Q 21: Poster I

Time: Tuesday 16:00–19:00 Location: Lichthof

Q 21.1 Tu 16:00 Lichthof

Excitation spectrum of Bose-Einstein condensates in correlated disorder — •Christopher Gaul and Cord A. Müller — Physikalisches Institut, Universität Bayreuth, Deutschland

We consider a Bose-Einstein condensate in a speckle disorder potential. By a saddlepoint expansion of the Gross-Pitaevskii energy functional around the disordered groundstate [1], we compute the effective dispersion relation of Bogoliubov excitations perturbatively for weak disorder. Analytical predictions for the mean free path, the speed of sound and the density of states are derived for any dimension and the entire parameter space of healing length, disorder correlation length, and excitation wavelength. Notably, the speed of sound turns out to be reduced by correlated disorder [2]. We confirm our prediction in 1D by numerical simulations.

[1] Gaul and Müller, Europhys. Lett., 83, 10006 (2008)

[2] Gaul et al. PRA 80, 053620 (2009)

Q 21.2 Tu 16:00 Lichthof

Matter Wave Turbulence — •Boris Nowak, Christian Scheppach, and Thomas Gasenzer — Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg

Turbulence phenomena are studied in an ultracold Bose gas away from thermal equilibrium analytically and numerically. In the framework of functional quantum field theory turbulence fixed points of the dynamical evolution can be characterized analytically in terms of universal scaling exponents of correlation functions. It is shown that certain scaling exponents derived within the Kolmogorov theory of wave turbulence are not necessary found in the full dynamical theory considered here. Our results indicate, however, that the Kolmogorov picture remains useful even in the strong turbulence regime at long wavelengths. To explore possibilities for accessing this strong turbulence regime at low momenta in experiments with ultracold atomic gases, we study the dynamics numerically by means of c-field methods.

Q 21.3 Tu 16:00 Lichthof

Second Josephson oscillations — •Martin P. Strzys and James R. Anglin — Technische Universität Kaiserslautern, FB Physik, 67663 Kaiserslautern, Germany

A four-mode Bose-Hubbard model with two highly differing tunneling rates is considered as a model for two quantum systems in thermal contact. In addition to coherent particle exchange a novel slow second Josephson mode, which is not predicted by linear Bogoliubov theory, can be identified by a series of Holstein-Primakoff transformations. This energy exchange mode can be interpreted as heat exchange between the subsystems, is in close analogy to second sound in liquid helium, and may shed light on the emergence of thermodynamics in mesoscopic systems.

Q 21.4 Tu 16:00 Lichthof

Dynamics of cold Bose gases: effects of incoherent scattering — •Luis Rico-Pérez and James R. Anglin — Technische Universität Kaiserslautern, Germany

The correct description of the dynamics of a Bose gas at low temperatures is of extreme importance in the study of trapped BECs. Although some previous theoretical treatments can bring some light on the behavior of the non-condensed fraction of the gas, the condensation process and other interesting non-equilibrium phenomena, a global - and simple - formalism describing all of these is still necessary. We develop a formalism for the evolution of a cold and dilute Bose gas based in S-wave scattering calculations. In the Wigner representation and under certain assumptions, classical behavior terms appear. We use these terms in simulations of simple systems, like the double well potential, to check its validity and describe the effect that incoherent scattering processes have in the tunneling of particles.

Q 21.5 Tu 16:00 Lichthof

Collisional properties of ultracold ^{40}Ca atoms — •Oliver Appel, Sebastian Kraft, Felix Vogt, Fritz Riehle, and Uwe Sterr — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

We recently succeeded in achieving a ^{40}Ca Bose-Einstein condensate [1]. The understanding of collisional properties like the ground state scattering length and the 3-body loss coefficient were crucial steps on our way to the BEC. On the other hand the dense ensemble near the critical temperature provides us with new opportunities to study collisions both between ground state and excited atoms. Here we present various methods of determining the ground state scattering length and the 3-body loss coefficient as well as the current status of our photoassociation measurements on the $^1S_0$–$^3P_1$ asymptote.

[1] S. Kraft, F. Vogt, O. Appel, F. Riehle, and U. Sterr, Phys. Rev. Lett. **103**, 130401 (2009).

Q 21.6 Tu 16:00 Lichthof

Towards the realization of an erbium BEC — •Henning Brammer, Riad Bourouis, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany

The erbium atom in its $4f^{12}6s^2\ ^3H_6$ ground state has a large orbital angular momentum of L = 5. Quantum gases realized so far have an S-ground state configuration, so that in far detuned laser fields with detuning above the upper state fine structure splitting the trapping potential is determined by the scalar electronic polarizability. In contrast, for an erbium quantum gas with its $L > 0$ ground state the trapping potential also for far detuned dissipation-less trapping laser fields becomes dependent on the internal atomic state (spin).

Moreover, Raman transitions between different ground state spin projections become possible with e.g. Nd:YAG laser fields, which can allow for a Fourier-synthesis of in principle arbitrarily shaped lattice potentials using the technique of multiphoton lattices. This has prospects for novel quantum phase transitions in e.g. strongly correlated frustrated lattice configurations.

We present experimental work aimed at the laser cooling and dipole trapping of atomic erbium, which should then allow for evaporative cooling towards quantum degeneracy. The setup including both our vacuum and optical system will be shown. For frequency stabilization of the cooling laser, we use a home-built erbium hollow chathode lamp. The laser frequency has been stabilized to the erbium cooling transition near 400.9 nm by Doppler-free FM-spectroscopy. These results and the current status of the cooling experiment will be reported.

Q 21.7 Tu 16:00 Lichthof

Dynamics of 1D fermionic systems using Matrix Product States — •Michael Lubasch, Mari Carmen Bañuls, and Juan Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, D-85748 Garching, Germany

The focus of our work lies on the Fermi-Hubbard model which is an effective model for strongly interacting fermions on a lattice allowing to study the interplay between kinetic energy, local interaction and Pauli principle. More precisely, we investigate the 1D Fermi-Hubbard model in a harmonic confinement. This is experimentally realized by ultracold fermions in an optical lattice which is confined by a superimposed harmonic trap. All theoretical parameters of the model can be tuned precisely in the experiment.

Concerning our numerical approach, the confined 1D Fermi-Hubbard Hamiltonian can be mapped to a local 1D spin Hamiltonian. These kinds of local spin Hamiltonians are perfectly suited for investigation within the framework of Matrix Product States (MPS). MPS provide an alternative formulation of the Density Matrix Renormalization Group, laying particular emphasis on the amount of entanglement present in the state (Verstraete et al., PRL 93, 227205 (2004)).

Within this framework, we simulate thermal states and the time evolution of easily preparable initial states as they may appear in current experiments with ultracold fermions.

Q 21.8 Tu 16:00 Lichthof

Towards a two-species quantum degenerate gas of ^{6}Li and ^{133}Cs — •Rico Pires, Marc Repp, Kristina Meyer, Johannes Deiglmayr, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Heidelberg, Germany

We present the design of the new experimental apparatus currently being built. The setup will allow the formation of clouds of ultracold Li and Cs atoms via standard laser cooling techniques. Successive loading into optical dipole traps and subsequent evaporative cooling enables us to achieve quantum degeneracy. From this starting point, two different routes can be taken. The ramping of Feshbach fields followed by stimulated Raman adiabatic passage (STIRAP) can be used to create deeply bound LiCs molecules. As these exhibit the largest dipole moment among all alkali atom combinations, they present a promising candidate for the observation of dipolar effects such as new quantum phases. On the other side, the ability to tune the interaction strength via the magnetic field, allows one to study few body effects in this ensemble.

Q 21.9 Tu 16:00 Lichthof

Towards disorder experiments in 2D optical lattices — •Mathis Baumert[1], Nadine Meyer[1,2], Mike Holynski[1], Amy Rudge[1], Jochen Kronjäger[1], and Kai Bongs[1] — [1]School of Physics and Astronomy, University of Birmingham, UK — [2]Institute for Laser Physics, University of Hamburg, Germany

We are presenting progress towards a new setup for a ^{87}Rb - ^{40}Ka quantum gas mixture experiment aiming for in situ single site resolution in order to investigate disorder effects in the phase diagram. The disorder will be implemented either by the fermionic species or by a spatial light modulator (SLM).

In addition the interactions can be tunable via well known Feshbach resonances to look into Bose glass phases and Anderson localisation in 2D.

In this poster we display glueing techniques for glass-metal window seals and a low power consuming magnetic coil design. We also present simulations for optical lattices in 2D and possible realisations of arbitrary optical potentials via SLM techniques.

We acknowledge support by EPSRC under grants EP/E036473/1 and EP/H009914/1.

Q 21.10 Tu 16:00 Lichthof

Parametric amplification of vacuum fluctuations in spinor Bose-Einstein condensates — Carsten Klempt[1], Oliver Topic[1], Garu Gebreyesus[2], Manuel Scherer[1], •Bernd Lücke[1], Frank Deuretzbacher[2], Phillip Hyllus[3], Wolfgang Ertmer[1], Luis Santos[2], and Jan Arlt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Institut für theoretische Physik, Leibniz Universität Hannover — [3]INFM BEC, Trento

The nature of the vacuum state and its fluctuations constitutes one of the most fascinating aspects of modern physics. Particularly in optics parametric amplification of such fluctuations is an important tool for generating non-classical states of light. These concepts can be transfered to matter-wave optics using spinor Bose-Einstein condensates.

To demonstrate this we use a sample initially prepared in the $m_F = 0$ state, where spin-changing collisions triggered by quantum fluctuations may lead to the creation of correlated pairs in $m_F = \pm 1$. We show that the pair creation efficiency is strongly influenced by the interplay between the quadratic Zeeman effect and the confinement in the external trapping potential. This confinement has previously been neglected in homogeneous approximations and leads to a multi-resonant dependence on the magnetic field.

On these resonances we conclusively demonstrate that the system can act as a parametric amplifier for vacuum fluctuations, providing a new microscope to investigate the vacuum state and a promising method for entanglement and squeezing production in matter waves.

Q 21.11 Tu 16:00 Lichthof

Far-from-equilibrium dynamics in a Kondo lattice of ultracold fermionic alkaline-earth atoms — •Matthias Kronenwett[1], Thomas Gasenzer[1], Michael Foss-Feig[2], and Ana Maria Rey[2] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]JILA, University of Colorado, Boulder CO-80309, USA

We study the dynamics of ultracold Fermi gases far from thermal equilibrium. We employ a functional-integral approach based on the Schwinger-Keldysh closed time path integral to derive the two-particle irreducible (2PI) effective action. From this, the two-point correlation functions are determined self-consistently. The action is expanded in inverse powers of N, where N is the number of atomic hyperfine states. The dynamic equations are derived in next-to-leading order of this expansion. This approach reaches far beyond mean-field theory and includes quantum statistical aspects of equilibration dynamics. This formalism is especially suited to describe far-from-equilibrium dynamics in a Kondo lattice of ultracold fermionic alkaline-earth atoms where N can be as large as 10.

Q 21.12 Tu 16:00 Lichthof

Massless Dirac-Weyl Fermions in a $\mathcal{T}_3$ Optical Lattice — •Dario Bercioux[1,2], Daniel F. Urban[2,3], Hermann Grabert[1,2], and Wolfgang Haeusler[2,4] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [3]Departamento de Física de la Materia Condensada C-XII, Facultad de Ciencias, Universidad Autónoma de Madrid, E-28049, Madrid, Spain — [4]Institut für Physik, Universität Augsburg, D-86135 Augsburg, Germany

We propose an experimental setup for the observation of quasi-relativistic massless Fermions. It is based on a $\mathcal{T}_3$ optical lattice, realized by three pairs of counter-propagating lasers, filled with fermionic cold atoms. We show that in the long wavelength approximation the $\mathcal{T}_3$ Hamiltonian generalizes the Dirac-Weyl Hamiltonian for the honeycomb lattice, however, with a larger value of the pseudo-spin $S = 1$. In addition to the Dirac cones, the spectrum includes a dispersionless branch of localized states producing a finite jump in the atomic density. Furthermore, implications for the Landau levels are discussed.
Bercioux *et al.*, Phys. Rev. A **80**, 063603 (2009).

Q 21.13 Tu 16:00 Lichthof

A new type of hexagonal optical lattice for ultracold quantum gases — •Julian Struck, Parvis Soltan-Panahi, Wiebke Plenkers, Andreas Bick, Georg Meineke, Christoph Becker, Patrick Windpassinger, and Klaus Sengstock — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg

Ultracold atoms in optical lattices offer unique access to controllable quantum many-body systems, reaching from the weakly-interacting to the strongly-correlated regime. Here we report on the realization of a new type of optical lattice with a hexagonal symmetry.
The lattice laser configuration allows for the generation of spin-dependent as well as spin-independent optical potentials by changing the polarizations of the beams. Our experimental setup gives us the full control over the internal degrees of freedom in the hyperfine ground-state manifold of ^{87}Rb. This enables us to prepare and to investigate multi-component systems in this type of lattice. We will report on important experimental aspects like the phase stabilization of the lattice beams.
The first results obtained in the spin-dependent lattice show rich prospects with respect to transport, interaction and entropy phenomena when mixtures of different spin-states are loaded in this lattice. The spin-independent lattice can be used to simulate the effects of geometrical frustration on spins in the quantum magnetism regime.

