Q 55: Poster II

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

Q 55.1 Th 16:00 Lichthof

Process-chain approach and its application to bosonic lattice systems — •Dennis Hinrichs, Niklas Teichmann, and Martin Holthaus — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany

Using Kato's formulation of the perturbation series we implement a diagrammatic process-chain approach, which enables us to obtain ground state expectation values and phase boundaries for lattice boson models [1]. We study the transition from a Mott insulator to a superfluid in the Bose-Hubbard model for various dimensions and geometries at zero temperature, employing the method of the effective potential. Furthermore, we find a scaling relation that maps critical hopping parameters for different filling factors onto each other [2]. Currently, we are extending this method to other lattice models.

[1] N. Teichmann, D. Hinrichs, M. Holthaus and A. Eckardt, Phys. Rev. B **79**, 224515 (2009)

[2] N. Teichmann, D. Hinrichs, EPJ B **71**, 219 (2009)

Q 55.2 Th 16:00 Lichthof

BEC and atom-optics in optical waveguides — •Johannes Küber, Thomas Lauber, Oliver Wille, Martin Hasch, and Gerhard Birkl — Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt

In our experiment we aim to study and control the properties of Bose-Einstein condensates in optical potentials. We use a crossed dipole trap at 1070nm to prepare up to 25000 condensed Rb atoms. This approach gives us the advantage of being independent of the magnetic properties of our atoms.

After previous experiments with ultra-cold thermal atoms in optical waveguide structures we are going to work with condensed matter in optical potentials. Using miniaturized lens structures we are able to implement attractive or repulsive potentials in different geometries.

Our approach allows us to combine multiple potentials to create complex structures like a one-dimensional resonator for guided atoms or a ring shaped waveguide. For controlled manipulation of atoms, such as accelerating and coherent splitting, we use a blue detuned one dimensional optical lattice and achieve a versatile setup for coherent matter wave manipulation.

Q 55.3 Th 16:00 Lichthof

Quantum brownian motion of grey solitons in 1D-condensates — •Philip Walczak and James R. Anglin — Fachbereich Physik, TU Kaiserslautern, D-67663 Kaiserslautern

In interferometry experiments with quasi-one-dimensional Bose-condensed gases [1] one can observe local shifts in the interference pattern which are due to thermal phase fluctuations of the condensates. In the semi-classical limit, large phase slips can occur on healing length scales through the formation of so-called grey solitons. Using a path integral with canonical collective co-ordinates for a grey soliton, we compute probabilities for phase slips as quantum and thermal fluctuations. We incorporate Brownian motion of the soliton due to back reaction on the soliton co-ordinates from the Bogoliubov modes of the quasi-one-dimensional dilute Bose gas. The derivation of the soliton collective co-ordinates is illustrated with a two dimensional example.

[1] J. Schmiedmayer *et al.*, Nature **449**, 324-328 (2007)

Q 55.4 Th 16:00 Lichthof

Parametric Excitation of Bose-Einstein Condensate Modes — Hamid Jabber Haziran Al-Jibbouri[1] and •Axel Pelster[2,3] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Physik und Astronomie, Karl-Liebknecht-Str. 24 14476 Potsdam, Germany — [3]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

A recent experiment at Rice University studies how the lowest-lying quadrupole mode of a Bose-Einstein condensate of ^{7}Li is excited by modulating periodically the atomic scattering length via a Feshbach resonance [1]. Measuring the amplitude of the quadrupolar oscillation as a function of the excitation frequency Ω reveals both a resonance enhancement at $\Omega = \omega_{\rm Q}$ and a parametric enhancement at $\Omega = 2\omega_{\rm Q}$. We investigate theoretically how the heights of these resonance peaks depend on the anisotropy of the harmonic trap. To this end we follow Refs. [2,3] and apply techniques of nonlinear dynamics in order to analyze the coupled set of ordinary differential equations for the widths of a Gaussian function which solves variationally the underlying Gross-Pitaevskii theory.

