{40}K and bosonic ^{87}Rb gases is based on loading of a multiple-species magneto-optical trap with lithium from a Zeeman slower and potassium and rubidium from vapor dispensers. The atoms are then magnetically trapped and transferred from the MOT chamber to a UHV chamber, where the fermions are sympathetically cooled by rubidium. We present details of our setup and show the latest experimental results.

Q 64.6 Do 16:30 Poster C

Towards ultracold quantum gas mixtures of Rb and Cs atoms — •Andrea Prantner[1], Almar Dankmar Lange[1], Karl Pilch[1], Hanns-Christoph Nägerl[1], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wis-

senschaften, Innsbruck, Austria

We report on our experimental effort to produce heteronuclear mixtures of Rb and Cs atoms for the realization of double-species condensates and for the formation of ultracold heteronuclear molecules. The central part of our experimental setup is a glass cell which provides optimum optical access and allows rapid magnetic field switching. We have implemented a double-species Zeeman slower to simultaneously trap Rb and Cs in a magneto-optical trap. Currently we are implementing a high-power crossed beam dipole trap in order to search for interspecies Feshbach resonances and by this to determine the interspecies collision properties. Our next step will then be to produce a double condensate and to investigate double-condensate dynamics. A double condensate is also a good starting point for efficient formation of RbCs Feshbach molecules followed by the creation of an ultracold ensemble of molecules in the ro-vibrational ground state.

Q 64.7 Do 16:30 Poster C

Precision measurements of collective oscillations in the BEC-BCS crossover regime — •Alexander Altmeyer[1], Stefan Riedl[1,2], Christoph Kohstall[1], Matthew J. Wright[1], Edmundo R. Sanchez[1], Johannes Hecker Denschlag[1], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften

Experiments with ultracold fermionic atoms in the vicinity of a magnetic Feshbach resonance recently entered the crossover regime between Bose-Einstein condensation (BEC) and Bardeen-Cooper-Schrieffer superfluidity (BCS). The long lifetime of pairs of two fermionic atoms makes such a system ideal for experimental studies. We present precision experiments of collective oscillations and provide detailed quantitative insights into this BEC-BCS crossover regime[1]. At any point in the crossover regime the equation of state and the density dependence of the chemical potential of the system can be determined by measuring the normalized frequencies of compression modes. Our measurements are in agreement with a quantum Monte Carlo simulation including hydrodynamic theory in the local density approximation and rule out simple mean-field BCS approaches.

[1] A.Altmeyer *et. al.*, arXiv.org/abs/cond-mat/0611285, 2006, accepted for publication in PRL.

Q 64.8 Do 16:30 Poster C

Perturbative corrections to the numerical truncated Wigner representation — •Bettina Berg, Lev Plimak, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We investigate perturbative corrections to the truncated Wigner representation for nonlinear bosons interacting via a quartic potential. Our scheme includes the third-order-noise correction to the "Langevin"equation in the phase space. Unlike the method developed recently by Polkovnikov [1], our approach allows for corrections to multi-time averages, giving access to spectra and similar characteristics of the quantum system. We present the results for the nonlinear oscillator and for two nonlinear oscillators coupled by a Josephson junction.

[1] Anatoli Polkovnikov, *Quantum corrections to the dynamics of interacting bosons: Beyond the truncated Wigner approximation*, Phys. Rev. A 68, 053604 (2003).

Q 64.9 Do 16:30 Poster C

Bloch-Oscillations of Atoms in Optical Multi-Photon Lattices — Tobias Salger[1], •Sebastian Kling[1], Carsten Geckeler[1,2], Gunnar Ritt[2], and Martin Weitz[1,2] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

We report on experiments studying quantum transport of atoms in periodic potentials of variable spatial periodicity. Besides ordinary standing wave lattices with $\lambda/2$ spatial periodicity, we studied four-photon lattices with $\lambda/4$ spatial periodicity. Such multiphoton lattices are realized using the dispersion of higher order Raman transitions. The spatial structure of both lattices can be investigated by diffraction of an atomic Bose-Einstein condensate off the periodic potential. In subsequent experiments, we studied Bloch oscillation in accelerated $\lambda/2$ and $\lambda/4$ spatial periodic lattices. The Bloch oscillation frequency is directly related to the spatial periodicity of the corresponding lattice potential. Of special interest were determinations of the effective atom mass, which at comparable lattice depth for the multiphoton-lattice near the band edge reaches its smallest absolute values.

Q 64.10 Do 16:30 Poster C

Generation and investigation of filled solitons in spinor BEC — •Simon Stellmer, Jochen Kronjäger, Christoph Becker, Parvis Soltan-Panahi, Kai Bongs, and Klaus Sengstock — Institut für Laserphysik, Uni Hamburg, Germany

We discuss a scheme to generate filled solitons in a multi-component BEC. Phase-imprinting on one component and a simultaneous transfer between hyperfine-states using a Raman-laser system creates so-called filled solitons. This will be achieved by the use of two spatial light modulators (SLM). We present several options for the manipulation of quantum gases by nearly arbitrary light patterns in intensity, phase, and time resolution. These can be addressed with these systems by a conventional computer. The SLMs, as well as the detection system, have been tested with sufficient precision. Future investigation will focus on the dynamics of a single soliton as well as the interaction of several solitons.

Q 64.11 Do 16:30 Poster C

Interacting Rubidium and Caesium Atoms — •Shincy John, Michael Haas, Vanessa Leung, Lars Steffens, Claudia Weber, Daniel Frese, Dietmar Haubrich, Arno Rauschenbeutel, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn

In our experimental set up we simultaneously store Rubidium and Caesium in a magnetic trap. We use species-selective microwave cooling on the Rubidium groundstate hyperfine transition. Caesium is sympathetically cooled via elastic collisions with Rubidium. We are thus able to cool down the mixture to temperatures below 1 μK. Below 4 μK we observe strong losses of Caesium.
Analysing the dynamics of sympathetic cooling we are able to estimate a lower limit for the Rubidium-Caesium s-wave scattering length.

Q 64.12 Do 16:30 Poster C

A Scanning Electron Microscope for Ultracold Atoms — •Peter Würtz, Daniel Reitz, Nils Hommerstad, Tatjana Gericke, and Herwig Ott — Institut für Physik, Universtität Mainz; 55099 Mainz, Germany

We present our experimental apparatus that we are setting up in order to detect single atoms with high spatial resolution in ultracold quantum gases. For this purpose we have implemented a scanning electron microscope in a standard BEC apparatus. In our main chamber we achieve a vacuum level of 1×10^{-10} mbar. With help of a movable test target which is installed inside the chamber we have demonstrated a spatial resolution of $50\,nm$ for a beam current of $10\,nA$ and a beam energy of $6\,keV$. The atoms are collected in a 3D MOT and successfully transferred in a single beam CO_2 dipole trap. We are currently preparing the system for evaporative cooling and perform first tests of the ion detectors.

Q 64.13 Do 16:30 Poster C

Solitary Excitations in Suprafluid Quantum Gases from the Viewpoint of the Kuramoto Model — •Stefan R. Arnold, Reinhold Walser, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, Germany

We examine the stability of solitons in superfluid quantum gases by means of the Kuramoto model [1,2]. This popular model of statistical physics describes the synchronization of classical oscillators with different eigen frequencies and a non-linear coupling. For example, this is experienced in every day life by the sudden synchronization of applause in a concert hall. When the coupling strength is increased beyond a critical value, a phase transition occurs.

In this presentation we will study an analogous situation by considering the time dependent excitations of the soliton [3,4] in a harmonic trap as the non-linearly coupled oscillator modes. By including quadratic corrections beyond the standard linear response calculations we can formulate a Kuramoto-like situation where different Bogoliubov modes exhibit a phase dependent coupling.

[1] U. Parlitz, A. Pikovsky, M. Rosenblum, and J. Kurths, Physik Journal **5**, 33–40 (2006)
[2] S. H. Strogatz, Physica D **143**, 1–20 (2000)
[3] S. Burger *et al.*, Phys. Rev. Lett. **83**, 5198–5201 (1999)
[4] J. Denschlag *et al.*, Science **287**, 97–100 (2000)

Q 64.14 Do 16:30 Poster C

Quantum Dynamical vs. Boltzmann description of an equilibrating Ultracold Bose Gas — •Alexander Branschädel and Thomas Gasenzer — Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg

A dynamical many-body theory is presented which systematically extends beyond mean-field and perturbative quantum-field theoretical procedures. It allows us to study the dynamics of strongly interacting quantum-degenerate atomic gases. The non-perturbative approximation scheme is based on a systematic expansion of the two-particle irreducible effective action in powers of the inverse number of field components. This yields dynamic equations which contain direct scattering, memory and "off-shell" effects that are not captured by the Gross-Pitaevskii equation and go far beyond Quantum Boltzmann type descriptions. We apply the theory to a homogeneous ultracold Bose gas in one spatial dimension. Considering the time evolution of an initial state far from equilibrium we show that it quickly evolves to a non-equilibrium quasistationary state and discuss the possibility to attribute an effective temperature to it. The approach to thermal equilibrium is found to be extremely slow. We compare in detail the predictions of the full quantum dynamical theory to that of a kinetic, i.e. Quantum Boltzmann description of the equilibration.

Q 64.15 Do 16:30 Poster C

Transport Properties in a Mott-like State of Molecules — •Niels Syassen, Dominik M. Bauer, Matthias Lettner, Daniel Dietze, Thomas Volz, Stephan Dürr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

In Ref. [1] we prepared a Mott-like quantum state of molecules. This state has exactly one molecule at each site of an optical lattice. We now study the transport properties in this state. The tunneling amplitude for a molecule J_m can bring two molecules to the same site. If this happens, then the molecules can collide inelastically, leading to loss of both molecules from the sample. This loss occurs with a rate coefficient Γ which is typically much faster than $J_m/\hbar$. The fast on-site loss leads to a suppression of tunneling. Loss from the initial state effectively occurs with a rate $\Gamma_{\text{eff}} \propto J_m^2/\Gamma$. This prediction agrees with our experimental results measured at different lattice depths. It shows that a fast on-site loss rate Γ can suppress tunneling in the Mott-like state, much like a strong on-site repulsion suppresses tunneling in a usual Mott insulator.

[1] T. Volz et al. *Nature Physics* **2**, 692–695 (2006).

Q 64.16 Do 16:30 Poster C

Einzelatomdetektor auf einem Chip — •David Komma, Alexander Stibor, Sebastian Kraft, Andreas Günther, József Fortágh und Claus Zimmermann — Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

In bisherigen Experimenten in magnetischen Mikrofallen werden überwiegend atomare Wolken mit großen Atomzahlen manipuliert, welche durch Absorptionsabbildung nachgewiesen werden können. Die Manipulation einzelner Atome erfordert jedoch die Entwicklung neuartiger Detektionsmethoden.

Wir präsentieren einen Einzelatomdetektor, der auf der zustands- und ortsselektiven Photoionisation von Atomen und dem anschließenden Nachweis der Ionen durch ein Channeltron beruht. Wir stellen den experimentellen Aufbau und die Ergebnisse zur Photoionisation von Atomen an der Chipoberfläche vor. Die Effizienz des Detektors bestimmen wir durch Korrelationsmessungen.

Q 64.17 Do 16:30 Poster C

Theory of spinor Bose-Einstein condensates: ground state and coherent dynamics — •Frank Deuretzbacher[1], Kai Bongs[2], Klaus Sengstock[2], and Daniela Pfannkuche[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We study the dynamics of F = 1 and F = 2 spinor Bose-Einstein condensates following the experiments of Kronjäger *et al.* [1]. The evolution of these systems is commonly described by a coupled set of mean-field equations. We apply the single-mode approximation and afterwards diagonalize the Hamiltonian exactly in spin space [2,3]. In this approximation the Hamilton matrix has a band structure allowing the description of condensates with large particle numbers. We compare our results with mean-field simulations.