Q 21.14 Tu 16:00 Lichthof

Momentum-resolved Bragg spectroscopy in optical lattices — •Jasper S. Krauser, Sören Götze, Philpp T. Ernst, Jannes Heinze, Malte Weinberg, Christoph Becker, and Klaus Sengstock — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

Quantum gases in optical lattices are particularly well suited to provide an experimental interface between quantum optics and solid-state physics. However, their detection and analysis, especially the characterization of their excitation spectrum, still remain challenging.

Here we report on a comprehensive study of superfluids in optical lattices by Bragg spectroscopy. We show systematic measurements of the band structure with momentum resolution over the whole first Brillouin zone and for different lattice depths. The results clearly show the influence of interaction on the excitations such as the sensitivity to density and particle numbers. In addition, we discuss several technical issues like the experimental setup and methods.

Our measurements demonstrate the applicability of Bragg spectroscopy in optical lattices and pave the way for detailed studies of strongly correlated phases and quantum gas mixtures.

Q 21.15 Tu 16:00 Lichthof

Bosonic Optical Lattice with a Staggered Magnetic Field — Georg Wirth, •Matthias Ölschläger, and Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg

Using a bichromatic light-shift potential a two-dimensional square optical lattice with a time-modulation term can be realized that introduces rotation with alternating directions in each plaquette. This scenario can be described by a Hubbard model with an additional staggered magnetic field. For bosons, besides the uniform superfluid and Mott insulating phases, known from the conventional Bose-Hubbard model, the zero-temperature phase diagram exhibits a novel kind of finite-momentum superfluid phase, characterized by quantized staggered rotational flux in each plaquette.

In addition to a brief physical motivation we present the experimental progress.

Q 21.16 Tu 16:00 Lichthof

Fermionic quantum gases with tunable interactions in optical lattices — •Michael Schreiber[1], Ulrich Schneider[1], Jens Philipp Ronzheimer[1], Lucia Hackermüller[2], Thorsten Best[3], Sebastian Will[1], Simon Braun[1], Tim Rom[1], Kin Chung Fong[4], and Immanuel Bloch[1] — [1]Ludwig-Maximilians-Universität München — [2]University of Nottingham, UK — [3]Albert-Ludwig Universität Freiburg — [4]Caltech, Pasadena, USA

Fermionic atoms in optical lattices form a very rich many-body system that can serve as a quantum simulator for condensed matter physics. The atoms implement the Fermi Hubbard Hamiltonian with high experimental control over the relevant parameters.

In our system we sympathetically cool ^{87}Rb and ^{40}K in an optically plugged quadrupole trap and an optical dipole trap. After evaporation, a balanced spin mixture of ^{40}K atoms, whose interactions can be changed using a Feshbach resonance, is loaded into a blue-detuned optical lattice.

In the case of repulsive interactions we observe a transition from compressible, metallic states over Mott-insulating to band insulating states for increasing harmonic confinements. On the attractive side we investigate an anomalous expansion, which is related to the pseudogap phase, when the interaction becomes strongly attractive. In addition we study the free expansion of a band insulator in a homogeneous lattice and identify different regimes ranging from ballistic expansion to diffusion dynamics. The latter can effectively suppress the expansion of the high density core of the cloud.

Q 21.17 Tu 16:00 Lichthof

Experiments on entanglement of ultracold atoms on an atom chip — •Jad Camille Halimeh[1,2], Max Fabian Riedel[1,2], Pascal Böhi[1,2], Theodor Wolfgang Hänsch[1,2], and Philipp Treutlein[1,2] — [1]Ludwig-Maximilians-Universität, 80799 München, Germany — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

Atom chips provide a robust, compact, and scalable experimental setup that is ideal for the development, implementation, and testing of quantum-enhanced technologies such as quantum information processing, quantum simulation, and quantum metrology. On our atom chip, state-selective microwave near-field potentials allow for the coherent manipulation of both internal and motional states of ultracold atoms. Elastic collisional interactions are used to create multi-particle entanglement within a single Bose-Einstein condensate (BEC). Proposals to further use these microwave near-field potentials to realize a quantum phase gate with single atoms on an atom chip have been presented. We are currently investigating methods to experimentally entangle two small BECs. This will allow us to study quantum collisional phase shifts and investigate the possibility of using small BECs for quantum information processing.

Q 21.18 Tu 16:00 Lichthof

Non-abelian atom optics with cold atoms — •Torben Alexander Schulze[1], Ernst-Maria Rasel[1], and das QUANTUS Team[1,2,3,4,5,6,7,8,9] — [1]Institut für Quantenoptik, LU Hannover — [2]ZARM, Uni Bremen — [3]Institut für Physik, HU Berlin — [4]Institut für Laserphysik, Uni Hamburg — [5]Institut für Quantenphysik, Uni Ulm — [6]MPQ, München — [7]Institut für angewandte Physik, TU Darmstadt — [8]Midlands Ultracold Atom Research Centre, University of Birmingham, UK — [9]FBH, Berlin

The flexibility and the versatility of ultra-cold gases allowed for exploring a multitude of aspects in solid state physics, which are very difficult to observe in condensed matter systems where the control of the order parameter or the interaction impose many challenges. However, the broad spectrum of possible applications is limited by the charge neutrality of the atoms. This motivates the quest for Artificial Electromagnetism, where atoms mimic charged particles in electromagnetic fields. In our project, we investigate realistic schemes for non-abelian potentials with ultra-cold quantum gases based on spatially dependent atom-light-interaction. In such systems, fascinating effects could be observed, i.e. Double and Negative Reflection, the non-Abelian Aharonov-Bohm effect or quasi-relativistic behavior of cold atoms.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM0835-0839.

Q 21.19 Tu 16:00 Lichthof

Optical interface created by laser-cooled atoms trapped in the evanescent field surrounding an optical nanofiber — •Rudolf Mitsch, Melanie Müller, Daniel Reitz, Eugen Vetsch, Samuel T. Dawkins, and Arno Rauschenbeutel — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We optically trap neutral cesium atoms close to the surface of an optical nanofiber with a diameter of 500 nm. The atoms are cooled with a standard magneto-optical-trap and loaded into a 1d optical lattice formed 200 nm above the fiber surface by a two-color evanescent field surrounding the fiber. The red- and blue-detuned trap lasers are far detuned and have a total power of about 40 mW, resulting in a trap depth of a few hundred μK. In order to detect the atoms in the trap, we measure the transmission of a weak resonant probe beam, launched through the fiber. At resonance, each atom absorbs about one percent of the probe via evanescent field coupling, yielding a high optical density of up to 18 for about 2000 trapped atoms. In the dispersive regime, we measure the interaction-induced phase shift experienced by the probe via the effect on its polarization state. Finally, using an optical conveyor belt technique, we demonstrate transport of the atoms along the fiber. Our work opens the route towards the realization of hybrid quantum systems that combine atoms with, e.g., solid state quantum devices and towards non-linear optics applications based on electromagnetically induced transparency.

Financial support by the ESF (EURYI Award) and the Volkswagen Foundation (Lichtenberg Professorship) is gratefully acknowledged.

Q 21.20 Tu 16:00 Lichthof

State-insensitive micro dipole trap for cesium atoms — •Piyaphat Phoonthong, Peter Douglas, Arne Wickenbrock, and Ferruccio Renzoni — Department of Physics and Astronomy, Univerity College London, WC1 5BT London, UK

We describe the experimental realization of a state-insensitive dipole trap for cesium atoms. By tightly focussing a running beam at the cesium "magic wavelength" of 935.6 nm, we demonstrate trapping of cesium atoms with lifetimes up to 2.5 s. The lifetime is strongly dependent on the actual atomic ground state, as verified with the use of a depumper to control ground state preparation. We measured a beam waist of $w_0 = (6.69 \pm 0.05)\mu$m. For the typical laser power used in the experiment, this results into a trap with depth of 2mK and measured oscillation frequencies equal to $\omega_r/(2\pi) = (18.5 \pm 0.1)$ kHz, $\omega_z/(2\pi) = (550 \pm 10)$ Hz.

Q 21.21 Tu 16:00 Lichthof

Cooling of an optically trapped ion — •Stephan Duewel[1,2], Christian Schneider[1], Martin Enderlein[1], Thomas Huber[1], and Tobias Schaetz[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Deutschland — [2]Ludwig-Maximilians-Universität München, München, Deutschland

Recently, an optical dipole trap for atomic ions has been realized by our group. However, the reported lifetime of a few milliseconds is limited because of heating. Here we want to discuss cooling schemes for ions in optical dipole traps and report on first experimental data. Due to large Stark shifts and the requirements on the polarization of the dipole trap lasers, cooling mechanisms have to be modified in a way as to suit this new regime of optical trapping. Arising possibilities for new experiments at the border between atom and ion trapping are presented.

Q 21.22 Tu 16:00 Lichthof

A new Experiment for the investigation of ultra-cold Potassium Rubidium Mixtures — Georg Kleine Büning, •Johannes Will, Jan Peise, Wolfgang Ertmer, and Jan Arlt — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

We present an experimental apparatus, which will allow us to investigate mixtures of ^{87}Rb with the bosonic isotopes of potassium (^{39}K, ^{41}K) and also enable the use of Feshbach-resonances. In the experiment the desired isotopes are collected in a magneto-optical trap from the background vapour. A magnetic quadrupole trap is used to transport the pre-cooled atoms mechanically into a glass cell with better vacuum. There the atoms are transferred into a novel hybrid optical and magnetic trap. Subsequently sympathetic cooling will be used to bring the desired isotopes of rubidium and potassium to quantum degeneracy. Finally a magnetic field can be tuned to the Feshbach resonances to manipulate the interaction strength.

Particular attention will be given to the design of the novel hybrid trap, which recently allowed for the realisation of a BEC of about 1x10^6 ^{87}Rb atoms, and the microwave force evaporation method.

Q 21.23 Tu 16:00 Lichthof

Ultracold fermionic potassium atoms in a CO_2 -laser optical dipole trap — •Christian Bolkart, Alexander Gatto, Ondrej Sobora und Martin Weitz — Institut für Angewandte Physik, Rheinische Friedrich-Wilhelms-Universität Bonn, Wegelerstrasse 8, 53111 Bonn

We will report progress in an experiment directed towards realisation of a fermionic potassium Fermi gas with all-optical techniques. The quantum gas will be used for studies of a supersolid phase transition with fermionic atoms in an optical lattice. In our experiment a cold atomic 40K beam emitted from a two-dimensional MOT is used to load a dark magneto optic trap. The density of the trapped atoms is increased by switching to a compressed MOT where we ramp our magnetic field to higher values and reduce the intensity of our repumping laser. We subsequently transfer 10^6 fermionic potassium atoms in the quasistatic dipole trapping potential realized with a tightly focused CO_2-laser beam with wavelength near 10.6 μm. After 500 ms of plain evaporation the dipole traped atomic cloud is further cooled by forced evaporation, i.e. the potential depth is reduced by lowering the optical power of the CO_2-laser. At the final potential depth approximately 40000 atoms remain at a temperature of 200 nK. With the given geometrical trap frequency of the dipole trap and the atom number after evaporation, we estimate $T/T_F = 0.8$.

In the future, we plan to further improve the forced evaporation in order to reach the quantum degenerate regime, i.e. $T/T_F < 0.5$. The present status of the the experiment will be summarised.

Q 21.24 Tu 16:00 Lichthof

Uniting BECs in a ring cavity — •Christine Gnahm, Simone Bux, Gordon Krenz, Claus Zimmermann, and Philippe A.W. Courteille — Physikalisches Institut, Universität Tübingen

For the realization of the atom laser, consisting of bright coherent matter waves, it is of interest to be able to replenish the source of Bose-Einstein condensate from which the laser beam emerges. This could be done by feeding it from a second independently produced condensate. One obstacle in uniting two independently produced Bose-Einstein condensates is the random relative phase of their macroscopic wave functions. Jaksch et al. [1] propose a scheme in which the phase difference can be damped by a ring cavity acting as an effective zero temperature reservoir. Our aim is to measure this damping in a Ramsey-type experiment. Two condensates in two hyperfine ground states of ^{87}Rb are produced. They are coherently coupled by a two photon transition, realized by a microwave-radiofrequency combination. Additionally, they are coupled via a spontaneously decaying intermediate level. One transition of this irreversible Raman process is driven by a light field, the other stimulated by a ring cavity. We will present first experimental results on the way to ultracold fusion of Bose-Einstein condensates.

[1] D. Jaksch, S. A. Gardiner, K. Schluze, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **86**, 4733 (2001)

Q 21.25 Tu 16:00 Lichthof

High resolution imaging of an ultracold quantum gas — •Peter Würtz[1], Tatjana Gericke[1], Andreas Vogler[1,2], Fabian Etzold[1], Tobias Weber[1,2], Frank Markert[1], and Herwig Ott[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität, Mainz — [2]Fachbereich Physik, Technische Universität Kaiserslautern

We describe a detection and manipulation technique based on scanning electron microscopy which allows for the detection of single atoms in a quantum gas with a spatial resolution of better than 150 nm. A focussed electron beam with a FWHM of 100 nm is moved over the atom cloud and ionizes atoms by electron impact ionization. The produced atoms are subsequently extracted and detected.

We produce a ^{87}Rb condensate in a single beam optical dipole trap formed by a focussed CO_2 laser beam. We implemented a two-dimensional with 600 nm lattice spacing to study quantum gases in periodic potentials. Our imaging technique enables us not only to resolve single lattice sites but also to remove atoms from selected sites without affecting neighboring sites. The method offers a versatile experimental platform for the *in situ* study of ultracold quantum gases in various trapping geometries, as well as the study of dissipative manipulations on Bose-Einstein condensates.

Q 21.26 Tu 16:00 Lichthof

Ionization dynamics and antiblockade of an ultracold Ryd-berggas — •Nele Müller[1], Thomas Amthor[1], Christoph S. Hofmann[1], Georg Günter[1], Hanna Schempp[1], Christian Giese[2], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Using time-resolved spectroscopic measurements of the Penning ionization signal we are able to identify slight variations in the Rydberg pair distribution of randomly arranged ultracold atoms. For attractive interaction potentials, atoms excited to Rydberg states on the red-detuned wing of the resonance are observed to ionize first. In this case pairs of atoms with small separation are excited and these experience strong attractive forces[1]. This approach can also be applied to repulsively interacting Rydberg states, where atoms excited on the blue-detuned wing of the resonance ionize faster[2]. We further extend this method by using Autler-Townes-splittings to achieve specific detunings to match the coupling energy of one optical transition to the interaction energy of the long-range Rydberg interactions. Hence, the otherwise blocked excitation of close pairs becomes feasible (antiblockade)[3]. Our experimental results agree well with a pair interaction model[4].

[1] T. Amthor et al., Phys. Rev. Lett 98, 023004 (2007)
[2] T. Amthor et al., Phys. Rev. A 76, 054702 (2007)
[3] C. Ates et al., Phys. Rev. Lett. 98, 023002 (2007)
[4] T. Amthor et al., arXiv:0909.0837v1

Q 21.27 Tu 16:00 Lichthof

Linsensysteme zur Fokussierung und Nachbeschleunigung einzelner Ionen — •G. Jacob[1], W. Schnitzler[1], R. Fickler[2], F. Schmidt-Kaler[1] und K. Singer[1] — [1]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm, Deutschland — [2]Universität Wien, Institut für Quantenoptik, Quantennanophysik & Quanteninformation, Boltzmanngasse 5, A-1090 Wien, Österreich

Mittels einer elektrostatischen Einzellinse [1] haben wir einen Ionenstrahl aus einzelnen $^{40}Ca^+$ Ionen von anfänglich $83(^{+8}_{-3})\,\mu$m auf einen 1σ-Radius von $(4.62\pm1.25)\,\mu$m fokussiert [2] und somit auf 1/18 seiner ursprünglichen Größe reduziert. Erzeugt wurde dieser durch eine deterministische, auf einer linearen Paul-Falle basierenden Einzelionenquelle [3]. Des Weiteren wurden numerische Simulationen [4] durchgeführt, um eine geschaltete Einzellinse zu entwickeln, welche die extrahierten Ionen sowohl zu fokussieren, als auch deren kinetische Energie - etwa für eine Implantation in ein Substrat - durch Nachbeschleunigen zu steigern vermag. Die Ergebnisse lassen dabei einen 1σ-Radius in der Größenordnung weniger Nanometer bei einer gleichzeitigen Erhöhung der kinetischen Energie auf 2-6 keV erwarten.

[1] R. Fickler *et al.*, J. Mod. Optics **56**, 2061 (2009)
[2] W. Schnitzler *et al.*, quant-ph/0912.1258, submitted to NJP
[3] W. Schnitzler *et al.*, Phys. Rev. Lett. **102**, 070501 (2009)
[4] K. Singer *et al.*, quant-ph/0912.0196, submitted to RMP

Q 21.28 Tu 16:00 Lichthof

Kryogene Mikro-Ionenfalle mit integrierter Fasercavity — •Frank Ziesel, Max Hettrich, Michaela Petrich, Daniel Seyfried, Gerhard Huber, Ulrich Poschinger, Andreas Walther und Ferdinand Schmidt-Kaler — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm

Mikrostrukturierte Paulfallen ermöglichen die Manipulation der internen und externen Freiheitsgrade einzelner oder mehrerer Ionen, was sie zu einem wichtigen Werkzeug in der Quanteninformationsverarbeitung macht. Unser Aufbau umfasst eine Ionenfalle [1] mit minimalem Ion-Elektroden Abstand von 125 μm sowie einen Kryostaten, der die Kühlung der gesamten Falle auf Temperaturen von 77 K bzw. 4 K ermöglicht. Hierdurch lässt sich die Heizrate um mehrere Größenordnungen reduzieren [2], was die Fidelity von Gatteroperationen verbessert. Die verringerte Heizrate ermöglicht längere Transportzeiten, sowie den Betrieb eines integrierten Faserresonators mit einem Ion-Spiegel Abstand von 50 μm. Mit der gemessenen Finesse von über 30 000 und dem kleinen Modenvolumen lassen sich Experimente im Bereich starker Kopplung [3] zwischen einzelnen Ionen und dem Resonatorfeld durchführen.

[1] S. Schulz et al., New J. Phys. **10**, 045007 (2008)
[2] J. Labaziewicz *et al.*, Phys. Rev. Lett. **100**, 013001 (2008)
[3] Y. Colombe *et al.*, Nature **450**, 272-277 (2007)

Q 21.29 Tu 16:00 Lichthof

Real-Time Feedback on Single Atoms in a High-Finesse Optical Resonator of Variable Length — •Christian Sames, Markus Koch, Alexander Kubanek, Alexei Ourjoumtsev, Matthias Apel, Pepijn Pinkse, Karim Murr, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

Strongly coupling atoms to the light field of a high-finesse optical resonator is a key ingredient to study light-matter interaction at the single quantum level. A problem still awaiting a satisfactory solution is to keep the atom inside the resonator sufficiently long. The trapping time can be dramatically enhanced by applying real-time feedback onto the atomic motion [1]. We present improved experimental results obtained with a new setup consisting of an optical resonator with much higher information rate than in previous experiments. Moreover, the mirror spacing can be varied macroscopically, enabling us to alter physical parameters as the coupling-constant g or the cooperativity parameter C online.

[1] A. Kubanek et al., Nature 463, 898 (17th December 2009)

Q 21.30 Tu 16:00 Lichthof

Compact electronics for laser system in microgravity — •Thijs Wendrich for the Lasus Team — Institut für Quantenoptik, Leibniz Universität Hannover

Atom interferometers are a symbiosis of matter and photonic waves. A lot of effort needs to be invested in the lasers and the electronic components to achieve the required performance for the manipulation of atoms with light. In the existing framework of the Quantus collaboration, the Lasus project aims to develop robust and miniaturized diode laser systems with spectroscopy and the associated control electronics for use in a compact apparatus for experiments with ultra cold degenerate quantum gases, operating in microgravity environments such as the drop tower in Bremen. In addition, it will prepare us for future space missions. In particular the external cavity diode laser including optical isolator, the spectroscopy and all of the electronics (laser current driver, temperature controller, PID controller, etc.), have to fit in a volume of about 1 liter. However, due to the stringent limits on the volume as well as the mass, all components need to be custom built to achieve the desired compactness with a high degree of automation while still delivering the very high performance needed for high precision experiments. In this poster the current progress on the electronics part of the project, which is being developed in Hannover, will be presented. The Lasus project is a collaboration of FBH Berlin, HU Berlin, U Hamburg and LU Hannover supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number 50WM0939.

Q 21.31 Tu 16:00 Lichthof

Laser stabilisation for the production of rovibronic ground-state molecules — •Raffael Rameshan[1], Almar Lercher[1], Markus Debatin[1], Bastian Schuster[1], David Baier[1], Francesca Ferlaino[1], Tetsu Takekoshi[1], Grimm Rudolf[1,2], and Hanns-Christoph Nägerl[1] — [1]Institut für Experimentalphysik, Universität Innsbruck — [2]IQOQI Innsbruck

Samples of polar ground-state molecules in the quantum-gas regime offer intriguing prospects for the investigation of novel physical phenomena. We aim to produce a gas of RbCs ground-state molecules near quantum degeneracy by first associating atoms to weakly bound molecules on a Feshbach resonance. Subsequently, the molecules are coherently transferred to the rovibrational ground state of the ground electronic potential by two-photon Stimulated Raman Adiabatic Passage (STIRAP). The STIRAP lasers have to be phase-coherent on the timescale of the transfer process. Ultra-narrow-linewidth lasers enable long STIRAP transfer times and consequently optimized adiabaticity. In addition, long STIRAP times avoid Fourier broadening of the STIRAP resonance and hence allow frequency-selective addressing of individual hyperfine levels of the ground-state molecules. We plan to construct a Raman laser system with sub-Hertz relative linewidth by locking two grating-stabilised diode lasers to ultra-high finesse optical resonators(1). To suppress fast phase fluctuations, the lasers will feature a long external resonator design (2).

(1) M. Notcutt et al.; Optics Letters 30, 1815-1817 (2005) (2) J. Alnis et al.; Eur. Phys. J. Special Topics 163, 89-94 (2008)

Q 21.32 Tu 16:00 Lichthof

Matter wave interferometry for determination of molecular transition dipole moments — •Sha Liu, Horst Knöckel, and Eberhard Tiemann — Institut für Quantenoptik, Leibniz Universität Hannover

A molecular matter wave interferometer has been employed to measure the molecular transition dipole moment of the $B^1\Pi_u$ - $X^1\Sigma_g^+$ transition of K_2. A K_2 beam is created in a supersonic expansion of potassium vapor out of a nozzle. A pair of laser beams works as beam splitters to coherently split the matter wave, employing the $b^3\Pi_{0_u^+}$ - $X^1\Sigma_g^+$ transition. The high collimation of the molecular beam yields a large coherence length in transverse direction, such that under the given experimental conditions the two outgoing matter waves overlap laterally, establishing a Ramsey type matter wave interferometer. The phase difference between the matter waves is sensitive to phase drifts of the optical phases of the beam splitters, therefore the optical phases of the beam splitters are locked with respect to each other for high long term stability. A near resonant laser field is introduced between the laser beams for the beam splitter. This field couples near resonantly the ground state level of the beam splitter transition with an excited level of the $B^1\Pi_u$ state. Thus the passing molecule feels a potential hill or valley depending on the detuning. The phase shift of the matter wave interference by the AC-Stark effect is used to determine the transition dipole moment of the B-X transition of K_2. Details of the experiment and results and experience regarding the prospect of a matter wave interferometer in such applications will be presented.

Q 21.33 Tu 16:00 Lichthof

Atom Interferometry in a mobile setup to measure local gravity — •Matthias Hauth, Alexander Senger, Malte Schmidt, Sebastian Grede, Christian Freier, and Achim Peters — Humboldt Universität zu Berlin, Institut für Physik, AG Optische Metrologie, Hausvogteiplatz 5-7, 10117 Berlin

GAIN (Gravimetric Atom Interferometer) is a mobile gravimeter, based on interfering ensembles of laser cooled ^{87}Rb atoms in an atomic fountain configuration. With a targeted accuracy of a few parts in 10^{10} for the measurement of local gravity, g, this instrument will offer about an order of magnitude improvement in performance over the best currently available absolute gravimeters. Together with the capability to perform measurements directly at sites of geophysical interest, this opens up the possibility for a number of interesting applications.

We give an introduction into the working principle of our mobile atom interferometer and into the realisation of its subsystems optimized for mobility. Furthermore, first measurements of local gravity as well as some main characteristics of the instrument are presented.

Q 21.34 Tu 16:00 Lichthof

Atom interferometry in microgravity — •Markus Krutzik[1], Achim Peters[1], and das QUANTUS Team[1,2,3,4,5,6,7,8,9] — [1]Institut für Physik, HU Berlin — [2]Institut für Quantenoptik, LU Hannover — [3]ZARM, Uni Bremen — [4]Institut für Quantenoptik, Uni Ulm — [5]Institut für Laserphysik, Uni Hamburg — [6]IAP, TU Darmstadt — [7]MPQ, Garching — [8]FBH, Berlin — [9]Midlands Ultracold Atom Research Centre, University of Birmingham, UK

Microgravity promises to substantially extend the science of degenerate quantum gases towards nowadays inaccessible regimes of low temperatures, macroscopic dimensions of coherent matter waves and longer unperturbed evolution. To utilize this excellent environment for interferometry schemes and applications like inertial quantum sensors with high precision is one of the main goals of the QUANTUS project.