Furthermore, we study ground state properties of few (up to 5) strongly interacting spinor bosons. In this regime the *complete* Hamiltonian is diagonalized exactly and many properties, such as the energy spectrum, the densities, the momentum distribution, and the correlation function show an interesting new behavior.

[1] J. Kronjäger *et al.*, Phys. Rev. A **72**, 063619 (2005).
[2] C. K. Law, H. Pu, and N. P. Bigelow, Phys. Rev. Lett. **81**, 5257 (1998).
[3] L.I. Plimak, C. Weiß, R. Walser, and W. P. Schleich, Opt. Comm. **264**, 311 (2006).

Q 64.18 Do 16:30 Poster C

A new generation all-optical Cesium BEC — •Manfred Mark, Gabriel Rojas-Kopeinig, Anton Flir, Elmar Haller, Mattias Gustavsson, and Hanns-Christoph Nägerl — Institut für Experimentalphysik, Universität Innsbruck, Austria

We report on producing a BEC with Cs atoms in a new generation setup. The condensate with 10^5 atoms is formed every 8 sec in a glass cell apparatus with maximum optical access and fast magnetic field control.

A BEC of Cs atoms with tunable s-wave scattering length and several Feshbach resonances at low magnetic fields represents an ideal starting point for experiments in which the interaction properties are to be tuned and for the production of ultracold molecules.

After optical pre-cooling we load 10^7 atoms at a temperature of 1 μK into a large-volume crossed optical dipole trap generated by a high power fiber laser. To reach degeneracy the atoms are transferred to a focused crossed "dimple" trap where the density is high enough to allow for efficient evaporation.

Here we report on our progress with setting up an atom interferometer in the non-interacting limit to determine the fine structure constant α via a measurement of the photon recoil frequency* without perturbing mean-field shifts.

* *S. Gupta et al., Phys. Rev. Lett.* **89** *140401 (2002)*

Q 64.19 Do 16:30 Poster C

Towards an atom laser by all-optical means for Atom Interferometry — •Maic Zaiser, Waldemar Herr, Christian Schubert, Tobias Müller, Michael Gilowski, Thijs Wendrich, Wolfgang Ertmer, and Ernst Maria Rasel — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

We present the current status of our all-optical ATom LASer (ATLAS), an experiment aiming at Bose-Einstein-Condensation (BEC) in a dilute atomic gas of ^{87}Rb by all-optical means. The project is motivated by the ultra-low temperatures feasible in a BEC which may improve the accuracy of matter wave interferometers for precision measurements. Optical dipole traps make a fast production of BEC possible allowing for a high repetition rate in an interferometer. Dipole traps also allow for the trapping of all m_F-substates, especially $m_F = 0$, being intrinsically very insensitive to magnetic noise.

The atomic source consists of a two-stage design, where a three dimensional magneto-optical trap (3D-MOT) is loaded by a 2D-MOT. We present the experimental setup consisting of a specially designed and very compact vacuum chamber and a compact laser system for atom cooling employing modular integrated and fiber-based optics allowing for a high stability of the system. We will also give a characterization of our 2D- and 3D-MOT. In the future we will investigate the suitability of a high power Thulium fiber laser at 2 μm wavelength for trapping and evaporatively cooling atoms to quantum degeneracy. This work is part of the project FINAQS funded by the European Union. (www.finaqs.uni-hannover.de)

Q 64.20 Do 16:30 Poster C

Localisation and delocalisation of ultracold bosonic atoms in finite optical lattices — •Dirk-Sören Lühmann[1], Kai Bongs[2], Klaus Sengstock[2], and Daniela Pfannkuche[1] — [1]Institut für Theoretische Physik, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg, Germany — [2]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

By tuning the potential of optical lattices from shallow to deep, repulsively interacting bosonic atoms can undergo a quantum phase transition from a superfluid phase to a Mott insulator. The transition was predicted theoretically using the Bose-Hubbard modell [1] and was recently observed experimentally [2]. We have focused on finite quasi one-dimensional lattices which can be treated with great accuracy by exact diagonalisation of the full Hamiltonian in a multiple band eigenbasis. Surprisingly, lattices with few sites show already a very similar

behaviour as known macroscopically. The transition from delocalisation to localisation is reflected in the momentum distribution as well as in the energy spectrum and was proved using spatial correlation functions. In deep lattices with non-integer filling factors a precursor of a Bose glass can be observed. Beside the formation of a lowest (gapped) many-particle band the momentum distribution and correlation functions were explored.

[1] D. Jaksch et al., Phys. Rev. Let. **81**, 3108 (1998)
[2] M. Greiner et al., Nature **415**, 39 (2002)

Q 64.21 Do 16:30 Poster C

Transport of an ultracold gas of atoms into an ultrahigh-finesse optical cavity — •Ferdinand Brennecke, Tobias Donner, Stephan Ritter, Anton Öttl, Thomas Bourdel, Michael Köhl, and Tilman Esslinger — Institut für Quantenelektronik , ETH Zürich, 8093 Zürich, Schweiz

The combination of Bose-Einstein condensation and cavity quantum electrodynamics in the strong coupling regime opens the possibility to study the interaction of matter fields with a single light field mode in a highly controllable way. Here we report on the first step toward this goal which consists in the controlled transport of an ultracold gas of ^{87}Rb atoms into the mode of a Fabry-Perot type optical resonator of ultrahigh finesse. Our starting point is a Bose-Einstein condensate of about 10^6 atoms trapped in a magnetic trap located 36 mm above the cavity. We load the atoms into a vertically aligned optical standing wave potential which can be moved with a micrometer resolution by detuning the frequency difference of the two counter-propagating laser beams. Ending up with an ultracold cloud of about 5×10^5 atoms in a crossed beam optical dipole trap intersecting the resonator mode, we reach the regime of very strong coupling in cavity quantum electrodynamics characterized by a cooperativity parameter larger than 10^6. By optically pumping this coupled atom-cavity system and analyzing the resulting cavity-light spectrum we study cavity enhanced Rayleigh scattering off the atoms and the excitation properties of the system.

Q 64.22 Do 16:30 Poster C

Ultrakalte bosonische und fermionische Quantengase in optischen Gittern — •Sebastian Will, Thorsten Best, Tim Rom, Ulrich Schneider, Lucia Hackermüller, Dries van Oosten, Martin Zwierlein und Immanuel Bloch — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

Ultrakalte bosonische und fermionische Quantengase in optischen Gittern erlauben die kontrollierte Simulation fundamentaler Systeme der Festkörperphysik. In unserem experimentellen Aufbau können bosonisches ^{87}Rb und fermionisches ^{40}K bis zur Quantenentartung gekühlt werden. Der externe Einschluss der Atome in einer gekreuzten Dipolfalle und ein blauverstimmtes, dreidimensionales optisches Gitter erlauben eine außergewöhnliche Flexibilität in der Wahl der Potentialeigenschaften. Darüber hinaus können in dieser Konfiguration verschiedenste interne atomare Zustände präpariert und gespeichert werden. Damit ist eine große Bandbreite von Experimenten mit Fermi-Fermi- und Bose-Fermi-Gemischen möglich.

Mit unserem System konnte erstmals das "antibunching" neutraler fermionischer Atome in Rauschkorrelationen beobachtet werden. Daraus lassen sich Rückschlüsse auf die Struktur des fermionischen Bandisolators im optischen Gitter ziehen. Es war uns möglich, die Bildung und Auflösung dieses Zustands unter Änderung des externen Einschlusses zu untersuchen.

Zudem stellen wir erste Ergebnisse zu RbK-Gemischen im optischen Gitter vor und gehen dabei auf die Verteilung der Atome auf die Gitterplätze ein.

Q 64.23 Do 16:30 Poster C

Bose-Einstein Condensates in superconducting Nb microtraps — •Daniel Cano, Brian Kasch, Matthias Kemmler, Michael Gierling, Dieter Kölle, Reinhold Kleiner, Claus Zimmermann, and József Fortágh — Physikalisches Institut der Universität Tübingen

This poster shows technical and theoretical aspects of a new experiment that aims to realize Bose-Einstein condensation (BEC) in superconducting microtraps.

A cloud of 87-Rb atoms will be evaporatively cooled in a magnetic trap until a BEC is formed. Subsequently, the condensate will be transferred by means of optical tweezers into a magnetic micro-trap generated on a Niobium chip at 4,2 K.

Magnetic fields in the vicinity of superconducting surfaces have been simulated. Inhomogeneous current densities within the superconductor have been calculated using an energy-minimization procedure that relies on the London equations.

Superconducting chips have been produced by means of optical lithography and a lift-off technique. Different magnetic-field configurations as well as possible trap geometries are depicted. The measured electronic properties of the fabricated chips are shown together with the current stage of the experiment.

Q 64.24 Do 16:30 Poster C

Quantum fluctuations in the time-dependent BCS-BEC crossover — •Bernhard M. Breid and James R. Anglin — Technische Universität Kaiserslautern, Fachbereich Physik, D-67653 Kaiserslautern

We present current work on a path integral approach to the time-dependent BCS-BEC crossover. In order to describe the creation of a molecular BEC out of cold fermionic atoms by a slow Feshbach sweep, we treat the molecules by means of a coherent state path integral formalism. Within the path integral, the molecules can be seen as a classical background field for the fermions. However, the dynamics of the fermionic atoms is calculated using multiple timescale analysis, assuming that the Feshbach sweep is adiabatically slow and that the resonance is narrow compared to the Fermi energy. By solving the fermionic part of the time evolution first, a coherent state path integral for the molecular part remains. Using this as a starting point, we want to analyze the behaviour of the correlation length and the quantum fluctuations in the frame of an adiabatic dynamics. To reach this goal we start with the analytically solveable toy model of just two fermions forming one boson which we treat by the formalism described above. We expect that we can then generalize this method to the many-body problem.

Q 64.25 Do 16:30 Poster C

Time Evolution of a Tonks Gas in Disorder — Birger Horstmann[1,2], •Tommaso Roscilde[1], and Ignacio Cirac[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Institut für Theoretische Physik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany

Waves propagating in static disorder can become localized in a finite region of space, even for energies for which classical motion is not bounded, a phenomenon known as Anderson localization. There have been proposals and experimental attempts to observe Anderson localization in Bose-Einstein Condensates and optical lattices. In these experiments, where disorder was introduced by using laser speckles, non-classical localization by coherent backscattering could not be achieved due to the large length scale of the disorder.

We analyse a system of cold atoms in an optical lattice in presence of disorder created by the interaction with a different immobile/frozen species of atoms. Two distinguishable species of atoms in optical lattices can be realized by addressing two different internal states of the atoms. The atoms are prepared in a Tonks Gas, i.e. a one dimensional system of hard core bosons, that has been realized in experiment and can easily be treated numerically.

We find that an initially localized wavepaket remains localized during time evolution for any value of the interaction strength between the two species and that the quasi-condensation in a Tonks Gas without disorder disappears in the presence of disorder.

Q 64.26 Do 16:30 Poster C

Quantum transport of matter waves in optical speckle potentials — •Robert Kuhn[1], Christian Miniatura[2], Dominique Delande[3], Olivier Sigwarth[1], and Cord Müller[1] — [1]Universität Bayreuth — [2]Institut Non-Lineaire de Nice — [3]Laboratoire Kastler Brossel, Paris

We study quantum transport properties of ultracold atoms propagating in a disordered optical potential. Within the framework of a microscopic diagrammatic perturbation theory we derive a general expression for the disorder-averaged probability density of the expanding atomic cloud for any initial phase space distribution. We calculate weak localization corrections to the diffusion constant and determine the threshold to the Anderson localized regime.