As a source for coherent matter waves we use a Bose-Einstein condensate of Rubidium 87, whose ultra-long free evolution of 1 second in microgravity was already demonstrated at the drop tower in Bremen (ZARM). In order to realize a Mach-Zehnder interferometer we choose Bragg diffraction as a coherent beam splitting process. With this setup we are able to measure spatial and temporal coherences in the extended parameter regime available during free fall.

In addition we are working on a dual-species interferometer with Bose-Fermi gases. With this new apparatus we focus on precision measurements of the universality of the free fall. A major experimental challenge is to design catapult capable Raman laser systems, which have to withstand 30g accelerations during the catapult launch.

Q 21.35 Tu 16:00 Lichthof

A mobile Strontium optical frequency standard — •Ole Kock, Steven Johnson, Jochen Kronjaeger, and Kai Bongs — School of Physics and Astronomy, University of Birmingham, United Kingdom

Today first optical clocks have demonstrated performance beyond the current Cs atomic frequency standard. They are entering a sensitivity regime, where interdisciplinary applications such as relativistic geodesy , i.e. the determination of the earth geoid potential via relativistic frequency shifts, become feasible. On this poster we present the progress of a mobile optical frequency standard with Strontium necessary for such an application. We acknowledge support by EPSRC under grant EP/E036473/1.

Q 21.36 Tu 16:00 Lichthof

Towards an optical lattice clock with ^{87}Sr — •Stephan Falke, Christian Lisdat, Joseph Sundar Raaj Vellore Winfred, Thomas Middelmann, Fritz Riehle, and Uwe Sterr — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Optical clocks can achieve a higher stability and lower systematic uncertainty than the best current microwave clocks. Both, ion clocks and optical lattice clocks are currently under investigation as candidates for a redefinition of the SI second. A very promising candidate for an optical lattice clock is strontium, in particular the fermionic isotope ^{87}Sr where the doubly forbidden $^1S_0 - {}^3P_0$ transition is weakly allowed (natural linewidth 1.2 mHz) and collisional shifts are suppressed because two identical fermions cannot undergo s-wave scattering.

We trap ^{87}Sr atoms in a horizontal 1-D 'magic wavelength' optical lattice, in which the atoms are confined in the Lamb-Dicke regime and hence motional effects are suppressed. Due to the hyperfine structure, the laser cooling and trapping of ^{87}Sr is more complicated compared to the most abundant isotope ^{88}Sr, which has been investigated in our laboratory previously. We will present how we cool, trap, prepare, and interrogate ^{87}Sr as well as considerations and measurements towards reducing the uncertainty budget of a ^{87}Sr optical lattice clock.

The work is supported by the Centre for Quantum Engineering and Space-Time Research (QUEST), ESA, DLR, and the ERA-NET Plus Programme.

Q 21.37 Tu 16:00 Lichthof

Atomic structure of the Th II — •Jerzy Dembczyński, Magdalena Elantkowska, Jarosław Ruczkowski, Danuta Stefańska, and Gustaw Szawioła — Chair of Quantum Engineering and Metrology, Faculty of Technical Physics, Poznan University of Technology, Nieszawska 13B, 60-965 Poznan, Poland

Recently, the ^{229}Th isomer attracts attention, as a possible optical frequency standard. The detailed knowledge concerning the fine and hyperfine structures of the thorium isomer should help in searching for the transition suitable for detecting of the clock isomer resonance.

It stimulates our extensive work on the fine structure of ^{232}Th and the hyperfine structure of ^{229}Th. In our multi-configuration, semiempirical calculations, based on the experimental data, we determine the even and odd parity level scheme of Th ion, taking into account higher excited electron configurations. The predicted values of the hyperfine splittings of ^{229}Th will be also presented.

This work was supported by Polish Ministry of Science and Higher Education under the project N519 033 32/4065

Q 21.38 Tu 16:00 Lichthof

High performance iodine frequency reference for tests of the LISA laser system — •Klaus Döringshoff, Katharina Möhle, Moritz Nagel, Evgeny V. Kovalchuk, and Achim Peters — Humboldt Universität zu Berlin, Institut für Physik, AG Optische Metrologie, Hausvogteiplatz 5-7, 10117 Berlin

In our group different concepts for tunable optical frequency references for the spaceborne gravitational wave detector LISA are developed and tested. Here we present our fixed and absolut frequency reference for the validation of tunability and stability of these new frequency references.

For absolut frequency stabilization the frequency doubled output of a 1064 nm Nd:YAG laser is stabilized to the a_{10} component of the R(56)32-0 transition of $^{127}I_2$. Using a threefold-pass scheme through a 80 cm iodine cell and the modulation transfer spectroscopy technique a frequency stability of $\sim 1 \times 10^{-14}$ at 1s integration time and frequency noise $\sim 4\,\mathrm{Hz}/\sqrt{\mathrm{Hz}}$ at Fourier frequencies of 1-100 Hz is achieved. We give a detailed analysis of significant parameters and systematic effects and present our efforts aiming at a frequency stability in the 10^{-16} range at averaging times of 1000 s. An outlook will be given for a frequency stabilization at 508 nm, where transitions with linwidths below 10 kHz have been observed. These are promising for high performance frequency references superior to those at 532 nm.

In addition the frequency stability of a high performance ULE cavity with a turning point of it's thermal expansion curve above room temperature will be presented.

Q 21.39 Tu 16:00 Lichthof

Thermal noise of optical reference cavities — •Thomas Legero, Thomas Kessler, and Uwe Sterr — Physikalisch-Technische Bundesanstalt (PTB) and Centre for Quantum Engineering and Space-Time Research (QUEST), Bundesallee 100, 38116 Braunschweig, Germany

The frequency stability of state-of-the-art cavity-stabilized laser systems is limited by the thermal noise (Brownian motion) of the cavity. Simple estimates of the thermal noise level for spacer, mirror substrates and mirror coatings have been given by Numata *et al.* [1]. To reduce the noise, cavity designs with fused silica mirrors and additional ULE rings for compensating thermal expansion effects [2] have been proposed. To model the more complex cavities we calculate the thermal noise from the fluctuation dissipation theorem using the finite element method [1,3]. The simulations show that a considerable part of the dissipated energy in the spacer derives from a deformation in radial direction leading to an increased noise level compared to the simple estimates of [1]. We discuss consequences for future desgins of low thermal noise cavities.

[1] K. Numata *et al.* Camp, Phys. Rev. Lett. **93**, 250602 (2004).
[2] T. Legero and U. Sterr, German Patent DE 102008049367 B3
[3] Y. Levin, Phys. Rev. D. **57**, 659-663 (1998)

Q 21.40 Tu 16:00 Lichthof

High precision cold atom gyroscope — •Timo Denker, Sven Abend, Peter Berg, Michael Gilowski, Christian Schubert, Gunnar Tackmann, Wolfgang Ertmer, and Ernst Rasel — Institut für Quantenoptik, Leibniz Universität Hannover

Over the years, matter wave interferometry has become a powerful tool for high precision inertial measurements. The research goal of the CASI project (Cold Atom Sagnac Interferometer) is to realize a gyroscope with a sensitivity of a few 10^{-9} rad/s/Hz$^{1/2}$ for 10^8 atoms per shot, using laser cooled Rubidium. The atomic ensemble is launched in a pulsed mode onto a flat parabola with a forward drift velocity of 2,79 m/s leading to an interrogation time of over 50 ms. Via coherent beamsplitting using Raman transitions, the atomic trajectories forming the interferometer paths can enclose an area of several mm^2. Vibrations, acoustics, as well as intensity fluctuations, the electronic feedback, and wave front distortions, contribute to the phase noise budget of the interferometer. In addition, the detection system also affects the integrity of the signal. Since the various interferometer noise sources limit the achievable sensitivity, their impact on the performance of the interferometer has to be considered. In this poster, the improvements of the individual parts of the interferometer and the resulting enhancement of the sensitivity will be presented. This work is supported by the DFG, QUEST, and IQS.

Q 21.41 Tu 16:00 Lichthof

Quantum Gate Operations on Logical Qubits in a Decoherence-Free Subspace using Geometric Optimal Control Theory — •Anton Haase[1], Lorenza Viola[2], and Christiane P. Koch[1] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Germany — [2]Department of Physics and Astronomy, Dartmouth College, Hanover, New Hampshire, USA

We study single qubit operations on logical qubits in a decoherence-free subspace of an open quantum system. The decoherence dynamics are described in the framework of the Lindblad master equation. Our model system allows for the encoding of one logical qubit in two physical qubits, where environment induced dephasing takes place.

The main difficulty is that effecting operations on the logical qubit introduces couplings with decohering states through the action of the available control fields on the physical qubits. We address this problem with optimal control theory based on Pontryagin's maximum principle to find the global optimum for carrying out logical single qubit operations.

Q 21.42 Tu 16:00 Lichthof

Stabilizing two-qubit interactions by dynamical decoupling — •Holger Frydrych[1], Pavel Bazant[2], Gernot Alber[1], and Igor Jex[2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt — [2]Department of Physics, FJFI CVUT, Prague

Certain tasks of quantum information processing, such as swap operations or more general perfect state transfer, may require particular two-qubit interactions between the qubits involved. In such cases any additional perturbations, even if they affect single qubits only, are harmful and have to be avoided. In this contribution a dynamical decoupling method is presented with which arbitrary one-qubit perturbations of a qubit network can be suppressed without affecting any two-qubit couplings up to third order average Hamiltonian theory. This method applies to arbitrary numbers of qubits and it relies on the existence of appropriate orthogonal arrays with three levels and of strength two. Possibilities of fault-tolerant implementations are discussed.

Q 21.43 Tu 16:00 Lichthof

Error Suppression in a Quantum Register with Non-ideal Controls — •Pavel Bažant[1], Oliver Kern[2], Gernot Alber[2], and Igor Jex[1] — [1]Department of Physics, FNSPE at Czech Techical University, Prague, Czech Republic — [2]Institut für Angewandte Physik, TU Darmstadt, Germany

Unwanted interactions among qubits in a quantum register can be effectively suppressed by means of external control operations. However, if the control is non-ideal, it acts as an additional error source. We show that if this additional error remains constant among different applications of the same control operation, it can be suppressed together with the interqubit interactions.

Q 21.44 Tu 16:00 Lichthof

Optimierung eines Rydberg-Phasengatters — •Matthias Müller[1], Tommaso Calarco[1], Christiane P. Koch[2] und Daniel Reich[2] — [1]Institut für Quanteninformationsverarbeitung, Universität Ulm — [2]Institut für Theoretische Physik, Freie Universität Berlin

Mithilfe der Optimal Control Theory soll ein Laserpuls berechnet werden, der ein Phasengatter zwischen zwei Rydbergatomen realisiert. Die beiden Rydberg-Atome sind in optischen Fallen eingefangen und der Laser stimuliert Übergänge zwischen Hyperfeinstrukturniveaus. Ziel der Arbeit ist es, mit dem Krotov-Algorithmus, einem Algorithmus zur numerischen Minimierung von Funktionalen, die Pulsintensität als Funktion der Zeit so zu optimieren, dass nach einer festen Zeit ein Phasengatter auf einem logischen Unterraum des gesamten Zustandsraumes erreicht wird.

In einem zweiten Schritt wird der Krotov-Algorithmus abgewandelt, sodass das Optimierungsziel nicht mehr das Quantengatter selbst, sondern nur sein verschränkender Anteil ist. Das Quantengatter kann dann durch zusätzliche (zeitkostengünstige) Einzelqubittransformationen hergestellt werden.

Auf dem Poster präsentiere ich den aktuellen Stand meiner Diplomarbeit zu diesem Thema.

Q 21.45 Tu 16:00 Lichthof

How to quantify simultaneity in quantum measurements? — •Michael Busshardt and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm

The prototype for a simultaneous measurement of two conjugate variables was introduced by Arthurs and Kelly in 1965. Nowadays, it serves as a blueprint for a variety of similar setups. Starting from this seminal approach we investigate a refined scheme to measure position and momentum of a free particle. The setup relies on coupling the particle at hand to two ancilla systems, which serve as measurement pointers. By considering explicitly time-dependent interactions we can quantify the simultaneity of the measurement. The question arises, how much information can be obtained in such a measurement setup.

Q 21.46 Tu 16:00 Lichthof

Light-induced charging effects on dielectric surfaces in the vincinity of trapped ions — •Maximilian Harlander[1], Wolfgang Hänsel[2], Michael Brownnutt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck — [2]Institut für Quantenoptik und Quanteninformation der Akademie der österreichischen Wissenschaften

Microfabricated ion traps are discussed as one of the most promising candidates for a quantum mechanical computer. Reducing the electrode-ion distance offers a rich selection of trapping potentials and arrays of traps can, in principle, be operated in parallel. However, the proximity of the electrodes and other surfaces poses strong constraints on the materials used. In particular, near-by glass surfaces that may be used for high-finesse cavities around the ions or for light collection represent a challenge, since the dielectric surfaces may charge up and perturb the trapping potential. Furthermore, thin oxide layers formed on the electrodes of the ion trap may accumulate charges and contribute to this perturbation.