Q 64.27 Do 16:30 Poster C

Collective Excitations in a Trapped Bose-Einstein Condensate with Weak Quenched Disorder — •Giovanni Falco, Axel Pelster, and Robert Graham — Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We study how the collective mode frequencies of a condensate in a harmonic trap are shifted by the presence of additional weak quenched disorder. To this end we apply the Huang-Meng theory [1] to an inhomogeneous condensate in the Thomas-Fermi approximation. This approach describes how local condensates in the minima of the disorder potential interfere with the superfluid properties of the condensate. The consequences for the hydrodynamic equations are worked out in detail. We find that the negative shifts of the collective frequencies for the monopole and the dipole mode decrease rapidly with increasing correlation length of the disorder potential, at least if we assume that its the spatial correlation function is a Gaussian. Thus, our theory makes it possible to experimentally test the predictions of the Huang-Meng theory.

[1] K. Huang and H.F. Meng, Phys. Rev. Lett. **69**, 644 (1992)

Q 64.28 Do 16:30 Poster C

A Fermion mixture of ultracold ^{6}Li and ^{40}K — •Antje Ludewig, Tobias Tiecke, Sebastian Kraft, Steve Gensemer, and Jook Walraven — Van der Waals-Zeeman-Instituut, Universiteit van Amsterdam, Valckenierstraat 65, 1018 XE Amsterdam, The Netherlands

We report on our progress in the construction of a new apparatus for the simultaneous cooling of the Fermionic alkali isotopes ^{6}Li and ^{40}K. Our goal is to cool the mixture to degeneracy and search for novel pairing mechanisms involving Fermions of different masses.

We have constructed, for the first time, a 2D-MOT source of Li atoms directly loaded from a thermal vapor, thereby circumventing the need for a Zeeman slower. The 2D-MOT is loaded from a Li oven and as a source for K, a second 2D-MOT is loaded from ^{40}K-enriched thermal vapor.

The cold beams of both species are then loaded via differential pumping sections into a dual MOT in the main chamber. From there the cold atoms are transferred into a magnetic trap, where they can be cooled by forced microwave evaporation. After this cooling the atoms will be loaded into a dipole trap.

For the ^{40}K we have already achieved magnetic trapping and evaporation.

Q 64.29 Do 16:30 Poster C

Ultracold Atomic Gases in 1D Lattices: A combined Bloch- and Wannier Approach — •Ilona Tuerschmann, Felix Schmitt, Markus Hild, and Robert Roth — Institut fuer Kernphysik, Technische Universitaet Darmstadt

We compare different methods to describe the correlated regime of ultracold quantum gases in 1D optical lattices. Primarily we use an exact diagonalization technique which is limited to moderate system sizes. In order to reduce the dimension of the Hilbert space we apply a physically motivated basis truncation scheme. Alternativly we accomplish pertubation theory. For the single particle basis we employ Bloch functions to describe the system in the superfluid regime. In combination with the Wannier-Basis approach for the strongly interacting regime this yields to a consistent description over the full phase diagram.

Q 65: Poster Photonik

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 65.1 Do 16:30 Poster C

Comparison of time integration schemes in FDTD simulations in two dimensions — •Christian Matyssek[1], Oleksiy Kiriyenko[1], Markus Däne[1], Wolfram Hergert[1], Helmut Podhaisky[2], Rüdiger Weiner[2], and Martin Arnold[2] — [1]MLU Halle-Wittenberg, Institut für Physik, Von-Seckendorff-Platz 1, 06120 Halle — [2]MLU Halle-Wittenberg, Institut für Mathematik, Theodor-Lieser-Straße 5, 06120 Halle

The Yee formulation of the finite difference time domain (FDTD) method uses a fully explicit leapfrog time-stepping process which is second-order accurate. A limitation of the method is, that its stability is conditional, depending on time steps and spatial discretisation. Thus, during the last years unconditonally stable algorithms to solve the time-dependent Maxwell equations, e.g. based on exponential integrators, have been studied.[1]

We construct FDTD algorithms based on a spatial Yee-grid combined with different higher-order accurate time integration schemes using Krylov subspace techniques. The performance of these integrators is compared. Areas of applications like nonlinear effects in Maxwell's equations will be discussed.

[1] J.S. Kole, M.T. Figge, H. De Raedt, Phys. Rev. E, 066705 (2003)

Q 65.2 Do 16:30 Poster C

Effective permittivity and optical properties of photonic/plasmonic structures in glass — •Oleksiy Kiriyenko, Wolfram Hergert, Stefan Wackerow, and Heinrich Graener — Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Friedemann-Bach-Platz 6, 06108 Halle

Nanocomposite glass containing metallic nanoparticles are of considerable interest as photonic structures with special optical properties. The effective dielectric properties of such nanocomposite glass has to be known first for a successful calculation of optical properties of photonic/plamonic structures in this material. The finite element method (FEM) is used to calculate the complex effective permittivity of two-phase disordered composite media consisting of silver nanoparticles which are randomly placed in a homogeneous dielectric (glass). Volume fractions know from experiments are studied. The results are compared with effective medium theories (EMT). The results are used to calculate optical properties of photonic structures generated in such material. The calculations are compared with experimental results.

Q 65.3 Do 16:30 Poster C

Simulation von Mikroresonatoren in photonischen Kristallen in Diamant — •Christine Kreuzer, Elke Neu und Christoph Becher — Universität des Saarlandes, Fachrichtung 7.3, Technische Physik, 66041 Saarbrücken

Die Verwendung von optisch aktiven Defektzentren in Diamant für Anwendungen in der Quanteninformation ist Gegenstand aktueller Forschung. Für den Einsatz in Quantennetzwerken [1] und probabilistischen Quantencomputern [2] ist die Ankopplung von einzelnen Defektzentren an eine Mode von Mikroresonatoren hoher Güte Voraussetzung. In diesem Zusammenhang betrachten wir Mikroresonatoren in zweidimensionalen photonischen Kristallen in Diamantfilmen. Die Lokalisierung der Moden wird durch Braggreflexion an der periodischen Struktur im Film und Totalreflexion an den Oberflächen des Diamantfilms erreicht. Zur Simulation und Charakterisierung der photonischen Kristalle werden zwei verschiedene Methoden verwendet, die die Vorteile der Lösung der Maxwellgleichungen im Frequenz- und Zeitraum kombinieren (FDTD). Wir diskutieren Strategien zur Maximierung des Gütefaktors Q der Defektresonatoren und die mögliche experimentelle Realisierung.

[1] L. Childress et al., Phys. Rev. Lett. **96**, 070504 (2006).
[2] Y.L. Lim et al., Phys. Rev. A **73**, 012304 (2006).

Q 65.4 Do 16:30 Poster C

Fabrication and Strain Tuning of Glass Fiber-Based Whispering-Gallery-Mode Bottle Resonators — •Michael Pöllinger[1,2], Florian Warken[1], Wolfgang Alt[1], Dieter Meschede[1], and Arno Rauschenbeutel[1,2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institut für Physik, Universität Mainz, 55099 Mainz

We present our recent results on the fabrication and characterization of a novel type of highly prolate shaped whispering-gallery-mode resonators with an advantageous mode geometry and spectrum [1]. We realize the "bottle resonator" structures starting from glass fibers. The fibers are flame heated and elongated to produce a 15-μm diameter waist and then microstructured by focused CO_2 laser heating. The resulting small radius modulations are then measured using a diffraction technique that allows us to determine the resonator profile with a sub-micron precision. The resonators are spectrally characterized in a setup where light is coupled in and out by means of micron sized coupling fibers. Furthermore this setup allows us to apply strain to the resonator, thereby tuning its resonance frequency. Tuning over more than one free spectral range has been achieved. Quality factors in the $Q = 10^5$ range have been observed. Our current efforts aim at enhancing Q by working with custom made glass fibers made of high quality

glass. Ideally, values in the $Q = 10^8$–10^9 range should be achievable.
We acknowledge financial support by the DFG research unit 557.
[1] Y. Louyer, D. Meschede, and A. Rauschenbeutel, Phys. Rev. A **72**, 031801(R) (2005).

Q 65.5 Do 16:30 Poster C

Selective excitation of electric and magnetic resonances in nanoscopic structures with radially and azimuthally polarized light — •Peter Banzer, Susanne Quabis, Ulf Peschel, and Gerd Leuchs — Max Planck Researchgroup, Institute of Optics, Information and Photonics, Guenther-Scharowsky-Straße 1, 91058 Erlangen, Germany

A couple of years ago the research in the domain of so-called metamaterials started. Metamaterials are a form of effective media of which the properties do not depend on the intrinsic material parameters but their macroscopic periodic structure. They can show a rather contra intuitive behaviour. In this context the electric and magnetic resonances of the nanoscopic unit cells of the material play an important role.

We investigate the selective excitation of magnetic and electric resonances in single nano-structures. For this purpose we use radially and azimuthally polarized light which provides a non-homogeneous polarisation distribution at a sub-wavelength scale. The polarized light is focussed by a high numerical aperture microscope objective (NA 0.9). The existence of longitudinal and transversal electric and magnetic fields which are formed in the focal plane of the beam allow us to choose the direction of the induced electric and/or magnetic dipole and therefore its plane of radiation. In order to check for resonances we measure angular spectrum of the scattered light sensitive to polarisation with a tuneable light source.

The measurements are performed using single sub-wavelength gold spheres as well as so-called split-ring-resonators.

Q 65.6 Do 16:30 Poster C

Talbot effect at two-dimensional microscopic periodic structures — •Ralf Ameling, Manuel Gonçalves, André Siegel, and Othmar Marti — Universität Ulm, Institut für Experimentelle Physik, D-89069 Ulm

The Talbot effect is a self-imaging phenomenon observable at periodic objects illuminated with coherent light. The intensity distribution at the grating is reproduced at distances that are mutiples of the Talbot distance. This lenght is dependent on the array symmetry, the lattice constant and the wavelength of the incident light.

We investigated self-imaging at two-dimensional hexagonal colloidal crystals consisting of polysterene spheres and their inverse egg-box-like structures. The observed diffraction patterns (especially at the Talbot-length) have been compared with computer simulations based on different theoretical models like the Rayleigh-Sommerfeld-theory and the Hertz-vector diffraction theory. In addition, several computer programs for the simulation of the propagation of electromagnetic waves and the optical near-field have been used to verify the results. They are based on the finite-difference time-domain (FDTD) algorithm and the finite element method .

Q 65.7 Do 16:30 Poster C

Thermo-acoustic optical path length stabilization in a single mode optical fiber. — •Wojciech Lewoczko-Adamczyk[1], Max Schiemangk[1], Holger Müller[2], and Achim Peters[1] — [1]Humboldt Universität zu Berlin, Institut für Physik, Quantenoptik und Metrologie, Hausvogteiplatz 5-7, 10117 Berlin — [2]Physics Department, Stanford University, Stanford, CA 94305

We present a simple technique to actively stabilize the optical path length in an optical fiber. A part of the fiber is coated with a thin electrically conductive layer, which acts as a heater. The optical path length is thus modified by temperature dependent changes in the refractive index and in the mechanical length of the fiber. The dynamic response of the latter is dominated by the speed of sound in glas rather than by slow thermal diffusion. Making use of this fact we succeeded in actively stabilizing the optical path length with a closed-loop bandwidth greater than 1 kHz.

Q 66: Poster Optische Messtechnik

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 66.1 Do 16:30 Poster C

Nachweis einer schmalen Absorptionslinie in breitbandigem Licht — •Kai Zimmermann, Christian Tamm und Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Braunschweig

Wir stellen eine neue Methode vor, die es erlaubt, eine spektral schmale Absorptionslinie mit einer breitbandigen Lichtquelle nachzuweisen. Die Methode benötigt weder ein dispersives optisches Element noch präzise Information über die Lage der Linie. Mögliche Anwendungen sind der Nachweis von Spurengasen oder die bei der Entwicklung neuer Frequenznormale manchmal notwendige breitbandige Suche nach der Wellenlänge verbotener Übergänge. Es wird hierzu die Nichtlinearität des Beerschen Absorptionsgesetzes genutzt, die bei einer Modulation der Linienform zu einer Variation in der transmittierten Intensität führt. Zum experimentellen Nachweis des Verfahrens wird die Absorption einer kurzen Cs-Zelle bei Raumtemperatur auf der D2-Linie bei 852 nm im Licht einer LED von etwa 50 nm spektraler Breite nachgewiesen. Zur Modulation der Linienform befindet sich die Cs-Zelle in einem oszillierenden Magnetfeld von bis zu 0,1 T Amplitude. Die experimentellen Signale werden durch eine theoretische Modellierung des Verfahrens gut wiedergegeben.

Q 66.2 Do 16:30 Poster C

Weiterentwicklungen eines Langpfadteleskops zur Messung Atmosphärischer Spurenstoffe — •Jens Tschritter, André Merten und Ulrich Platt — Institut für Umweltphysik, im Neuenheimer Feld, 69120 Heidelberg

Messungen von atmosphärischen Surenstoffen mittels der Differentieller Optischer Absorption Spektroskopie (DOAS) werden vorgenommen im dem ein Lichtstrahl über eine Messstrecke auf ein Empfangsteleskop projiziert wird. Durch Verwendung von Retroreflektoren lässt sich ein Teleskop als Sender und Empfänger benutzen. Bisher wurde der Hauptspiegel eines Newtonteleskops mittels zweier Umlenkspiegel in Sende und Empfangsbereiche eingeteilt. Da bei diesem koaxialen Teleskopsystem jeweils nur ein Teil des Hauptspiegels verwendet wird, reduziert dies den Wirkungsgrad des Systems. Durch die Verwendung eines Quarzfaserbündels (statt herkömmlicher Umlenkspiegel), bei dem ein Teil der Fasern zum Senden und ein anderer für das Empfangen des Lichts zuständig ist, konnte ein Intensitätsgewinn um das achtfache erzielt und die Justage des Teleskops erheblich vereinfacht werden. Dadurch wird der Bau kleinerer Teleskopeinheiten ermöglicht, welche komfortabler zu bedienen sind, den Aufwand bei Feldmessungen verringern und neue Anwendungsgebiete eröffnen. Weiterhin können Referenzspektren der Lichtquelle mittels eines, direkt vor das Faserbündel positionierter Streuscheibe wesentlich leichter aufgenommen werden. Dies ermöglicht eine genauere Charakterisierung des Lampenspektrums und damit eine deutlich verringerte Nachweisgrenze.

Q 67: Poster Teilchenoptik

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 67.1 Do 16:30 Poster C

Matter wave interferometry for detecting collision between K atoms and K_2 molecules — •Sha Liu, Ivan Sherstov, Horst Knöckel, Christian Lisdat, and Eberhard Tiemann — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

We apply the method of matter wave interferometry implemented for K_2 molecules to investigate cold collisions between K atoms and molecules. The matter wave is coherently split and recombined by laser fields in a Ramsey-Bordé configuration. The two exits of this interferometer, with molecules in the excited state or in the ground state, give complementary detection schemes of the interference signal. The goal of this experiment is to investigate the suitability of such interferometer as a detector for collisions and to interpret the observed changes of the interference pattern in terms of the interaction potential between K and K_2. By means of resonant laser light, atoms are deflected out of the molecular beam and the atomic density decreases by one order of magnitude. Under such conditions we observe a phase shift of the interference structure relating to a pressure shift in the order of 10kHz for the selected molecular transition of K_2. The detection scheme for the ground state exit is set downstream of the particle beam sufficiently away from the interferometer zone for a good separation of the signals of both exits. Although the signals are in principle complementary to each other and can be recorded simultaeously, due to additional freedom in the experiment the ground state exit gives simpler profiles of the signals. The actual status of the experiment will be presented.

Q 67.2 Do 16:30 Poster C

The Visualization of the Gödel Universe — •Michael Buser[1], Endre Kajari[2], Wolfgang P. Schleich[3], Frank Grave[4], Hanns Ruder[5], and Günter Wunner[6] — [1]Universität Ulm — [2]Universität Ulm — [3]Universität Tübingen — [4]Universität Tübingen — [5]Universität Tübingen — [6]Universität Stuttgart

An intriguing solution of Einstein's field equations was found by Kurt Gödel in 1949. The Gödel universe describes a homogenous rotating universe in which closed time-like wordlines exist. Traveling along such a wordline allows an observer the mind-boggling journey into his own past. We discuss some properties of the metric, in particular its symmetries, and consider the propagation of light in that universe. It is well known that an optical horizon exists and that a lensing effect can be observed. In our main focus is the bending of the light rays in this universe and how they influence what an observer would see. For that purpose we use ray tracing, a well known method in computer graphics, and show how that technique can be applied to Gödel's universe.

Q 67.3 Do 16:30 Poster C

Matter wave Talbot-Lau interferometry beyond the eikonal approximation — •Stefan Nimmrichter and Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München

Our project deals with the theoretical description of a near-field matter wave interference experiment using the Talbot-Lau setup. Typically, it consists of three equal gratings, the second one responsible for the actual interference effect. It is particularly suited to demonstrate the wave nature of large molecules [1]. Unlike in far-field interference, the precise form of the interaction between the beam particles and the grating wall plays a decisive role for the quantitative description of the interference contrast. So far, the eikonal approximation has been sufficient for calculating the interference signal [2]. However, it ceases to be valid for beam molecules with masses beyond 2000 amu. Our aim is to develop a systematic framework for constructing higher order approximations of the grating interaction in the passage propagator for both the quantum and the classical treatment. The description will be based on the Wigner-Weyl representation of quantum mechanics. In particular, this permits to compare the quantum predictions with the corresponding classical model.

[1] Hackermüller et al., Phys. Rev. Lett. 91, 090408 (2003)
[2] Hornberger et al. Phys. Rev. A 70, 053608 (2004)

Q 68: Laserspektroskopie I

Zeit: Freitag 10:30–12:30 Raum: 5K

Q 68.1 Fr 10:30 5K

time and wavelength resolved fluorescence spectroscopy of photoinhibited photosynthetic organisms using a novel multi channel photomultiplier system — •Karin Wache[1], Franz-Josef Schmitt[1], Justus Fuesers[1], Christoph Theiss[1], Stefan Andree[1], Hans Joachim Eichler[1], and Hann-Jörg Eckert[2] — [1]Optisches Institut - P 1-1, Technische Universität Berlin, Strasse des 17. Juni 135, D-10623 Berlin — [2]Max-Volmer-Laboratorium, Technische Universität Berlin, Strasse des 17. Juni 135, D-10623 Berlin

A novel multi channel photomultiplier PML-16C (Becker & Hickl, Berlin) is used for time and wavelength resolved fluorescence measurements of photosynthetic organisms. The photomultiplier detects fluorescence photons simultaneously in the time domain and in 16 wavelength channels. As a result of high count rates up to 10^6 counts/sec very short measurement times are possible. Therefore this detector can be used for fast monitoring of changes of the fluorescence kinetics appearing after photoinhibition of the photosynthetic organisms with strong white light. Due to the short measurement times it is possible to investigate the dynamics of metabolic changes and repair mechanisms. The cyanobacterium Acaryochloris marina is an unique photosynthetic organism containing mainly Chl d instead of Chl a in the membrane intrinsic light harvesting systems. The investigation of photoinhibited cells of A. marina showed changes of the Chl d-fluorescence at 725 nm due to quenching after photoinhibition similar to what is observed in the Chl a fluorescence in typical Cyanobacteria or higher plants.

Q 68.2 Fr 10:45 5K

Laserspektroskopie mit zwei korrelierten, unverschränkten Atomen — •Christian Roos[1,2], Michael Chwalla[2], Kihwan Kim[2], Mark Riebe[2] und Rainer Blatt[1,2] — [1]Institut für Quantenoptik und Quanteninformation der österreichischen Akademie der Wissenschaften, Technikerstr. 21a, 6020 Innsbruck, Österreich — [2]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, 6020 Innsbruck, Österreich

Dekohärenzfreie Unterräume erlauben es, quantenmechanische Überlagerungszustände gegen bestimmte Rauschprozesse zu schützen. Dies ermöglicht Präzisionsspektroskopie mit langen Anregungszeiten, wie wir in [1] am Beispiel von zwei quantenmechanisch verschränkten 40Ca+ Ionen demonstriert haben. In diesem Beitrag diskutieren wir, wie man auch mit unverschränkten Atomen Kohärenzzeiten realisieren kann, die weitaus länger sind, als die mit einem einzelnen Atom erzielbaren. Die Technik beruht auf der Analyse von (klassischen) Korrelationen der atomaren Zustände nach der spektroskopischen Anregung. Wir verwenden diese Methode zur Messung des elektrischen Quadrupolmoments des metastabilen D5/2-Zustandes in 40Ca+.

[1] C. F. Roos et al., Nature 443, 316 (2006).

Q 68.3 Fr 11:00 5K

Untersuchung eines Konzeptes zur Bestimmung der Sauerstoffkonzentration in Luft-Kraftstoffgemischen mittels der Laserinduzierten Fluoreszenz (LIF) — •Christina Lumme[1,2], Stefan Dankers[2], Werner Hentschel[2] und Wolfgang Schade[3] — [1]Lehrstuhl für Medizintechnik, TU München, Boltzmannstrasse 15, 85748 Garching — [2]Volkswagen AG, Postfach 1785, 38436 Wolfsburg — [3]Institut für Physik und Physikalische Technologien, Technische Universität Clausthal, Leibnizstr. 4, 38678 Clausthal-Zellerfeld

Zur Verbesserung moderner motorischer Verbrennungsverfahren ist es u.a. notwendig die räumliche Sauerstoffverteilung im Brennraum zu bestimmen. Eine neue Idee sieht vor, zwei kurz aufeinander folgende Laserpulse zur Induzierung von linearer respektive gesättigter Fluores-

zenz einzusetzen und die Fluoreszenzintensitäten geeignet zu kombinieren. Hierzu muss zunächst die Abhängigkeit der induzierten Strahlung von der eingestrahlten Laserbestrahlung analysiert werden. Die Untersuchungen zeigen bis zu welcher Strahlungsintensität Fluoreszenz im linearen Bereich an Kraftstoff bzw. an Aceton oder 5-Nonanon induziert werden kann. Beim Kraftstoff kann beobachtet werden, dass die Fluoreszenzintensität bei noch weiter steigender Strahlungsintensität nach Erreichen eines Maximums aufgrund von Photodissoziationsprozessen abfällt. Bei Aceton und 5-Nonanon deutet eine quadratische Abhängigkeit der Fluoreszenzintensität von der Strahlungsintensität auf das Auftreten von Zwei-Photonenprozessen hin. Diese These kann durch Ermittlung vergleichender Fluoreszenzspektren, die deutlich unterschiedliche Bandenstrukturen aufweisen, gestützt werden.