By bringing a glass substrate close to a surface ion trap, the charging has been studied in a controlled manner. Two distinct mechanisms of charging have been observed, both being light-induced with different wavelength dependence. The results allow an estimate of the rate of charge production and will prove useful for future designs of integrated microscopic ion traps.

Q 21.47 Tu 16:00 Lichthof

Secret key rates in quantum key distribution using Rényi entropies — •Silvestre Abruzzo, Hermann Kampermann, Markus Mertz, Sylvia Bratzik, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, D-40225 Düsseldorf, Germany

The secret key rate r of a quantum key distribution protocol depends on the involved number of signals and the accepted "failure probability". We reconsider a method to calculate r focusing on the analysis of the privacy amplification given by [1]. This approach involves an optimization problem with an objective function depending on the Rényi entropy of the density operator describing the classical outcomes and the eavesdropper system. This problem is analyzed for a generic class of QKD protocols and the current research status is presented.

[1]R.Renner and R. König, in *Second Theory of Cryptography Conference, TCC 2005*, Vol. 3378 of LNCS, edited by J.Kilian (Springer, New York, 2005), pp. 407-425

Q 21.48 Tu 16:00 Lichthof

Construction of complete sets of cyclic mutually unbiased bases — Oliver Kern[1], Kedar Ranade[1,2], •Ulrich Seyfarth[1], and Gernot Alber[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Institut für Quantenphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany

Complete sets of mutually unbiased bases (MUBs) have interesting applications in quantum information science. The quantum cryptographic six-state protocol, for example, relies on a special kind of complete set of MUBs. Contrary to general complete sets of MUBs [1,2] it has the additional property of being cyclic, i.e. all bases involved are generated from one particular basis by multiple applications of a single unitary transformation. In this contribution details of a recently developed method [3] are presented which allows to construct complete sets of cyclic mutually unbiased bases in even prime power dimensions. The relevance of these complete sets of cyclic MUBs for security bounds of quantum cryptographic protocols are discussed. This work was supported by CASED.

[1] A. Klappenecker and M.Rötteler, LNCS 2948, 262 (2004)
[2] R. Gow, arXiv:math/0703333v2
[3] O.Kern, K. Ranade and U.Seyfarth, in preparation

Q 21.49 Tu 16:00 Lichthof

Quantum Teleportation Between Stationary Macroscopic Objects — •Bao Xiao-Hui[1,2], Xu Xiao-Fan[1], Li Che-Ming[1,3], Yuan Zhen-Sheng[1,2], and Pan Jian-Wei[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 — [3]Department of Physics and National Center for Theoretical Sciences, National Cheng Kung University, Tainan 701, Taiwan

Quantum teleportation is a process to transfer a quantum state of an object without transferring the state carrier itself. So far, most of the teleportation experiments realized are within the photonic regime. For the teleportation of stationary states, the largest system reported is a single ion. We are now performing an experiment to teleport the state of an macroscopic atomic cloud which consists about 10^6 single atoms. In our experiment two atomic ensembles are utilized. In the first ensemble A we prepare the collective atomic state to be teleported using the quantum feedback technique. The second ensemble B is utilized to generate entanglement between it collective state with a scattered single-photon. Teleportation is realized by converting the atomic state of A to a single-photon and making a Bell state measurement with the scattered single-photon from ensemble B.

Q 21.50 Tu 16:00 Lichthof

Pulsed coherent Rydberg excitation in thermal microcells — •Bernhard Huber, Thomas Baluktsian, Harald Kübler, Andreas Kölle, Christian Urban, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Germany

In order to create quantum devices based on the Rydberg blockade mechanism, it is necessary to have a confinement of the excitation volume to less than the blockade radius in a frozen gas of atoms; i.e. the excitation times need to be shorter than the timescales of the respective dephasing mechanisms. While ultracold gases seem to be the obvious choice, our approach utilizes thermal atomic vapor in small glass cells which offer multiple advantages like good optical access and scalability. Such a system can be realized by confining the atoms to geometries in the μm regime. Lifetime-limiting effects due to the method of confinement like resonant interactions of the Rydberg atoms with polaritonic excitations in the glass have been studied [1]. Utilizing a bandwidth-limited pulsed laser system for the excitation we can create high Rabi-frequencies and thus short enough excitation times. First measurements of two-photon-excitations permitted probing of the Rydberg excitation dynamics on a ns-timescale.

[1] H. Kübler et al., accepted by Nature Photonics, arXiv:0908.0275

Q 21.51 Tu 16:00 Lichthof

Using ultra-high Q bottle microresonators for cold atom cavity quantum electrodynamic experiments — •Danny O'Shea, Christian Junge, Christian Hauswald, Sebastian Nickel, Alexander Rettenmaier, and Arno Rauschenbeutel — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We describe the active frequency stabilization of a fully tunable whispering-gallery-mode microresonator with an ultra-high quality factor exceeding 3×10^8 using the Pound-Drever Hall technique. The critically coupled bottle microresonator is stabilized to 8–10% of its linewidth, or 200 kHz rms, in an ambient air environment. This represents an important advancement for our planned cavity quantum electrodynamic experiment with a bottle microresonator coupled to laser-cooled rubidium atoms. We have constructed an apparatus to deliver the atoms to the location of the bottle microresonator using an atomic fountain. The current status of our experiment is presented and we show first results towards the active stabilization of the bottle resonator to an atomic resonance in ultra-high vacuum.

Financial support by the DFG (Research Unit 557), the ESF (EURYI Award), and the Volkswagen Foundation (Lichtenberg Professorship) is gratefully acknowledged.

Q 21.52 Tu 16:00 Lichthof

Spin dynamics of one and two atoms strongly coupled to an optical resonator — •René Reimann[1], Wolfgang Alt[1], Martin Eckstein[1], Tobias Kampschulte[1], Mkrtych Khudaverdyan[1], Lingbo Kong[1], Sebastian Reick[1], Alexander Thobe[1,2], Artur Widera[1], and Dieter Meschede[1] — [1]Institut für Angewandte Physik, Universität Bonn — [2]Institut für Laser-Physik, Universität Hamburg

In our experiment we transport a predetermined small number of cold caesium atoms into a high-finesse optical resonator using an optical dipole trap [1]. By monitoring the transmission of a probe laser beam resonant with the cavity we measure the atomic spin state: A single atom in the strongly coupled state shifts the cavity out of resonance with the laser and strongly reduces its transmission, while an atom in the uncoupled state does not change the transmission. Continuous observation reveals quantum jumps between the two hyperfine ground states [2]. The spin dynamics of one and two atoms is inferred from these random telegraph signals using Bayesian analysis and optimal binning time, yielding maximum information about the system.

[1] M. Khudaverdyan *et al.*, New J. Phys. **10**, 073023 (2008)
[2] M. Khudaverdyan *et al.*, Phys. Rev. Lett. **103**, 123006 (2009)

Q 21.53 Tu 16:00 Lichthof

Atom-Photon-Interfaces - Single-Photon Generation and Shaping — •Peter Nisbet[1], Jerome Dilley[1], Gunnar Langfahl-Klabes[1], Genko Vasilev[2], Daniel Ljunggren[3], and Axel Kuhn[1] — [1]Clarendon Laboratory, Oxford, UK — [2]Dept. of Phys., Sofia University, Bulgaria — [3]Dept. of Appl. Physics, KTH Stockholm, Sweden

Single atoms coupled to high-finesse cavities provide a unique way to deterministically generate a stream of single photons of MHz bandwidth [1]. Atom-cavity schemes are also in principle reversible, this would allow quantum state mapping between static (atom-cavity) and flying (photon) qubits which could be scaled up into a quantum network.

We report on the latest status of a strong coupling atom-cavity system based on ^{87}Rb. Atoms are loaded into the cavity ($\mathcal{F} = 125000$, $L = 90\mu m$) using an atomic fountain which gives rise to millisecond interaction times.

We also show a tweak to deliver single photons of arbitrary temporal shape. For any possible shape we derive an analytic expression for the driving laser pulse [2].

[1] Hijlkema, M. *et al.* Nature Physics **3**, 253 (2007)
[2] Vasilev, G. *et al.* arXiv:0907.0761v1

Q 21.54 Tu 16:00 Lichthof

A cavity QED system for atom-photon interfacing and multi-atom investigations — •Kyle Arnold, Markus Baden, and Murray Barrett — Centre for Quantum Technologies, National University of Singapore, Singapore

We report our progress towards an atom-photon network using cavity QED. Our system utilizes a far detuned optical lattice to transfer atoms into a high finesse cavity and permits us to load single atoms in a deterministic way. In addition, a secondary dipole force trap facilitates loading atoms at very high density giving approximately 104 atoms per lattice site transferred to the cavity mode. An intra-cavity trapping laser and an additional optical lattice permit a 3-D lattice to be established in the cavity. Trapping frequencies in this geometry easily allow atoms to be cooled to the ground state. We will present our ongoing investigations with this system.

Q 21.55 Tu 16:00 Lichthof

Methods in Implementing 2 Dimensional Arrays of Ion Traps — •Muir Kumph[1], Michael Niedermayr[1], Regina Lechner[1], Michael Brownnutt[1], and Rainer Blatt[2] — [1]Institut für Experimentalphysik, Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria

Microfabricated ion traps are one of the most promising candidates for a scalable quantum mechanical computer. In such a system, individual ions can be held with long coherence times, while allowing the ions to interact in a controlled way via laser mediated gates (eg.Molmer-Sorensen). 2D arrays of ion traps open up new possibilities of gate operation and algorithm implementation. Investigating a mesoscopic scale, low-count array, surface ion trap, we look at the feasibility of addressing the ions by magnetic fields, micro-lens arrays and tightly-focussed free-space light. Adjacent linear Paul traps as well as 2 dimensional arrays of ring traps are discussed in relation to the above addressing techniques. Methods for driving the array of micro ion traps in a cryostat via novel radio frequency resonators are also to be highlighted.

Q 21.56 Tu 16:00 Lichthof

Analytic approximations of the Jaynes-Cummings-Hubbard model with application to ion chains — •Alexander Mering[1], Michael Fleischhauer[1], Peter A. Ivanov[2], and Kilian Singer[2] — [1]Fachbereich Physik and research center OPTIMAS, Technische Universität Kaiserslautern — [2]Institut für Quanteninformationsverarbeitung, Universität Ulm

We discuss analytic approximations to the ground-state phase diagram of the homogeneous Jaynes-Cummings-Hubbard (JCH) Hamiltonian with general short-range hopping. Specifically, we consider the cases of a linear array of coupled cavities and a linear ion chain describing radial phonon excitations of the ions coupled to an external laser field tuned to the red motional sideband with Coulomb-mediated hopping. We derive approximate analytic expressions for the boundaries between Mott-insulating and superfluid phases and give explicit expressions for the critical value of the hopping amplitude within the different approximation schemes together with a comparison to mean-field results. Additionally, in the case of an array of cavities which is represented by the standard JCH model, we compare both approximations to numerical data from density-matrix renormalization-group (DMRG) calculations.

Q 21.57 Tu 16:00 Lichthof

Characterisation of non-classical radiation generated in semiconductor systems using multi-pixel photon detectors — •Robert Löffler, Gerolf Burau, and Heinrich Stolz — Univer-

sität Rostock, Institut für Physik, Universitätsplatz 3, 18055 Rostock

The characterisation of multi-photon quantum states requires the use of photon number resolving detectors. Such devices are urgently needed for applications in quantum computation and information. But beside that, they are also suitable for a more fundamental view on nature like identifying whether a quantum state is classical or non-classical (coherent or squeezed) due to their photon statistics. Here we propose an adequate setup consisting of a multi-pixel photon counting diode and a low noise amplification circuit integrated in a modified low temperature cryostat (down to 10K). We present recent measurements on photon statistics of semiconductor lasers and LEDs and compare them with reconstructions of the photon distributions in the presence of dark counts, cross talk and loss with high precision. Our system is appropriate for measuring and reconstructing unknown quantum states e.g. excitons in quantum dots as well.

Q 21.58 Tu 16:00 Lichthof

Femtosecond pulsed ultraviolet enhancement cavity as high power spontaneous parametric down conversion source — •Roland Krischek[1,2], Witlef Wieczorek[1,2], Akira Ozawa[1], Nikolai Kiesel[1,2], Patrick Michelberger[1,2], Thomas Udem[1], and Harald Weinfurter[1,2] — [1]Max-Planck-Institut für Quantenoptik, D-85748 Garching — [2]Department für Physik, LMU München, D-80799 München

Current multi-photon entanglement experiments are mostly based on the process of spontaneous parametric down conversion (SPDC). Typically, the SPDC process is pumped by femtosecond ultraviolet (UV) pulses obtained from a frequency-doubled titanium-sapphire (Ti:Sa) laser at a repetition rate of about 80MHz. However, today's pump sources suffer from weak pump powers (<2W) resulting in low multi-photon count rates. Here, we present a new setup to boost the multi-photon generation rate of SPDC experiments. For this purpose we introduce a femtosecond enhancement cavity in the UV to pump a nonlinear crystal inside. The cavity enhances resonantly the frequency-doubled Ti:Sa pulses. We reach a maximal UV power of 7W at the repetition rate of the Ti:Sa laser (80MHz). We characterize the spectra of the intra-cavity laser pulses and estimate the pulse duration inside the cavity by interferometric autocorrelation. In addition, we show the multi-photon count rates as a function of the pump power, reaching an improvement of the six-photon count rates by two orders of magnitude. Our results pave the way to various applications not only in photonic quantum logic, but also in nonlinear optics research.