Q 68.4 Fr 11:15 5K

Direkte Messung der Extinktion eines Laserstrahls durch ein einzelnes Molekül — •Gert Wrigge, Ilja Gerhardt, Jaesuk Hwang, Gert Zumofen und Vahid Sandoghdar — Laboratorium für Physikalische Chemie, ETH Zürich, CH-8093 Zürich

In einen organischen Kristall eingebaute Farbstoffmoleküle zeigen bei Temperaturen unter T=2K lebensdauerbegrenzte optische Linienbreiten. Ähnlich wie bei Atomen oder Ionen lässt sich dieses System als reines Zwei-Niveau-System beschreiben, besitzt aber den Vorteil einer starken, rotverschobenen Fluoreszenz, über welche einzelne Moleküle üblicherweise detektiert werden. Wir berichten hier von direkten Messungen der Extinktion von Laserlicht durch einzelne Moleküle. Diese wird durch destruktive Interferenz von Anregungslicht und kohärenter Vorwärtsstreuung am Molekül verursacht. Wir benutzen optische Nahfeldsonden [1] und Konfokalmikroskopie [2], um das anregende Laserlicht auf eine Fläche von circa der Grösse des molekularen Absorptionsquerschnittes zu fokussieren. Ein einzelnes im Fokus positioniertes Molekül kann das Laserlicht um mehr als 10% abschwächen. Diese Messungen, die eine effiziente Wechselwirkung des Lichtfeldes mit dem Molekül vorraussetzen, erlauben zudem Untersuchungen an der resonanten Emission einzelner Moleküle. Wir präsentieren die Intensitätsabhängigkeit der kohärenten und inkohärenten Resonanzfluoreszenz, sowie das Auftreten des Mollow-Triplets in diesem System.

[1] I. Gerhardt et. al., ArXiv: quant-ph/0604177 erscheint in Phys.Rev.Lett., [2] G. Wrigge et al., in Vorbereitung

Q 68.5 Fr 11:30 5K

Die Auswirkungen von Puffergas auf FADOF-Systeme — •Ingo Massmann, Alexandru Popescu und Thomas Walther — Institut für Angewandte Physik, AG Laser und Quantenoptik, Technische Universität Darmstadt, Schlossgartenstr. 7, D-64289 Darmstadt

Faraday **A**nomalous **D**ispersion **O**ptical **F**ilter (FADOF) eignen sich als schmalbandige Kantenfilter. Sie sind in der Lage minimale Frequenzverschiebungen des Eingangssignals in große Intensitätsänderungen des Ausgangsignals zu überführen. Erreichbar sind Transmissionsänderungen von nahezu 100% bei Frequenzverschiebung von einem GHz und kleiner. Diese ausgezeichneten Filtercharakteristika sind nur in der Nähe der atomaren Übergangslinien des eingesetzten Zellengases erreichbar, da dort die große anomale Dispersion ausgenutzt wird. Ihre prinzipielle Unempfindlichkeit gegenüber Erschütterungen zeichnet diese Systeme als Ersatz für konventionelle interferometrische Techniken aus. Dies ist z.B. für flugzeuggestützte Systeme von Vorteil. Im aktuellen Fall soll ein **E**xcited **S**tate FADOF (ESFADOF) Detektorsystem in einem flugzeuggestützten Brillouin-LIDAR zur tiefenaufgelösten Temperaturmessung des Ozeans entwickelt werden. Der dazu benötigte Kantenfilter soll in der Nähe des Absorptionsminumums von Wasser Frequenzverschiebungen der temperaturabhängigen Brillouin-Streuung von ±7-8 GHz auflösen können. Um diese Frequenzverschiebungen abdecken zu können wird auf zusätzliche Puffergase zurückgegriffen. Diese versprechen einen größeren Bereich um die Absorptionslinie nutzbar zu machen.

Q 68.6 Fr 11:45 5K

Modelling the time- and wavelength resolved fluorescence dynamics in the PBP-antenna of the phototrophic cyanobacterium Acaryochloris marina — •Justus Fuesers[1], Karin Wache[1], Franz-Josef Schmitt[1], Stefan Andree[1], Christoph Theiss[1], Hans Joachim Eichler[1], and Hann-Jörg Eckert[2] — [1]Institute of Optics, Technical University Berlin, Germany — [2]Max-Volmer-Laboratory for Biophysical Chemistry, Technical University Berlin, Germany

A.marina discovered only in 1996 has a unique composition of the light harvesting system. The membrane intrinsic chlorophyll (Chl) antenna contains mainly Chl d instead of the usually dominant Chl a and the membrane extrinsic phycobiliprotein (PBP) antenna has a simpler rod shaped structure than in typical cynobacteria [1].

Time- and wavelength resolved fluorescence spectroscopy with a time resolution of 20 ps showed fast excitation energy transfer kinetics of 20-30 ps along the PBP antenna of A.marina followed by a transfer to the Chl d antenna with a time constant of about 70 ps. Calculations of different models describing the energy transfer in the PBP-antenna system of A.marina are compared with the experimental results.

[1] J. Marquardt, H. Senger, H. Miyashita, S. Miyachi, E. Mörschel, "Isolation and Characterization of phycobiliprotein aggregates from Acaryochloris marina, a prochloron like prokaryote containing mainly chlorophyll d" FEBS Lett 410 ,428-432 (1997)

Q 68.7 Fr 12:00 5K

Eine neue zerstörungsfreie Methode zur Bestimmung von Fluoreszenzlebensdauern in hochdotierten Kristallen — •Henning Kühn[1], Susanne Teruko Fredrich-Thornton[2], Klaus Petermann[1] und Günter Huber[1] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Institute for Laser Science, University of Electro-Communications, 1-5-1 Chofu, Tokyo 182-8585, Japan

In Kristallen mit hoher Absorption und einem großen Überlapp zwischen Absorptions- und Emissionsspektrum verhindert wiederholte Emission und Reabsorption von Photonen eine genaue Bestimmung der strahlenden Lebensdauern angeregter Zustände. Die Pinhole-Methode ist eine zerstörungsfreie Möglichkeit, trotz dieses Radiation Trappings die intrinsische Lebensdauer zu ermitteln.

Es wird eine theoretische Beschreibung des Radiation Trappings in Festkörpern gegeben. Weiterhin werden Modelle und Näherungsmethoden für verschiedene Kristallgeometrien und Randbedingungen vorgestellt, die es erlauben, aus der gemessenen Lebensdauer auf die intrinsische Lebensdauer eines Energieniveaus zu schließen. Besonderer Wert wird dabei auf die Geometrie der bei der Pinhole-Methode angeregten Kristallbereiche gelegt. Es erfolgt ein Vergleich der von den theoretischen Modellen gelieferten Daten mit experimentellen Resultaten.

Q 68.8 Fr 12:15 5K

Absorptionsmessungen im Resonator eines Er-dotierten Faserlasers von 6200 cm^{-1} bis 6550 cm^{-1} — Philip von Ende, •Benjamin Löhden, Sergej Wexler, Klaus Sengstock und Valeri Baev — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Er-dotierte Faser-Laser erlauben höchstempfindliche in-situ Absorptionsmessungen im Laserresonator [1] im spektralen Bereich von 6200 cm^{-1} bis 6550 cm^{-1}. Die Emissionsbandbreite wird durch eine asphärische Linse im Resonator bestimmt und beträgt ca. 20 cm^{-1}. Das Emissionsspektrum wird mit der Linse und der Dotierungskonzentration der Faser durchgestimmt. Die Empfindlichkeit der Absorptionsmessungen entspricht einer äquivalenten Absorptionslänge von bis zu 30 km. Absorptionsspektren mehrerer Moleküle, die u.a. für die Medizin, die Optimierung von Verbrennungsprozessen und die Umweltanalyse wichtig sind, wie z.B. C_2H_2, HCN, HN_3, $^{12}CO_2$, $^{13}CO_2$, H_2O, CO, CH_4 und HI wurden mit diesem Laser bei verschiedenen Konzentrationen aufgenommen.

[1] A. Goldman, I. Rahinov, S. Cheskis, B. Löhden, S. Wexler, K. Sengstock, V.M. Baev, Chem. Phys. Lett 423, 147 (2006)

Q 69: Photonik III

Zeit: Freitag 10:30–11:30 Raum: 5J

Q 69.1 Fr 10:30 5J

Asymmetrically pumped optical lattices: collective excitations and instability — •Janos Asboth[1,2], Helmut Ritsch[1], and Peter Domokos[2] — [1]Institut für Theoretische Physik, Univ. Innsbruck, Innsbruck, Österreich — [2]Institute for Solid State Physics and Optics, Budapest, Hungary

We solve the self-consistent, coupled equations of motion for trapped atoms and the field of a one-dimensional optical lattice in the large detuning limit. In steady state the refractive index of the particles reduces the lattice constant, an effect, which is greatly enhanced if the lattice is formed by unbalanced pump beams. For pump asymmetry above a finite value, independent of the lattice size, no equilibrium configuration exists. Below this limit, the optomechanical coupling mediates collective oscillations of the particles around their steady state positions, which for asymmetric pumping take the form of traveling density waves. Above an asymmetry threshold, which decreases with the lattice size, these waves are amplified and the equilibrium becomes unstable, even in the presence of arbitrarily large viscous damping.

Q 69.2 Fr 10:45 5J

Evanescent mides are virtual photons — •Günter Nimtz[1] und Alfons Stahlhofen[2] — [1]Uni Köln, II. Physikal. Inst., Zülpicher Str. 77, 50937 Köln — [2]Uni Koblenz, Physik, Universitätsstr. 1, 56070 Koblenz

Former QED-based studies of evanescent modes indentified these with virtual photons. Recent experimental studies confirmed the resulting predictions about non-locality, non-observability, violation of the Einstein relation and the existence of a commutator of field operators between two space-like separated points. Relativistic causality thus is violated by the near-field phenomenon evanescent modes while primitive causality is untouched.

Q 69.3 Fr 11:00 5J

Propagation of Electromagnetic Fields in Inhomogeneous Dielectric Media — •Igor Drozdov[1] und Alfons Stahlhofen[2] — [1]Uni Koblenz, Physik, Universitätsstr. 1, 56070 Koblenz — [2]Uni Koblenz, Physik, Universitätsstr. 1, 56070 Koblenz

The second order differential equation for classical electromagnetic field in a dielectric medium with a space-dependent dielectric permittivity (wave-equation) is derived in a rigorous way from the Maxwell equations. The resulting equation exhibits some differences to the commonly used generalization of the ordinary wave equation for this case. The latter is shown to be inconsistent with classical electrodynamics. Some optical features of inhomogeneous media resulting from this approach are elucidated.

Q 69.4 Fr 11:15 5J

On a local concept of wave velocities — •Igor Drozdov[1] und Alfons Stahlhofen[2] — [1]Uni Koblenz, Physik, Universitätsstr. 1, 56070 Koblenz — [2]Uni Koblenz, Physik, Universitätsstr. 1, 56070 Koblenz

The classical far field concept of wave velocities has its merits while exhibiting intrinsic difficulties. A general local approach for the definition of velocities and especially phase velocities for waves avoiding these difficulties is proposed. It includes the classical definitions as particular cases and can be applied to waves of an arbitrary structure, and to arbitrary propagation media as well. Applications of the formalism are elucidated and some basic properties of the local concept defined here are discussed.

Q 70: Ultrakalte Atomstöße (gemeinsam mit A)

Zeit: Freitag 10:30–12:30 Raum: 6G

Hauptvortrag Q 70.1 Fr 10:30 6G

Quantum effects in collisions of ultracold atoms with walls and nanostructures — •Javier Madroñero, Florian Arnecke, Alexander Jurisch, and Harald Friedrich — Physik Department, Technische Universität München, München

Collisions of ultracold atoms with walls and nanostructures are, at sufficiently low energy, dominantly influenced by quantum effects, e.g. quantum reflection in the nonclassical region of an attractive atom-surface potential and dominance of low partial waves in the elastic scattering by nanospheres. We discuss possibilities of exploiting such effects to probe atom-surface potentials or to trap atoms without the help of auxiliary fields.

Q 70.2 Fr 11:00 6G

Ellastic collisions in a mixture of Yb and Rb atoms — Sven Kroboth, •Nils Nemitz, Florian Baumer, Claudia Höhl, and Axel Görlitz — Institut für Experimentalphysik, Universität Düsseldorf

The collisional properties of atoms play an important role in determining the features and realizability of quantum gases.

We report on an experimental study of inter-species collisions in a mixture of cold ytterbium and rubidium atoms. The Yb atoms are held in a bichromatic optical dipole trap designed to have minimal effect on the evaporatively cooled ^{87}Rb atoms which are held in a Ioffe-Pritchard type magnetic trap.

Collisions are observed through sympathetic cooling of Yb by Rb. In our experiment, the Yb temperature decreases from initially 50μK to near the Rb temperature of 20μK on a time scale of a second for the isotopes ^{174}Yb and ^{176}Yb. In contrast, a much smaller thermalization rate found for ^{172}Yb indicates a significantly smaller cross-section for collisions with Rb.

Our results are an important step towards the creation of a mixed quantum gas and heteronuclear Yb-Rb molecules.

Q 70.3 Fr 11:15 6G

Wechselwirkungen ultrakalter Li-Rb-Gemische — •Carsten Marzok, Benjamin Deh, Philippe W. Courteille und Claus Zimmermann — Physikalisches Insitut, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

Gemische ultrakalter Gase erleben in den letzten Jahren rasant wachsendes Interesse. BEC–BCS–Übergänge sowie reichhaltige Phasendiagramme in optischen Gittern im Falle von Fermi–Bose–Gemischen ebenso wie Wechselwirkungen in Doppel–BECs im Falle von Bose–Bose–Gemischen sind Beispiele für das breite Spektrum an beobachtbaren Effekten. Dem System Li–Rb kommt mit seinem großen Massenunterschied eine besondere Rolle zu, da man sich dem Gültigkeitsbereich der Born–Oppenheimer–Näherung annähert. Das ^{6}Li–^{87}Rb Fermi–Bose–Gemisch kann damit in einem optischen Gitter prinzipiell als Modellsystem eines Festkörpers verwendet werden. Repulsive Wechselwirkungen im Bose–Bose–Gemisch ^{7}Li und ^{87}Rb hingegen könnten das instabile ^{7}Li BEC im Hyperfeinzustand $|F, m_F\rangle = |2, 2\rangle$ stabilisieren. Um diese Effekte zu studieren, benötigt man Informationen und Kontrolle über die gegenseitigen Wechselwirkungen, ausgedrückt in der s–Wellen–Streulänge. Magnetische heteronukleare Feshbachresonanzen können hier sowohl als Bestimmungsgröße als auch als wertvolles Werkzeug dienen. Beide $^{(6/7)}$Li–^{87}Rb Gemische konnten wir durch sympathetisches Kühlen zu ultrakalten Temperaturen bringen und heteronukleare Wechselwirkungsparameter bestimmen.

Q 70.4 Fr 11:30 6G

Magnetic noise in atom chips: impact of finite wire size — •Bo Zhang and Carsten Henkel — Institute fuer Physik, Universitaet Potsdam,Germany

We provide a detailed analysis of spin-flip transitions in atom chips, taking into account complex geometries. We focus on metallic wires of different shapes and cross-sections deposited on dielectric substrates. Our results show that the finite thickness and width of a metallic wire have an obvious impact on the atom trap lifetime. The spin orientation makes a big difference for magnetic noise above finite wires, in striking contrast to infinitely extended planar structures. Different interpola-

tion formulas and approximations for magnetic field fluctuations in the near field of the wire are compared to exact numerical calculations. We work with surface integral equations and the boundary element method. Comparing to the surface impedance approximation familiar from microwave engineering, we find significant differences when the distance between the atom and the metallic surface is smaller than the skin depth.

Q 70.5 Fr 11:45 6G

Interacting Rubidium and Caesium Atoms — •Claudia Weber, Michael Haas, Shincy John, Vanessa Leung, Lars Steffens, Daniel Frese, Dietmar Haubrich, Arno Rauschenbeutel, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn

In our experimental set up we simultaneously store Rubidium and Caesium in a magnetic trap. We use species-selective microwave cooling on the Rubidium groundstate hyperfine transition. Caesium is sympathetically cooled via elastic collisions with Rubidium. We are thus able to cool down the mixture to temperatures below 1 μK. Below 4 μK we observe strong losses of Caesium.
Analysing the dynamics of sympathetic cooling we are able to estimate a lower limit for the Rubidium-Caesium s-wave scattering length.

Q 70.6 Fr 12:00 6G

Interactions of metastable neon atoms in magnetic and optical traps — •N. Herschbach[1], W.J. van Drunen[1], W. Ertmer[2], and G. Birkl[1] — [1]Institut für Angewandte Physik; Technische Universität Darmstadt, Schlossgartenstr. 7, D-64289 Darmstadt, Germany — [2]Institut für Quantenoptik; Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany

We investigate the cooling and the phyisics of interactions of metastable neon atoms. We measured elastic and inelastic collisional properties of cold metastable neon ($^3P_2$ state) in a magnetic trap. We found suppression of Penning ionization and achieved a 200-fold increase in phase space density by rf-forced evaporative cooling in the magnetic trap with ^{22}Ne [1]. However, efficiency of evaporative cooling has to be improved in order to reach quantum degeneracy.

Therefore we implemented a crossed optical dipole trap, which we can load from a magneto-optical trap as well as from a magnetic trap. This enables us to investigate the magnetic field dependence of collisional properties of metastable neon. More importantly, we can now trap metastable neon in states which cannot be trapped magnetically.

As a result we trapped, for the first time, neon in the $^3P_0$ metastable state. Measurements of the number decay of trapped atoms will allow to infer the rate coefficient for two-body loss of neon in the $^3P_0$ metastable state for both bosonic isotopes ^{20}Ne and ^{22}Ne. For this purpose, a careful characterization of the optical trap is required.

[1] P. Spoden et al., Phys. Rev. Lett. 94, 223201 (2005)

Q 70.7 Fr 12:15 6G

Laser cooling of relativistic C^{3+} beams at the ESR — •M. Bussmann[1], U. Schramm[2], D. Habs[3], M. Steck[3], T. Kühl[3], P. Beller[3], B. Franzke[3], F. Nolden[3], T. Stöhlker[3], W. Nörtershäuser[3], C. Geppert[5], S. Reinhardt[4], S. Karpuk[5], and C. Novotny[5] — [1]Department f. Physik, Ludwig-Maximilians-Universität München, Garching — [2]Forschungszentrum Dresden Rossendorf, Dresden — [3]Gesellschaft f. Schwerionenforschung, Darmstadt — [4]Max-Planck-Institut für Kernphysik, Heidelberg — [5]Institut für Physik, Johannes-Gutenberg-Universität Mainz, Mainz

We report on new results for laser cooling of bunched C^{3+} beams at the ESR stored at an energy of 1.46 GeV. We observe a longitudinal momentum spread one order of magnitude smaller compared to conventional electron cooling.
Using a setup of two cw Ar^+ lasers, one at a fixed frequency, the other constantly detuned with respect to the first, we were able to increase the momentum acceptance of the laser force compared to recent experiemnts [1]. If laser cooling is assisted by moderate electron cooling 3D cold beams can be achieved.
The focus of the talk lies on the dynamical aspects of the transition from temperature dominated beams to space charge dominated beams.

[1] U. Schramm, M. Bussmann, D. Habs, M. Steck, T. Kühl, P. Beller, B. Franzke, F. Nolden, G. Saathoff, S. Reinhardt, S. Karpuk, *AIP Conf. Proceedings* **821** (2006), 501-509

Q 71: Ultrakalte Moleküle I (gemeinsam mit MO)

Zeit: Freitag 10:30–12:45 Raum: 6B

Fachvortrag Q 71.1 Fr 10:30 6B

Magnetic dichroism of alkali atoms and molecules on the surface of helium nanodroplets — Johann Nagl, Gerald Auböck, Carlo Callegari, and •Wolfgang E. Ernst — Institute of Experimental Physics, TU Graz, Petersgasse 16, A-8010 Graz, Austria

We measured laser induced fluorescence spectra of K and Rb atoms, dimers and trimers, on the surface of superfluid helium droplets, with and without a moderately strong external magnetic field ($\approx 3\,$kG). Atomic spectra (D lines) are saturated with a few hundred mW of laser power. In a magnetic field, and under saturation, we observe a greater signal for linear polarization but no difference between the two states of (circular) polarization of the exciting laser. We take this as evidence that the two spin sublevels of the ground-state alkali atoms are equipopulated, despite a Zeeman splitting comparable in magnitude to kT (at the temperature of the droplet, $T = 0.38\,$K). We estimate that the rate of spin relaxation induced by the droplet must be < 1000/s. We thus demonstrate that by selective depletion it is possible to create a beam of He droplets doped with spin-polarized alkali atoms.

Measurements on triplet dimers do show magnetic circular dichroism, indicating that, unlike atoms, molecules do undergo fast spin relaxation and do thermalize to the temperature of the droplet.

Q 71.2 Fr 11:00 6B

Simulation der Dotierung von Heliumnanotröpfchen mit Alkaliatomen — •Oliver Bünermann und Frank Stienkemeier — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Heliumnanotröpfchen haben die Eigenschaft jegliche Teilchen über inelastische Stöße aufzusammeln. Dies kann zum Dotieren der Tröpfchen ausgenutzt werden: In einer Streuzelle wird ein entsprechender Dampfdruck des zu untersuchenden Materials eingestellt, die Tröpfchen passieren die Zelle und sammeln je nach Dampfdruck eine bestimmte Anzahl von Teilchen auf. Die Wahrscheinlichkeit $P_k(p)$, dass ein Tröpfchen k Teilchen aufgesammelt hat, ist poissonverteilt. Experimentell ermöglicht die Aufnahme von Dotierungskurven (Signal in Abhängigkeit vom Dampfdruck) einer gefundenen Absorbtion eine Komplexgröße zuzuordnen.

Im Experiment zeigen sich allerdings zum Teil starke Abweichung der Dotierungswahrscheinlichkeit von der Poissonverteilung. Insbesondere bei Alkaliatomen, -molekülen und -clustern kann man nicht mehr von einer Poissonverteilung sprechen. Eine Simulation des Dotierungsprozesses von Alkaliatomen wurde durchgeführt, die die Größenverteilung der Tröpfchen, die Tröpfchenschrumpfung nach er Dotierung, die Desorption der dotierten Komplexe und den Impuls Eintrag auf die Tröpfchen berücksichtigt. Im Rahmen der Simulation erhält man eine gute qualitative Übereinstimmung mit dem Experiment. Es zeigt sich, das die Wahl der Tröpfchenbedingungen einen entscheidenden Einfluss auf die Form der Dotierungskurven hat.

Q 71.3 Fr 11:15 6B

Aggregation von HCl in Heliumnanotröpfchen — •Markus Ortlieb, Anja Metzelthin, Melanie Letzner und Martina Havenith — Physikalische Chemie II, Ruhr-Universität Bochum, Universitätstr. 150, D-44780 Bochum

Wir untersuchen die Aggregation von HCl bei ultrakalten Temperaturen in Heliumnanotröpfchen im Bereich von 2820 bis 2940 cm^{-1}. Die Messungen wurden mit einem leistungsstarken IR-OPO (cw: 2,9 W) durchgeführt. Anhand der Druckabhängigkeit der Signalstärken konnten die Linien dem HCl Monomer, Dimer und Trimer zugeordnet werden. Dabei zeigte sich, dass die Frequenzen des Trimers auf die Ausbildung einer linearen Kette aus HCl hinweisen.

Weiterhin untersuchen wir das IR-Spektrum des Radikals NO in Heliumtröpfchen mit unserem Bleisalzdiodenlaser (Auflösung: 0,001 cm^{-1}). Der $^2\Pi_{1/2}$ R(1/2) Übergang des $^{15}N^{18}O$ Isotops konn-

te bei 1796,39 cm^{-1} gemessen werden, was einer Verschiebung von 0,12 cm^{-1} im Vergleich zur Gasphase entspricht.