Q 21.59 Tu 16:00 Lichthof

Biphoton source at 710nm using a periodically poled MgO doped stoichiometric lithium tantalate crystal — •Sebastian Wander, Dirk Puhlmann, and Martin Ostermeyer — Institute for Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Str 24/25, 14476 Potsdam, Germany

Correlations between photons are interesting for a number of applications and concepts in metrology, in particular for resolution improvements in different methods of quantum imaging. As used in most experiments of quantum imaging the most efficient single photon detectors, silicon avalanche photo detectors, have a sensitivity maximum around 700nm. To generate correlated photons in this wavelength region efficiently, special nonlinear optical materials are needed for this purpose. Periodically poled MgO doped Lithium Tantalate (PP-MgO:SLT) is an attractive nonlinear material because of its high nonlinear coefficients , its high resistance to optical damage and its wide optical transparency down to the UV spectral range [1]. In this paper we present a source for biphotons based on PP-MgO:SLT. The nonlinear crystal is pumped by the third harmonic of a Nd:YAG laser emitting 11ps long pulses. The generated biphotons have a central wavelength of 710nm. To characterize the correlations of the biphotons different methods are applied. Diffraction at a blazed grating [2] offers information about the spatial degree of correlation of the photons.

[1] A. Bruner et al, Optics Letters 28, 194 (2003)
[2] M. Ostermeyer, D. Puhlmann, D. Korn, JOSA-B 26, 2347 (2009)

Q 21.60 Tu 16:00 Lichthof

Studies on the gap of a solid immersion lens-diamond interface using raytracing — •Stefan Bischof — 3. Physikalisches Institut, Universität Stuttgart

An NV center is a vacancy in diamond with a neighboring nitrogen atom. Its flourescence gives allows to determine its quantum state. At low temperatures this read out process could be used for quantum computation. Its application as a photon source for quantum computation. An increase of collection of photons allows the realisation of single shot read out.

The loss of photons on a diamond-air interface can be reduced by using a half-ball shaped solid immersion lens (SIL). Light irradiated from the center of a ball suffers no internal reflexion on the ball surface. A raytracing simulation shows interesting properties of a SIL. The projection of the light beams on the object plane shows a gaussian profile.

The parameter x_0 for the misalignment from the optical axis broke the symmetry of the problem. Varying the parameters shows: the center of the gaussian profile still remains in the optical axis. Taking multi-beam-interference into account the gaussian profile is modulated depending on the gap height. The control of this modulation allows to have even higher count rates than without a gap.

Q 21.61 Tu 16:00 Lichthof

Towards emitter-cavity-coupling of new single color centers in diamond — Roland Albrecht, •Christian Hepp, Elke Neu, Janine Riedrich-Möller, David Steinmetz, and Christoph Becher — Technische Physik, Universität des Saarlandes, D-66123 Saarbrücken

An approach to increase the viability of single color centers in diamond is to couple their optical emission to microcavities. 2D photonic crystal microcavities (PhC) are being considered as well suited candidates for this task providing theoretical Q-factors of 10^5 at modal volumes of less than $1(\lambda/n)^3$ as well as an integral scalability. We show preliminary results on PhC realization in thin (300 nm) nanocrystalline diamond films produced by focused ion beam milling that suggest a Q-factor of ≈ 100 which is limited by the material absorption as we conclude from our theoretical models.

On the other hand the state-of-the-art single photon emitter in diamond - the NV-center - turns out to be only poorly suited for a coupling of its zero phonon line to a cavity mode because it radiates predominantly into broad vibronic sidebands. On the road to find defects with smaller linewidth we report on Si- and Ni-based color centers in bulk diamond. The Ni-center (810 nm) exhibits a high signal-to-noise-ratio (69 kcounts/s) and a small linewidth of 2 nm at room temperature; moreover it proofs clear single photon emission featuring a second-order-correlation function of $g^2(0) = 0.1$. Silicon vacancy (SiV) centers were created by spatially resolved ion implantation showing the high potential of this technique for SiV-centers.

Q 21.62 Tu 16:00 Lichthof

Model free, direct measurement of Casimir-Polder-Potentials in the transition regime — •Christian Stehle, Helmar Bender, Philippe W. Courteille, Carsten Marzok, Claus Zimmermann, and Sebastian Slama — Physikalisches Institut, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

The attractive force between atoms and surfaces is often referred to as Casimir-Polder force (CP). The form of the potential generating this force depends on the distance of the atoms from the surface. In the short range limit, for distances much closer than the wavelength of the atomic transition, the interaction can be regarded as an electrostatic interaction with a z^{-3} power law. In the long range limit retardation effects have to be taken into account, which leads to a z^{-4} power law. On the poster we present measurements of the CP force in the transition regime between these two limits. The measurements were performed by using a new method, which is based on the reflection of ultra cold atoms from an evanescent wave barrier. Note that this is the first method for the direct measurement of CP forces in the transition regime without the need for any assumption on the potential shape.

Q 21.63 Tu 16:00 Lichthof

Reproducible chaos-induced mesoscopic superpositions of Bose-Einstein condensates — •Bettina Gertjerenken, Stephan Arlinghaus, Niklas Teichmann, and Christoph Weiss — Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26111 Oldenburg

In a parameter regime for which the mean-field (Gross-Pitaevskii) dynamics become chaotic, mesoscopic quantum superpositions in phase space can occur in a double-well potential which is shaken periodically. For experimentally realistic initial states like the ground state of some 100 atoms, the emergence of mesoscopic quantum superpositions in phase space is investigated numerically. It is shown to be reproducible even if the initial conditions slightly change. While the final state is not a perfect superposition of two distinct phase-states, the superposition is reached an order of magnitude faster than in the case of the collapse and revival phenomenon. Furthermore, a generator of entanglement generation is identified.

Q 21.64 Tu 16:00 Lichthof

Retardation effects on entanglement between atoms in a cavity — •Qurrat-ul- Ain[1], Zbigniew Ficek[2], and Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]The National Centre for Mathematics and Physics, King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia

In the standard setup of atoms coupled to a cavity, a finite time is required by light to travel between the atoms and the cavity boundaries. In suitable parameter regimes, these retardation effects can affect the time evolution of the combined system of atoms and cavity field to a large degree [1].

Here, we study the effects of retardation on the entanglement dynamics of a system of two two-level atoms placed inside a one-dimensional ring cavity. For this, we calculate the time evolution of the concurrence [2], which quantifies the entanglement between the two atoms. We indentify suitable parameter ranges for the study of retardation effects, analyze sudden death of entanglement [3] in the presence of retardation, and interpret the obtained results in terms of the traveling time of light between the atoms and the cavity mirrors.

[1] E. V. Goldstein and P. Meystre, Phys. Rev. A **56**, 5135 (1997).
[2] W. K. Wootters, Phys. Rev. Lett. **80**, 2245 (1998).
[3] T. Yu and J. H. Eberly, Phys. Rev. Lett. **93**, 140404 (2004).

Q 21.65 Tu 16:00 Lichthof

Study of entanglement dynamics through a partial P-representation — •Ansgar Pernice and Walter T. Strunz — TU Dresden

We investigate entanglement dynamics of a qubit coupled to harmonic oscillators. Initially, we assume "system" and "environment" to be independent and represented by mixed states. We find it convenient to express the total state in terms of a partial P-representation, whose definiteness we relate to entanglement. Our results help to elucidate the role of entanglement in open system dynamics.

Q 21.66 Tu 16:00 Lichthof

Towards Coherent Control of Photons using Electromagnetically Induced Transparency — •Andreas Neuzner, Eden Figueroa und Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Over the last decade the effect of electromagnetically induced transparency (EIT) and the related effect of storage of light have received extensive attention as a potential candidate for the realization of quantum memories. Towards this goal several milestones have been reached, the most important being the storage of single photons using EIT [1]. Nevertheless, these experiments so far do not offer access to the temporal envelope of the single photon read back from the storage medium.

We envision a device that can store single photons and allows for full control over the temporal shape of the retreived photon. We have set up an EIT-experiment based on a ^{87}Rb vapour cell and store weak classical pulses. Currently a protocol to optimize the storage efficiency is being implemented [2] and we explore possibilities to employ this setup as a storage device for single photons generated from a cavity QED based source [3].

[1] M.D. Eisaman, A. André, F. Massou, M. Fleischhauer, A.S. Zibrov, and M.D. Lukin, Nature **438**, 837 (2005).

[2] I. Novikova, A.V. Gorshkov, D.F. Phillips, A.S. Sørensen, M.D. Lukin, and R.L. Walsworth , PRL **98**, 243602 (2007).

[3] M. Hijlkema, B. Weber, H.P. Specht, S.C. Webster, A. Kuhn, and G. Rempe, Nature Physics **3**, 253 (2007).

Q 21.67 Tu 16:00 Lichthof

Raman-Nath-Description of the Free-Electron Laser — •Matthias Knobl and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

The free-electron laser (FEL) is an alternative laser device with a widely tunable wavelength of the emitted radiation. Most FEL's operate in the regime of classical physics where quantum physical descriptions are not needed. Since recent projects are trying to go beyond the classical limit, we discuss the quantum mechanical regime of the FEL, using an approach based on a set of Lie-algebraic operators. This leads to the spherical Raman-Nath equation of the FEL.

Q 21.68 Tu 16:00 Lichthof

Photon diode: performing nonunitary operations on quantum light — •Gor Nikoghosyan and Michael Fleischhauer — Department of Physics and research center OPTIMAS, University of Kaiserslautern, Germany

We discuss the interaction of two quantized modes of light with a spectrally broadened atomic ensemble. We show that the system is analogous to a two level system interacting with a bosonic reservoir, where the photonic modes correspond to the atomic states and the atomic ensemble corresponds to the modes of the reservoir. In contrast to the photonic reservoirs, the atomic ensembles can be easily controlled which can be used to simulate the dynamics of an open two level system in a reservoir with tunable spectrum. Due to the coupling with the atoms the analog of spontaneous decay for photons is obtained. This process leads to an irreversible transfer of photons from one mode to the other. The effect can be used for large variety of applications; e.g. the creation of new quantum states, the transfer of photons of optical frequency to microwave domain and vice versa, or the construction of a diode for photons, i.e. a device where single photon pulses injected in any of the two input ports will be directed to the same output port.

Q 21.69 Tu 16:00 Lichthof

Multifractality in quantum maps — •John Martin[1], Ignacio Garcia-Mata[2], Olivier Giraud[3,4], and Bertrand Georgeot[3,4] — [1]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Bât. B15, B - 4000 Liège, Belgium — [2]Departamento de Física, Lab. TANDAR, Comisión Nacional de Energía Atómica, Av. del Libertador 8250, C1429BNP Buenos Aires, Argentina — [3]Université de Toulouse, UPS, Laboratoire de Physique Théorique (IRSAMC), F-31062 Toulouse, France — [4]CNRS, LPT (IRSAMC), F-31062 Toulouse, France

We present our results on the multifractal properties of wave functions for (a) a one-parameter family of quantum maps displaying the whole range of spectral statistics intermediate between integrable and chaotic statistics, (b) wave functions at the Anderson transition in the kicked rotator with three incommensurate frequencies (experiments on this system have been performed by Garreau et al.). We perform extensive numerical computations and provide analytical arguments showing that the generalized fractal dimensions are directly related to the parameter of the underlying classical map, and thus to other properties such as spectral statistics.

Q 21.70 Tu 16:00 Lichthof

Fluorescence Resonance Energy Transfer Microscopy — •Julia Tisler, Gopalakrishnan Balasubramanian, Rolf Reuter, Anke Lämmle, Fedor Jelezko, and Jörg Wrachtrup — 3. Physikalisches Institut, Stuttgart, Germany

We present fluorescence resonance energy transfer (FRET) between a single nitrogen-vacancy (NV) center in diamond and organic dye molecule.

A nanodiamond with a single NV colour center was placed to the tip of a atomic force microscope. Using this single NV center as a probe the sample was investigated. By scanning such tip over a sample containing dye molecules we were able to perform FRET microscopy. This new technique uses Förster energy transfer as optical contrast mechanism. Resolution of such scanning probe microscope is shown to be orders of magnitude better than that imposed by Abbe limit.