Q 71.4 Fr 11:30 6B

Spectroscopy of free radicals and radical containing entrance-channel complexes in superfluid helium nanodroplets — •Jochen Küpper[1,2], Jeremy M. Merritt[2], and Roger E. Miller[2] — [1]Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin — [2]University of North Carolina, Department of Chemistry, Chapel Hill, NC 27599, USA

The unique properties of superfluid helium nanodroplets, namely their low temperature (0.4 K) and fast cooling rates ($\sim 10^{16}$ $K\,s^{-1}$), provide novel opportunities for the formation and high-resolution study of metastable structures or molecular complexes containing free radicals.

We discuss methods for the production of radicals and their applicability for embedding the radicals in helium nanodroplets. The spectroscopy of free radicals (i. e. C_3H_3) and of radical containing entrance-channel complexes, for example X$\cdots$HY (X=Cl, Br, I, CH_3; Y=F, CN), embedded in helium nano-droplets is detailed. The observed complexes provide new information on the potential energy surfaces of several fundamental chemical reactions and on the intermolecular interactions present in open-shell systems. Prospects for further experiments of radicals embedded in helium droplets are discussed.

Q 71.5 Fr 11:45 6B

Sub-megaherz infrared spectroscopy of trapped HD^+ ions at millikelvin temperatures — •Jeroen Koelemeij, Bernhard Roth, Andreas Wicht, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, Universität Düsseldorf

We have performed an absolute frequency measurement of the ($v' = 4, J' = 3$) $\leftarrow$ ($v = 0, J = 2$) overtone transition at 1395 nm in the molecular HD^+ ion with sub-megaherz accuracy. Trapped HD^+ ions are sympathetically cooled to millekelvin temperatures by storing them together with Be^+ ions, which are laser cooled to ~ 10 mK using near-resonant 313 nm light. Vibrational overtone spectroscopy at 1395 nm is done using ($1 + 1'$) resonance-enhanced multiphoton dissociation (REMPD), where a second photon at 266 nm selectively dissociates the HD^+ ions in $v' = 4$. The loss of HD^+ ions due to the REMPD process manifests itself as a change in the 313 nm Be^+ fluorescence when the motion of the HD^+ ions is resonantly driven by an ac electric field. The 1395 nm probe laser is a narrowband grating-enhanced diode laser with resonant optical feedback, which is locked to a femtosecond frequency comb. The comb is stabilized to a hydrogen maser which is referenced to GPS for long term stability. This allows tuning and measurement of the 1395 nm laser frequency with an accuracy better than 10 kHz. The 0.5 MHz uncertainty in our final result is due to measurement noise, Doppler broadening and, to a lesser extent, systematic uncertainties associated with external fields in the ion trap, and uncertainties in the *ab initio* data used for the spectral fit model.

Q 71.6 Fr 12:00 6B

Buffer-gas cooling of CrH and MgH in a cryogenic magnetic trap for paramagnetic molecules — •Michael Stoll[1], Tim Steimle[2], Gerard Meijer[1], and Achim Peters[3] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft — [2]Department of Chemistry and Biochemistry, Arizona State University — [3]Humboldt Universität zu Berlin, Institut für Physik

The buffer gas loading and subsequent magnetic trapping of neutral molecules is a powerful tool for it can provide samples of cold molecules with very high densities. We report on the buffer-gas cooling of CrH and MnH radicals to a temperature of below 1 K, using a dilution refrigerator. We also present data on the first attempts to trap CrH and discuss inelastic scattering with the Helium background gas as a possible loss mechanism preventing effective trapping.

Further experiments using CrD, MnH and MnD should give additional information on the exact role of inelastic scattering processes. First estimations indicate that trapping of MnH should in principle be feasible in our current setup, whereas trapping of CrH would require substantial modifications to our cryogenic system.

Q 71.7 Fr 12:15 6B

UV photodissociation studies of polyatomic molecular ions at milli-Kelvin temperatures — •David Offenberg, Chaobo Zhang, Bernhard Roth, and Stephan Schiller — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

Photodissociation spectroscopy is a commonly used tool to investigate molecular properties. The spectral resolution can be enhanced by reducing the molecules' thermal energy [1], as recently demonstrated on *diatomic* molecular ions [2]. Here, we present our initial advances towards photodissociation spectroscopy of *polyatomic* molecules.

As a first model system we use translationally cooled, singly protonated molecules of Glycyrrhetinic Acid (GA) – a biomolecule of mass 471 amu consisting of 80 atoms. In our apparatus, the molecular ions are generated by an electrospray ionization source, transferred to and stored in a radio-frequency trap together with laser-cooled barium ions. Due to their Coulomb interaction with the atomic coolant, they cool down from ambient temperature to the hundred milli-Kelvin range and can be kept and investigated under these low-temperature and nearly collisionless conditions for more than one hour [3]. We have measured the photodissociation rate of GA ions using a single-frequency cw-laser at 266 nm. In further studies we plan to investigate the feasibility of resonance enhanced two-photon dissociation with additional tunable IR lasers.

[1] O. Boyarkin et al., J. Am. Chem. Soc. 128, 2816 – 2817 (2006)
[2] B. Roth et al., Phys. Rev. A 74, 040501(R) (2006)
[3] A. Ostendorf et al., Phys. Rev. Lett. 97, 243005 (2006)

Q 71.8 Fr 12:30 6B

Preparation of single molecular ions for time resolved electron diffraction — •Steffen Kahra, Günther Leschhorn, Axel Friedenauer, Hector Schmitz, Ernst Fill, and Tobias Schätz — Max-Planck-Institut für Quantenoptik, 85741 Garching

We present a scheme for the preparation of isolated single molecular ions. The ions will be confined in a linear Paul-trap. This allows besides for excellent spacial positioning with accuracy of only a few micrometers also for application of common sympathetic cooling techniques. Since the ions are accessible to manipulation by laser and electron beams, for example, a wide range of experimental opportunities arises. Investigation of one of the most intriguing realms in nature comes into reach when we combine our tool with the recent and foreseeable developments made in the field of short electron pulse generation. Doing electron or X-ray diffraction (100 fs) on isolated species in a time resolved manner, might provide us with direct information about the electronic motion inside the charged molecule. Hence, observing the molecule by means of diffraction and taking spectroscopic knowledge into account is expected to help us understand how the dynamic structure of an excited molecule on the few femtosecond timescale really evolves.

Supported by: IMPRS, MAP, MPG

Q 72: Ultrakalte Moleküle II (gemeinsam mit MO)

Zeit: Freitag 14:00–15:45 Raum: 6J

Gruppenbericht Q 72.1 Fr 14:00 6J

A Mott-like State of Molecules — •Stephan Dürr, Thomas Volz, Niels Syassen, Dominik Bauer, Eberhard Hansis, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Mott insulators of ultracold gases in optical lattices bear a great potential for applications in quantum simulations and quantum information processing, in particular when using particles with a long-range dipole-dipole interaction, such as polar molecules. Here we show the realization of a Mott-like state of molecules. The molecules are produced from an atomic Mott insulator with a density profile chosen such that the central region of the gas contains two atoms per lattice site. A Feshbach resonance is used to associate the atom pairs to molecules. Remaining atoms can be removed with blast light. In order to show that the resulting state has exactly one molecule per lattice site, the molecules are dissociated and the lattice depth is reduced. This restores phase coherence which is seen in time-of-flight images. Additional information is obtained from measurements of the excitation spectrum

[1].

[1] T. Volz et al. *Nature Physics* **2**, 692–695 (2006).

Q 72.2 Fr 14:30 6J

Resonant enhancement in ultracold atom-dimer scattering — •Steven Knoop[1], Michael Mark[1], Francesca Ferlaino[1], Johann Georg Danzl[1], Harald Schöbel[1], Tobias Kraemer[1], Hanns-Christoph Nägerl[1], and Rudi Grimm[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria

Ultracold quantum gases with tunable interaction yield the unique possibility to study universal properties of resonantly interacting few-body systems. A clear example has been the experimental evidence for Efimov quantum states in an ultracold Cs gas [1]. Their signature was found in a giant three-body loss feature due to resonant coupling between three free atoms and an Efimov trimer. Following the Efimov scenario an Efimov trimer can also couple to an atom and a dimer [2].

Here we will report on the experimental observation of resonant enhancement in the inelastic atom-dimer collision rate. By means of Feshbach association ultracold dimers in a weakly bound s-wave state are produced and trapped in an optical dipole trap [3]. Together with the remaining atoms they form an atom-dimer mixture which is at a temperature of 250 nK. By selectively measuring the loss of dimers the inelastic atom-dimer collision rate is obtained. A resonance in the collision rate at a scattering length of 400 Bohr radii is found which might represent an atom-dimer Efimov resonance.

[1] T. Kraemer et al, Nature 440, 315 (2006); [2] E. Braaten and H.-W. Hammer, Phys. Rep. 428, 259 (2006); [3] M. Mark et al, submitted to PRA (2007)

Q 72.3 Fr 14:45 6J

Formation and Detection of ultracold LiCs molecules — •Jörg Lange, Stephan Kraft, Johannes Deiglmayr, Christian Giese, Leif Vogel, Christian Glück, Peter Staanum, Roland Wester, and Matthias Weidemüller — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

We report on the first observation of ultracold LiCs molecules, formed by the trapping light in a double species magneto optical trap. After one-colour two-photon ionization, the molecules are detected with high resolution time-of-flight mass spectrometry. The molecule formation rate coefficient is found to be in the range of $10^{-18}\,\mathrm{cm^3\,s^{-1}}$ to $10^{-16}\,\mathrm{cm^3\,s^{-1}}$ [1]. This is an order of magnitude smaller than for other heteronuclear alkali dimers formed under comparable condtions, but in agreement with predictions.

In current experiments, we study controlled photoassociation via the [Li($2S_{3/2}$)+Cs($6P_{3/2}$)]-asymptote to increase the production rate of electronic ground state molecules. Together with a more detailed investigation of the resonantly enhanced two-photon ionization process, precise information on the rovibrational structure of the involved LiCs-potentials can be obtained.

[1] S. D. Kraft *et al.*, J. Phys. B **39**, S 993 (2006)

Q 72.4 Fr 15:00 6J

Experiments with an ultracold ^{6}Li-^{40}K Fermi-Fermi mixture — •Eric Wille[1,2], Frederik Spiegelhalder[1], Gabriel Kerner[1], Devang Naik[1], Andreas Trenkwalder[1,2], Clarice Aiello[1,2], Raquel Chulia-Jordan[1], Gerhard Hendl[1], Florian Schreck[1], and Rudolf Grimm[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Institut für Experimentalphysik, Innsbruck, Austria

Degenerate mixtures of the two fermionic species ^{6}Li and ^{40}K provide a new, intriguing many-body quantum system, which allows to study strongly interacting Fermi gases consisting of atoms with unequal masses. We have recently created our first molecular $^6Li_2$ BEC in a newly build machine. The ^{6}Li atoms were loaded into a crossed-beam optical dipole trap realized with a 100 W near-infrared fiber laser. The sample was cooled evaporatively by lowering the laser power by three orders of magnitude within 5 s, leading to quantum degeneracy of $^6Li_2$. To study heteronuclear mixtures, we have simultaneously trapped ^{40}K and ^{6}Li. We have sympathetically cooled ^{40}K with ^{6}Li during the evaporation process in the dipole trap. We will present our first investigations on heteronuclear interactions.

Q 72.5 Fr 15:15 6J

Molecular wavepacket oscillations of ultracold Rb_2 — •A. Merli[1], S. Weber[1], F. Sauer[1], M. Plewicki[1], F. Weise[1], S. Birkner[1], L. Wöste[1], A. Lindinger[1], W. Salzmann[2], J. Eng[2], T.G. Mullins[2], M. Albert[2], R. Wester[2], and M. Weidemüller[2] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D 14195 Berlin — [2]Physikalisches Institut, Universität Freiburg, Hermann Herder Str. 3, D 79104 Freiburg i. Br.

Our long-term aim is the efficient formation and vibrational cooling of ultracold Rb_2 molecules to their vibrational ground state by pump-dump like processes via an intermediate excited state, theoretical predicted by [1]. First pump-probe experiments with femtosecond light pulses in a dark SPOT magneto-optical trap were successfully performed in order to gain information about the molecular dynamic in the excited state of the Rb-Dimer. The observed wavepacket oscillation periods are depending from the cut-off of the spectral frequencies (made in the Fourier plane of a zero-dispersion compressor) in the pump pulse below the Rb atomic D1 and D2 resonances, respectively. Linear chirps of the excitation pulse influence the pump-probe spectra. Measurements at different bright state fractions [2] of the trapped molecules provide advice about the origin of the molecules which are oscillating.

[1] C. P. Koch, R. Kosloff, and F. Masnou-Seeuws, Phys. Rev . A, 73, 043409, 2006

[2] C.G. Townsend, N.H. Edwards, K.P. Zetie, C.J.Cooper, J. Rink, and C.J Foot, Phys. Rev.A 53, 1702, 1996

Q 72.6 Fr 15:30 6J

Temperature shift of a triatomic Efimov resonance in an ultracold gas of cesium atoms — •Almar Lange[1], Bastian Engeser[1], Karl Pilch[1], Andrea Prantner[1], Hans-Christoph Nägerl[1], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften

We report on measurements of three-body recombination at negative scattering lengths in an ultracold cesium gas. Magnetic tuning of the scattering length by means of a Feshbach resonance is used to investigate a strong loss peak resulting from an Efimov resonance. The position of maximum loss shifts significantly when the temperature of the gas is varied, providing quantitative insight into the evolution of an Efimov state into a triatomic continuum resonance. We compare our measurements with several calculations that extend the theory of three-body recombination to non-zero collision energies.

In our apparatus we prepare an ultracold gas of cesium atoms in an optical surface trap. The main part is a glass cell with an integrated prism, providing good optical access and accurate and fast control of the magnetic field. The atoms are located a few micrometers above the dielectric prism surface. Raman sideband and Sisyphus cooling are applied to reach temperatures of a few μK. We further reduce the temperature below 100nK via evaporative cooling. We then apply different magnetic fields and measure the rate of three-body recombination.

Q 73: Laserspektroskopie II

Zeit: Freitag 14:00–15:45 Raum: 5K

Q 73.1 Fr 14:00 5K

Einsatz von Quantenkaskadenlasern in der Molekülspektroskopie zur Detektion von Sprengstoffen — •Christoph Bauer[1], Claus Romano[2], Ashwini Kumar Sharma[2], Ulrike Willer[1,2], Antoine Muller[3] und Wolfgang Schade[1,2] — [1]TU Clausthal, LaserAnwendungsCentrum, Arnold-Sommerfeld-Str.6, 38678 Clausthal-Zellerfeld — [2]TU Clausthal, Institut für Physik und Physikalische Technologien, Leibnizstrasse 4, 38678 Clausthal-Zellerfeld — [3]Alpes Lasers SA , 1-3 Max.-de-Meuron, C.P. 1766 , CH-2001 Neuchâtel

Die schnelle Detektion von Explosivstoffen ohne vorherige Probenaufbereitung ist von zentraler Wichtigkeit in der Sicherheitstechnik. Es wird zum einen ein kompakter Aufbau zur Fernerkennung von Sprengstoffen und zum anderen eine Möglichkeit zur Detektion von Flüssigsprengstoffen wie TATP vorgestellt. In diesen Anwendungen kommen Quantenkaskadenlaser (QCL) mit unterschiedlichen Emissionswellenlängen im mittleren infraroten Spektralbereich (MIR) zum Einsatz. Das Fernerkennungssystem wird durch eine Kombination aus einem Faserverstärker (λ=1,55μm, E_P=200μJ, Repetitionsrate f_{rep}=4kHz) und einem gepulsten QCL (λ=5,3μm, Repetionsrate f_{rep}=400kHz, P=2mW) realisiert. Vor- und Nachteile des cw-Betriebs gegenüber dem gepulsten Betrieb der Laser bei der fasergekoppelten TATP Detektion werden vorgestellt und das Potential der QCL basierten MIR-Spektroskopie in der Sicherheitstechnik wird diskutiert.

Q 73.2 Fr 14:15 5K

Aufbau eines temperaturstabilen Cavity Leak-Out Spektrometers — •Kathrin Heinrich, Thomas Fritsch, Peter Hering und Manfred Mürtz — Universität Düsseldorf, Institut für Lasermedizin

Im menschlichen Atem befinden sich eine Reihe von Spurengasen in geringsten Konzentrationen im ppb (parts per billion) Bereich, die Rückschlüsse auf verschiedene Prozesse im Körper ermöglichen. Für den Echtzeitnachweis dieser Spurengase wird ein Verfahren benötigt, das gleichzeitig höchstempfindlich und schnell ist. Die Cavity Leak-Out Spektroskopie (CALOS) ermöglicht einen Nachweis dieser Spurengase im sub-ppb Bereich mit einer Zeitauflösung unter 1 s. Auf der Basis eines CO Fundamentalbandenlasers, der im mittleren Infrarot (Wellenlänge 4,7-5,4 μm) emittiert, wird die Abschwächung des Laserlichtes beim Durchgang durch die Gasprobe gemessen. Diese befindet sich in einem optischen Resonator, der aus zwei hochreflektierenden Spiegeln besteht, wodurch eine effektive Absorptionsweglänge von 10 km erreicht wird. Vorgestellt wird der Aufbau eines neuen, temperaturstabilen Resonators und erste Ergebnisse.

Q 73.3 Fr 14:30 5K

Doppler-Free Spectroscopy of Lines in the $X^1A_1 \rightarrow A^1A_2$ Transition of Formaldehyde — •Martin Zeppenfeld, Michael Motsch, Pepijn W. H. Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans Kopfermann Str. 1, 85748 Garching, Germany

One of the main obstacles to measuring optical molecular spectra at the natural linewidth is Doppler broadening. Doppler spreading can be circumvented using saturation spectroscopy, but applying this method to weak transitions can be a significant challenge. We employ a number of experimental techniques to obtain Doppler-free signals of lines in the $X^1A_1 \rightarrow A^1A_2$ transition. These include reduction of the laser beam diameter, use of a multi-pass cell and frequency modulation.

We have also developed a theoretical model to understand the observed height of our Doppler-free signals. Such a model must take into account spatial distribution of laser beam intensity, which has been neglected in previous models. We introduce the model and demonstrate its verification in our formaldehyde experiment. Comparison between theory and experiment allows us to obtain information about the molecular properties.

Q 73.4 Fr 14:45 5K

Verkürzung der Besetzungslebensdauer in CdTe Quantenpunkten durch Laserbestrahlung — •Benjamin Freyer, Axel Heuer, Christian Spitz und Ralf Menzel — Institut für Physik, AG Photonik Universität Potsdam, Am Neuen Palais 10, 14469 Potsdam

Bei der nichtlinearen Messung der Besetzungslebensdauer von CdTe Farbgläsern von Schott mit Hilfe der sättigbaren Absorption, wurde eine variable Besetzungslebensdauer beobachtet.

Es ist bekannt, dass die Besetzungslebensdauer von Halbleiter Quantenpunkten abhängig ist von der relativen Lage der betrachteten Energie zur Bandkante der Quantenpunkte. Dabei verschiebt sich die Bandkante der Quantenpunkte mit zunehmender Größe zu niedrigeren Energien und damit ergibt sich ggf. für eine gegebene Beobachtungsenergie eine Verkürzung der Besetzungslebensdauer.

In der vorliegenden Arbeit wurde nun ebenfalls eine Verkürzung der Besetzungslebensdauer beobachtet, die aber auf einer Vorbehandlung der Quantenpunkte mit ultrakurzen Laserpulsen beruht. Es werden experimentelle Ergebnisse und erste Modellvorstellungen für die Anregungsrelaxation und die Auswirkungen der Laserbestrahlung vorgestellt.

Q 73.5 Fr 15:00 5K

Ultra-sensitive surface absorption spectroscopy using sub-wavelength diameter optical fibers — •Eugen Vetsch[1,2], Florian Warken[1], Dieter Meschede[1], Moritz Sokolowski[3], and Arno Rauschenbeutel[1,2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz — [3]Institut für Physikalische und Theoretische Chemie, Universität Bonn, Wegelerstr. 12, 53115 Bonn

The guided modes of sub-wavelength diameter optical fibers exhibit a pronounced evanescent field surrounding the fiber. The absorption of particles on the fiber surface is therefore readily detected via the fiber transmission. We show that the resulting absorption signal for a given surface coverage can be orders of magnitude higher than for conventional surface spectroscopy methods. As a demonstration, we present measurements on sub-monolayers of 3,4,9,10-perylene-tetracarboxylic dianhydride (PTCDA) molecules at ambient conditions, revealing the agglomeration dynamics on a second to minutes timescale.

We acknowledge financial support by the DFG research unit 557.

Q 73.6 Fr 15:15 5K

Experimental investigations on the splitting of coherent population trapping resonances by the nuclear magnetic moment — •Roland Lammegger, Ivan Vasari, Christian Neureiter, and Laurentius Windholz — Inst. f. Experimentalphysik, Techn. Univ. Graz, Austria

Coherent population trapping (CPT) is a resonance phenomenon due to a quantum mechanical interference effect within an atomic system. The resonantly driven atomic level population is being trapped into a superpositional dark state, yielding the atomic medium transparent for the exciting electromagnetic fields. The observation of this effect requires a special electronic structure ($\Lambda-$system) and suitable lifetimes which can be found e.g. in alkali atoms.

We present experimental investigations on the behavior of the CPT resonances split by the nuclear magnetic moment under different external magnetic fields, laser polarizations and laser intensities. We focus our considerations on a special type of the $\Lambda-$System formation. In this case the center of gravity of the pair of split CPT resonances (called pseudoresonance) is sensitive to external magnetic fields only to second order in the magnetic field strenght.

The short term frequency stability of this pseudoresonance approaches the level of $10^{-14}/\sqrt{\tau}$. Thus such resonances seems to be a good candidate for applications in compact atomic clocks used e.g. in GPS receivers and Satellites.

Q 73.7 Fr 15:30 5K

Investigation of fast changes of the excitation energy transfer efficiency in the cyanobacterium Acaryochloris marina by time- and wavelength resolved fluorescence spectroscopy — •Franz-Josef Schmitt[1], Karin Wache[1], Justus Fuesers[1], Hann-Jörg Eckert[2], and Hans Joachim Eichler[1] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Strasse des 17. Juni 135, 10623 Berlin — [2]Max-Volmer-Laboratorium, Technische Universität Berlin, Strasse des 17. Juni 135, 10623 Berlin

The interaction of the photosynthetic subunits and especially the mechanisms regulating the energy transfer are presently interesting

and open fields in photosynthesis research. In this study we use time- and wavelength-correlated single photon counting to investigate the fluorescence dynamics in living cells of A.marina simultaneously in the visible and near infrared spectrum. Very short measurement times, low excitation light intensities and a high signal to noise ratio are attributes necessary to investigate photosynthetic processes in sensitive biological samples, when the light emission varies due to metabolic changes. Exposing of living cells of A.marina to low temperature (0°C) was found to cause a decoupling of the membrane extrinsic phycobiliprotein antenna from Photosystem II, which is partially reversible when the sample is kept at 25 °C for a short time. This reversible decoupling of the phycobiliprotein antenna could be a protection mechanism against photo damage of the reaction center of Photosystem II during cold stress .