Q 21.71 Tu 16:00 Lichthof

Vertikal emittierende Laserdioden als Seed-Quelle eines gepulsten Titan:Saphir-Lasers — •Simon Metzendorf, Daniel Depenheuer, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Vertikal emittierende Laserdioden (VCSEL, engl. Vertical-Cavity Surface-Emitting Laser) zeichnen sich u.a. durch ihr rotationssymmetrisches Strahlprofil, niedrige Betriebsströme sowie ihren longitudinalen Einmodenbetrieb und die damit verbundene gute Durchstimmbarkeit der Wellenlänge aus. Mittels eines mikroelektromechanischen Systems (MEMS) lässt sich der kontinuierlich abstimmbare Bereich eines VCSELs auf über 50 nm vergrößern [1].

Die Verwendung einer solchen Laserdiode als Injection-Seeder für einen gepulsten Titan:Saphir-Laser führt zu einem Lasersystem hoher Ausgangsleistung, welches ebenso kontinuierlich durchstimmbar ist und ns-Pulse nahe des Fourierlimits liefert. Das System ist im Hinblick auf seine Arbeitswellenlänge besonders flexibel, da mit Hilfe nichtlinearer optischer Prozesse der Spektralbereich von 190 nm bis 6000 nm abdeckt werden kann [2]. Der aktuelle Fortschritt des Projekts wird vorgestellt.

[1] B. Kögel et al., *IEEE Sens. J.*, **11**, 1483-1489 (2007)
[2] D. Depenheuer et al., *Appl. Phys. B*, **97**, 583-589 (2009)

Q 21.72 Tu 16:00 Lichthof

Resonatorinterne Frequenzverdopplung von grün emittierenden Praseodym-Lasern — •Teoman Gün, Ernst Heumann und Günter Huber — Universität Hamburg, Institut für Laser-Physik

In diesem Beitrag wird die Erzeugung von tief-ultravioletter (DUV) Strahlung bei einer Wellenlänge von 261,3 nm mittels resonatorinterner Frequenzverdopplung eines Praseodym-Lasers demonstriert. Dabei werden Praseodym-dotierte $LiYF_4$ (YLF)- und $LiLuF_4$ (LLF)-Kristalle über eine GaN-Laserdiode (LD) mit einer Ausgangsleistung von 1 W und der Emissionswellenlänge von 444 nm, oder einem optisch gepumpten Halbleiterlaser (OPS) mit einer Ausgangsleistung von 5,5 W und der Emissionswellenlänge von 479,5 nm gepumpt. Auf der Grundwelle des LD-gepumpten Pr(0,65at.%):YLF-Lasers konnten bei einer absorbierten Leistung von 594 mW und 1,9% Auskopplung maximal 42,5 mW Laserleistung bei der Wellenlänge von 522,7 nm erzielt werden. Die Frequenzkonversion erfolgt über einen 6,5 mm langen für 523 nm antireflexions-beschichteten Beta-Barium-Borat-Kristall unter kritischer Phasenanpassung vom Typ I. Dabei wurde eine maximale DUV-Leistung von 22,5 mW generiert, welches einer Konversionseffizienz von 53% bezogen auf die maximale Ausgangsleistung für die Grundwelle und einer optisch-optischen Gesamteffizienz von 3,8% entspricht. Experimente mit einem OPS-gepumpten Pr(0,45at.%):LLF-Kristall ergaben DUV-Ausgangsleistungen von maximal 416 mW und somit eine optisch-optische Gesamteffizienz von 7,6%.

Q 21.73 Tu 16:00 Lichthof

Faserverstärker basierter Ar^+-Laserersatz — •Benjamin Rein, Tobias Beck und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schloßgartenstraße 7

Ein Faserverstärker mit einer weit abstimmbaren Seedquelle und anschließender Frequenzverdopplung wird vorgestellt. Die Seedquelle besteht aus einem External Cavity Diode Laser mit einer leistungsstarken Laserdiode bei 1028 nm. Der Verstärker basiert auf einer Yb-dotierten, polarisationserhaltenden Faser und die Ausgangsstrahlung hat die spektralen Eigenschaften des Seedlasers. Mit einer anschließenden Intracavity-Frequenzverdopplung ist es möglich, einen durchstimmbaren schmalbandigen Ersatz für einen Ar-Ionenlaser bei einer-Wellenlänge von 514 nm zur Verfügung zu stellen. Diese weite modensprungfreie Abstimmbarkeit wird durch ein neues, auf Polarisationsspektroskopie basierendes, Locking-Verfahren realisiert.

Q 21.74 Tu 16:00 Lichthof

$Nd:YVO_4$ Hochleistungsverstärkersystem mit langen Pikosekunden Impulsen und effizienter Erzeugung der zweiten Harmonischen — •Markus Lührmann, Christian Theobald, Richard Wallenstein und Johannes A. L'huillier — Photonik-Zentrum Kaiserslautern e.V., Deutschland

Optisch parametrische Verstärkung gechirpter fs-Impulse (OPCPA) ist gut etabliert. Eine effiziente Verstärkung benötigt Pumpimpulse hoher Energie mit Impulsdauern von mehreren hundert ps und guter Strahlqualität. Bis jetzt wurden OPCPAs mit Wiederholraten von bis zu einem kHz bei Pumpimpulsenergien von wenigen mJ betrieben. Die so verstärkten fs-Impulse großer Spitzenintensität sind gut geeignet um hohe Harmonische oder Röntgenstrahlung zu erzeugen. Diese Strahlung wiederum ist interessant für verschiedene Anwendungen wie Photoelektronen Spektroskopie oder die Verbrennungsdiagnose. Die Anwendungen würden allerdings stark von Wiederholraten höher als 10 kHz profitieren.

Wir haben daher eine Pumpquelle für einen OPCPA mit 20 kHz Wiederholrate entwickelt. Ein bereits vorgestellter Diodengepumpter regenerativer Verstärker auf Basis von $Nd:YVO_4$ wurde um eine lineare Nachverstärkung erweitert. Es werden nahezu Fourier limitierte Impulse mit mehr als 2,5 mJ Impulsenergie bei einer Wiederholrate von 20 kHz und frei einstellbaren Impulsdauern von 180 ps bis etwa 1 ns erzeugt. Durch eine externe hocheffiziente Frequenzverdoppelung auf 532 nm können so Impulsenergien von über 2 mJ generiert werden. Die erzeugte Strahlung ist annähernd beugungsbegrenzt.

Q 21.75 Tu 16:00 Lichthof

Concept of a second order Littrow external cavity diode laser — •Björn Hemb, Michael Britzger, Daniel Friedrich, Maximilian Wimmer, André Thüring, Karsten Danzmann, and Roman Schnabel — Institut für Gravitationsphysik, Leibniz Universität Hannover und Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) Callinstrasse 38 D-30167 Hannover

Optical feedback for laser diodes is typically realised with gratings in first order Littrow or Littman configurations. The latter generates a better frequency selection, but includes a loss channel for the light power. An alternative concept is based on a so-called 3-port-grating that provides three diffraction orders. The external cavity is mounted in second order Littrow configuration. Hence the external cavity is assembled perpendicular to the grating surface. The first diffraction order serves for coupling into the external cavity.

We present a detailed analysis of the applicability of dieletric 3-port reflection gratings for external cavity optical feedback of laser diodes. The design is intended to engender optical feedback without any loss channel and with minor complexity.

Q 21.76 Tu 16:00 Lichthof

Towards a multi-Watt femtosecond optical parametric oscillator tunable between 1.5μm and 1.9μm wavelength — •Robin Hegenbarth[1], Jan-Philipp Negel[1], Felix Hoos[1], Bernd Metzger[1], Andy Steinmann[1], János Hebling[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Department of Experimental Physics, University of Pécs, Ifjúság út 6, H-7624 Pécs, Hungary

We develop a cost-effective, synchronously pumped singly resonant optical parametric oscillator (OPO) tunable between 1.5 μm and 1.9 μm signal wavelength. We expect up to 40 percent conversion efficiency and <200 fs FWHM pulse duration. The OPO signal is generated in an MgO-doped periodically poled lithium niobate (MgO:PPLN) crystal. The pump source is a fiber laser with 1030 nm wavelength, 3 W average output power, <500 fs FWHM pulse duration, and 37 MHz repetition rate. We also use a 5 W average output power Yb:KGW laser as pump source, which scales up the OPO's signal power even more. This OPO will be used as a pump source of a Mid-IR optical parametric oscillator with several hundred mW average output power tunable between 5 μm and 12 μm wavelength with $AgGaSe_2$ as a nonlinear crystal. Another application is the generation of terahertz radiation via optical rectification in GaAs.

Q 21.77 Tu 16:00 Lichthof

Ultra-sensitive fluorescence spectroscopy of isolated surface-adsorbed molecules using an optical nanofiber — •Ariane Stiebeiner, David Papencordt, Nils Konken, Ruth Garcia-Fernandez, and Arno Rauschenbeutel — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

The strong radial confinement and the pronounced evanescent field of the guided light in optical nanofibers allow the controlled interaction with particles which are deposited near or on the fiber surface. Using the guided mode of the nanofiber waist of a tapered optical fiber for excitation and fluorescence collection, we present spectroscopic measurements on surface-adsorbed organic dye molecules. In order to efficiently couple light into and out of the nanofiber over a broad spectral range, we have optimized the taper geometry based on numerical simulations and experimental studies. As a result, surface coverages as small as 0.1 % of a compact monolayer still give rise to fluorescence spectra with a good signal to noise ratio. The effect of self-absorption in our system can be quantitatively modelled and is negligible for low surface coverages. We are currently setting up a cryogenic apparatus for low temperature measurements. The new setup, together with the high sensitivity of our method, should allow us to perform nanofiber-based spectroscopy on the single molecule level.

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Q 21.78 Tu 16:00 Lichthof

Laser spectroscopy of trapped Th^+ ions: towards nuclear laser spectroscopy of Th-229 — •Kai Zimmermann, Oscar Andrey Herrera Sancho, Maxim Okhapkin, Christian Tamm, and Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Braunschweig

We have built a linear Paul trap for laser spectroscopy of Th^+ ions. The trap is loaded with up to 10^5 ions by ablation from a thorium metal target using a nitrogen laser. The ion cloud is cooled to room temperature by collisions with ≈ 10^{-3} mbar of helium buffer gas. An extended cavity diode laser is used to excite the strongest Th^+ resonance line at 401.9 nm. Low-lying metastable levels are quenched by collisions with the buffer gas. This allows cyclic laser excitation and the observation of a fluorescence signal of more than 1 photon/s/ion.

This is a first step in a project towards laser excitation and detection of the nuclear excited state of Th-229 at 7.6 eV. We plan to perform multi-photon excitation of the electron shell and resonant transfer of the excitation to the nucleus, making use of the dense electronic level structure of Th^+.

Q 21.79 Tu 16:00 Lichthof

Photodiodenarray für die Leistungsstabilisierung von Lasern — •Patrick Kwee, Benno Willke und Karsten Danzmann — Albert-Einstein-Institut Hannover

Hoch empfindliche Photodetektoren werden in fast allen optischen Experimenten benötigt, um optische Signale in elektronische zu wandeln. Leistungsstabilisierungen von Lasern für optische Präzisionsexperimente, wie z.B. interferometrische Gravitationswellendetektoren, haben dabei eine der höchsten Anforderungen an diese Photodetektoren. Neben technischen Rauschquellen limitiert Schrotrauschen die Empfindlichkeit eines Photodetektors fundamental. Um das relative Schrotrauschen zu reduzieren, muss die Laserleistung und damit der detektierte Photostrom erhöht werden, wobei bereits das Leistungslimit herkömmlicher Photodioden erreicht ist. Durch die Aufteilung der Laserleistung auf ein Array aus 8 Photodioden, konnte ein hoher Gesamtstrom von 400 mA detektiert werden und damit eine bislang unerreichte Empfindlichkeit erzielt werden. Das hoch empfindliche Photodiodenarray und Ergebnisse einer durch Schrotrauschen limitierten Leistungsstabilisierung im Bereich von $2 \times 10^{-9}\,\mathrm{Hz}^{-1/2}$ bei 10 Hz eines Nd:YAG Lasers bei 1064 nm werden vorgestellt.

Q 21.80 Tu 16:00 Lichthof

Performance of all-optical phase-preserving amplitude regeneration techniques — •Daniel Endres[1], Klaus Sponsel[2], Christian Stefan[2], Georgy Onishchukov[2], Bernhard Schmauss[1], and and Gerd Leuchs[2] — [1]University of Erlangen, Erlangen, Germany — [2]Max-Planck Institute for the Science of Light, Erlangen, Germany

With the advance to higher bitrates and advanced modulation formats in fiber optical communication, the demand for new all-optical signal regeneration techniques arises. Two widely considered types of such regenerators are the nonlinear amplifying loop mirror [1] (NALM) based on a nonlinear fiber Sagnac interferometer and a fiber optical parametric amplifier [2] (FOPA) driven as an optical limiter.

In this work we compare these two techniques in their capability to reduce amplitude noise of phase-modulated signals with emphasis on differential phase-shift keying and their possible application in transmission systems. Both regenerators deteriorate the signal by excess noise generation of various origins. While the NALM performance is mainly limited due to Rayleigh backscattering, the major noise source of a FOPA is the pump noise. The work involves both simulation and experimental results.

[1] K. Cvecek, K. Sponsel, G. Onishchukov, B. Schmauss and G. Leuchs: 2R-Regeneration of an RZ-DPSK signal using a nonlinear amplifying loop mirror, IEEE Phot.Tech.Lett. **17**,3 p.146 (2005)
[2] K. Inoue: Optical level equalization based on gain saturation in fibre optical parametric amplifier, Electronics Letters **36**,12 p.1016 (2000)

Q 21.81 Tu 16:00 Lichthof

Laser-based acceleration of non-relativistic electrons in a photonic structure — •John Breuer and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Garching bei München, Germany

We present simulation results of the acceleration of non-relativistic electrons passing by a fused-silica transmission grating that is illuminated with Titanium:sapphire femtosecond laser pulses. The concept of periodic field reversal is used to directly accelerate electrons with the electromagnetic field of the laser. We have optimized the grating parameters towards maximum momentum transfer and expect accelerating gradients of up to 100 MeV/m for 27-keV electrons traveling by the grating at a distance of 30 nm. We will describe the current status of a recently started proof-of-principle experiment and discuss applications of this new form of laser-based electronic motion control.

Q 21.82 Tu 16:00 Lichthof

A high-harmonic microfocus beamline for photoemission spectroscopy — •Roland Kalms, Armin Azima, Filip Budzyn, Patrick Rüdiger, Thomas Klee, Michael Schulz, Lasse Schroedter, Marek Wieland, and Markus Drescher — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We present the design and characterisation of a high-harmonic beamline with an experimental endstation suited for photoemission spectroscopy on (magnetised) surfaces. The pulses of a femtosecond laser system (800 nm, 3 mJ, 30 fs, 1 kHz) are focussed into a gas-filled tube to create high-harmonic emission. The output in the VUV-range (around 90 eV with Neon as target medium) which can be spectrally characterised with a self-made grating spectrometer has been optimised with respect to the intensity and the beam profile. After the selection of the desired harmonic order via a multilayer mirror the radiation is focussed with an ellipsoidal mirror onto the sample surface. The experimental endstation of the beamline allows the in-situ preparation of thin films and is equipped with a time-of-flight spectrometer and a scanning stage for spatially resolved photoemission studies. One can also apply a pulsed magnetic field to remanently magnetise the samples for XMLDAD measurements.

Q 21.83 Tu 16:00 Lichthof

Accurate generation of polarization-shaped fs laser pulses with application to photoelectron imaging spectroscopy — •Jens Köhler, Marc Krug, Cristian Sarpe-Tudoran, Tim Bayer, Matthias Wollenhaupt, and Thomas Baumert — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

Femtosecond polarization pulse shaping is a tool to generate laser pulses with a time-dependent polarization profile on an ultrashort timescale. The realization of such pulses is often affected by undesired polarization-dependent amplitude modulations and phase shifts introduced by the pulse shaper itself as well as other optical elements in the beam. In order to ensure *accurate* generation of polarization-shaped pulses, these effects have to be taken into account and the optical setup has to be corrected accordingly. Different schemes for detection and compensation of these effects are presented and compared. Recently, realization of accurately generated polarization-shaped laser pulses in the interaction region of a vacuum chamber has been demonstrated by photoelectron imaging spectroscopy [1]. Currently, we extend the application of our polarization shaping capabilities to the generation of complex-shaped free-electron wave packets characterized by three-dimensional tomographic reconstruction methods [2]. First results are presented.

[1] M. Wollenhaupt et al., Applied Physics B, 95(2), 245-259, (2009)
[2] M. Wollenhaupt et al., Applied Physics B, 95(4), 647-651, (2009)

Q 21.84 Tu 16:00 Lichthof

Single-sweep production of complex 3D-waveguide devices in fused-silica produced by adaptive femtosecond laser writing — •Matthias Pospiech[1], Benjamin Väckenstedt[1], Moritz Emons[1], Guido Palmer[1], and Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland — [2]Laser Zentrum Hannover e.V.

We report on a novel method to create multiple waveguides simultaneously in different depths in fused silica. A combination of adaptive beam shaping with femtosecond laser writing is used to simultaneously write two waveguides with changing separation and depth. The method is based on a programmable phase modulator with dynamically varying phase-pattern during the writing process. It can be employed to demonstrate various photonic devices such as couplers, splitters and interferometers. We give an introduction into the method and demonstrate the latest results.

Q 21.85 Tu 16:00 Lichthof

Status of the ELBE-DRACO X-ray source — •Axel Jochmann, Alexander Debus, Christoph Erler, Ulf Lehnert, Stephan Kraft, Michael Bussmann, Thomas Cowan, Roland Sauerbrey, and Ulrich Schramm — Forschungszentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany

We report on the latest status of the Thomson-Backscattering experiment at the FZ Dresden-Rossendorf. The unique opportunity to interact a 150 TW high intensity laser pulse with an electron linac of small emittance and high brilliance enables us to create a bright X-ray light source for a variety of medical and chemical studies. The high average current of the ELBE linear accelerator opens up the possibility to scale the experiment to high average power if matched with a laser of high repetition rate. To transport laser and electron beam to the also newly installed experimental chamber we built two beamlines into the shielded target area. Therefore we are using an active stabilization system which was installed and commissioned.

Q 21.86 Tu 16:00 Lichthof

Processes of different nature in femtosecond-laser-induced electron emission from ultrasharp metal tips — •Michael Krüger, Markus Schenk, Johannes Hoffrogge, Hanno Kaupp, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

We investigate electron emission from sharp tungsten tips induced by few-cycle femtosecond laser pulses. This unique combination of tip and laser pulse should provide high temporal and spatial coherence of the photo-emitted electrons. We report on emission processes triggered by 6fs Ti:sa laser pulses. A retarding field electron spectrometer enables identification of these processes. Typically we observe 10^{-4} to 10^{+3} electrons per pulse depending on the experimental parameters. At low laser intensities ($< 10^{12}$ W/cm^2), multiphoton absorption and subsequent over-barrier emission occur (3-photon process). We can tune the effective workfunction by applying a static electric field to the tip, and thus are able to decrease the number of photons necessary to overcome the potential barrier (2-photon process). At high DC electric fields, additionally tunneling of photo-excited electrons out of the tip is observed (photo-field emission, 1-photon process). At high laser intensities on the order of 10^{12} W/cm^2, electrons with energies corresponding to absorption of up to 7 photons are found (above-threshold photoemission). The nonlinearity of the processes can be determined by interferometric autocorrelation traces using the tip as nonlinear element. We model the observed energy distributions and have evidence that emission takes place via surface states for a certain parameter range.

Q 21.87 Tu 16:00 Lichthof

Glass-fiber-based Fabry-Perot resonators — •Christian Wuttke[1], Boris N. Chichkov[3], Andreas Jöckel[1], Michael Kappl[2], Jürgen Koch[3], Kotaro Obata[3], and Arno Rauschenbeutel[1] — [1]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Max-Planck-Institut für Polymerforschung, 55128 Mainz — [3]Laser Zentrum Hannover e.V., 30419 Hannover

We present experimental results on the fabrication and characterisation of glass-fiber-based Fabry-Perot resonators. In one approach Bragg-reflectors are created on optical nanofibers which can be used to build a fiber-coupled monolithic microresonator. Optical nanofibers are realised from standard optical fibers in a heat and pull process to produce a waist with a diameter of 500 nm. The structure is realised by coating the waist with periodically varying polymer films using two photon polymerization (2PP) or carving structures out of the nanofiber waist by focused ion beam milling (FIB) or laser ablation. The optical properties are spectrally characterised by transmission and reflection measurements and compared to theoretical predictions using a finite difference time domain model. Another approach uses dielectric mirrors that are applied to the endfacets of standard optical fibers with an integrated taper. These resonators can be used to precisely measure the loss of the taper. Long term measurements are made under different environmental conditions.

Financial support by the ESF (EURYI Award) and the Volkswagen Foundation (Lichtenberg Professorship) is gratefully acknowledged.

Q 21.88 Tu 16:00 Lichthof

Fabrication of Bragg Gratings for Silicon-on-Insulator Waveguides — •Harald Richter[1], David Stolarek[1], Lars Zimmermann[1,2], Joachim Bauer[1], Steffen Marschmeyer[1], Ivano Giuntoni[2], Andrzej Gajda[2], and Bernd Tillack[1,2] — [1]IHP Frankfurt, Im Technologiepark 25, 15236 Frankfurt (Oder) — [2]Technische Universität Berlin, HFT 4, Einsteinufer 25, 10587 Berlin

Bragg gratings established in the last years as an important waveguide component for achieving wavelength selective filter functions. Fiber based Bragg grating structures can be considered state of the art for applications in the optical communications and for sensing. The implementation of such components on silicon waveguides is highly desirable, to permit the realization of integrated resonators and optical filters for wavelength selection or for dispersion compensation. We present a wafer level technology based on deep ultra-violet (DUV) lithography to fabricate Bragg gratings on Silicon-on-insulator (SOI) rib waveguides. The principle of the used double patterning technique is presented, as well the influence of the process variations on the device performances. Usable structures were realized, exhibiting a small overlay error and non-rectangular grating profile. The optical characterization showed that the presented technique is capable to provide gratings with performance comparable to state of the art gratings patterned with electron-beam lithography.

Q 21.89 Tu 16:00 Lichthof

Propagation of ultrafast pulses in transparent media — Hatem Dachraoui, •Christian Oberer, Martin Michelswirth, and Ulrich Heinzmann — Molecular and Surface Physics, Faculty of Physics, Bielefeld University

Time- and space-resolved optical transmittance has been used to study the propagation of a femtosecond laser pulse in transparent media (fused silica, LiF) at various input laser energies (5 - 50 TW/cm^2). The results identify different regimes of propagation, revealing the interplay between self-focusing, multiphoton absorption, and plasma defocussing.

Q 21.90 Tu 16:00 Lichthof

Slow Light Enhanced Four Wave Mixing Processes — •Sebastian Jakobs, Bernd Schmid, Alexander Petrov, and Manfred Eich — Institute for Optical end Electronic Materials, Hamburg University of Technology

In this presentation slow light enhanced four wave mixing processes in a silicon based photonic crystal wave guide (PCW) are discussed. Slow light in the frequency range of interest is achieved through variation of hole radii and through variation of the position of holes in the second and third row. The focus will be on slow light enhancement of degenerate four wave mixing (DFWM) and third harmonic generation (THG) in the case of a pure silicon PCW as well as in the case of a PCW infiltrated with functionalised nonlinear organic polymers.

DFWM is proposed as an amplification method and the conversion efficiency is increased by means of the group index dependence of the nonlinear gain g. At the same time phase matching is achieved by adjusting the dispersion relation appropriately.

A concept for slow light enhanced THG is presented and analysed, in which the fundamental and the third harmonic waves are guided in the structure and phase matched.

Q 21.91 Tu 16:00 Lichthof

Purcell effect and light collection from a single emitter inside a diamond nano rod — •Helmut Rathgen[1], Birgit Hausmann[2], Marko Loncar[2], Fedor Jelezko[1], Jörg Wrachtrup[1], Phil Hemmer[1], and Tom Babinec[2] — [1]3. Physikalisches Institut, Uni Stuttgart — [2]Laboratory for Nanoscale Optics

We study the emission of light from single NV centers inside diamond nano rods. The rod acts on the emitter in two ways: 1. as an air clad optical fiber with a very high refractive index (n=2.4), resulting in an exceptionally high N.A., thus enabling efficient collection of emitted light 2. The strong optical confinement in radial direction results in an increase of the spontaneous emission rate and Purcell Effect. The device holds promis for a high brightness single photon source operating under ambient conditions, and is suitable for room temperature photonic and quantum information processing applications.

Q 21.92 Tu 16:00 Lichthof

Injection locking of a phonon laser — •Sebastian Knünz[1], Maximilian Herrmann[1], Valentin Batteiger[1], Guido Saathoff[1], Theodor W. Hänsch[1], Kerry Vahala[2], and Thomas Udem[1] — [1]MPQ, Garching, Germany — [2]Caltech, Pasadena, USA

A single trapped ion, addressed by a red-detuned cooling laser and simultaneously illuminated by a blue-detuned pump laser can exhibit oscillatory motion with a well defined threshold. We have shown that this is the result of stimulated emission of center-of-mass phonons, providing saturable amplification of the motion. This constitutes the mechanical analogue of a laser [1]. Additionally we report on a first application of our phonon laser which further substantiates the analogy to an optical laser: we lock the phonon laser to an external rf signal, an effect widely known as injection locking. Using phase sensitive stroboscopic imaging and a spatially selective Fourier transform technique to generate motional spectra we find excellent agreement with injection locking theory in and outside the locking range. Since the forces which evoke this effect are in the order of 10^{-21} N this system appears to be promising for ultra-sensitive force detection. [1] K. Vahala et al., Nature Physics 5, 682 (2009).