[1] R.G. Hulet, V.S. Bagnato *et al.* (in preparation)

[2] F.K. Abdullaev, R.M. Galimzyanov, M. Brtka, and R.A. Kraenkel, J. Phys. B **37**, 3535 (2004)

[3] N.N. Bogoliubov, Y.A. Mitropolsky, *Asymptotic Methods in the Theory of Non-Linear Oscillation* (Hindustan P. Corp. Delhi-6, 1961)

Q 55.5 Th 16:00 Lichthof

The Dicke Model Quantum Phase Transition in a Driven Condensate-Cavity System — •Ferdinand Brennecke, Kristian Baumann, Christine Guerlin, Silvan Leinss, Rafael Mottl, and Tilman Esslinger — Quantum Optics Group, ETH Zurich, Switzerland

The Dicke Model describes the collective interaction between an ensemble of two-level atoms and a single electromagnetic field mode, and remains a fundamental theme in quantum optics. In the thermodynamic limit this system was predicted to undergo a quantum phase transition from a normal to a superradiant phase. Here we present an experimental open-system realization of the Dicke model using a Bose-Einstein condensate coupled to a high-finesse optical cavity. The superfluid atoms collectively couple a far-detuned pump field to an empty cavity mode. Above a critical pump power the atoms self-organize into an emergent checkerboard pattern. When entering this self-organized phase, the gas initially maintains phase coherence and can thus be regarded as a supersolid. Over a wide range of parameters, the boundary of this novel quantum phase is mapped out and compared to a theoretical model. This work opens up new aspects of quantum many-body physics with global interactions mediated by the cavity field.

Q 55.6 Th 16:00 Lichthof

Single Atom Detection on Atomchips — •Saskia Kühnhold, Barbara Grüner, Michael Gierling, Philipp Schneeweiss, Gabriela Visanescu, Michael Jag, Alexander Stibor, Michael Häffner, Dieter Kern, Andreas Günther, and József Fortágh — Physikalisches Institut, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen

We present two single atom detection schemes for cold atom experiments on atom chips. The first detector is based on multi-photo-ionization of cold atoms and the adjacent ion-counting with a channel electron multiplier [1]. We present measurements on static and dynamic properties of ultracold atom clouds, ranging from temperatures to correlation measurements. The second detector is based on field-ionization of ground state atoms close to tips of positively charged carbon nanotubes (CNTs) and the detection of the produced ion [2]. We characterize the field strength at the CNT tips and determine the ionising area next to the nanotubes. We demonstrate the nanotube detector by counting atoms from a thermal beam of rubidium atoms and show up an application of the detector as a partial pressure gauge.

[1] Günther et al., Phys. Rev. A 80, 011604(R) (2009) [2] Grüner et al., arXiv:0911.1329 (2009), Phys. Rev. A in print

Q 55.7 Th 16:00 Lichthof

Feshbach resonances in mixtures of ^{6}Li and ^{40}K — •Antje Ludewig[1], Tobias Tiecke[1], Steve Gensemer[1,2], Sebastian Kraft[1,3], and Jook Walraven[1] — [1]Van der Waals-Zeeman Institute of the University of Amsterdam, The Netherlands — [2]Ethel Walker School, Simsbury, United States — [3]PTB, Braunschweig

We report on the measurement of Feshbach resonances in Fermi-Fermi mixtures. For this purpose we have created an ultracold mixture of the fermionic alkali isotopes ^{6}Li and ^{40}K in an optical dipole trap. In the same trap we have realized a three-component degenerate spin mixture of ^{40}K -atoms at T $0.3T_F$. To create the mixture we start by loading a two-species magneto-optical trap (MOT) from two separate 2D-MOT sources. We realized for the first time a 2D-MOT source for lithium, yielding a large cold flux of up to 10^9 s^{-1}. The mixture is then captured in an optically-plugged magnetic quadrupole trap. After sympathetic cooling of ^{6}Li by ^{40}K to T$\sim$10μK the mixture is loaded into optical tweezers. The mixture is optically transported over a distance of 21.5 cm into a science cell where we measure Feshbach resonances using magnetic field coils designed for high homogeneity. We report on our progress measuring the width of Feshbach resonances in ^{6}Li -^{40}K mixtures and locating resonances in mixtures of ^{40}K.

Q 55.8 Th 16:00 Lichthof

Mott insulator phases of spin-3/2 fermions in one-dimensional lattices — Karen Rodriguez, Arturo Arguelles, •Maria Colome-Tatche, Temo Vekua, and Luis Santos — Institut fur Theoretische Physik, Leibniz Universitat Hannover, Appelstr. 2, D-30167, Hannover, Germany

We study the ground state phase diagram of repulsive spin-3/2 fermions at zero magnetization in the presence of quadratic Zeeman effect (QZE). Starting from the Hamiltonian of the 4-component Hubbard model we derive the effective hard-core Hamiltonian, that can be understood as a spin-chain model. This model presents effective coupling constants which show a non-trivial dependence induced by the interplay between QZE and spin-changing collisions. In the absence of QZE the ground state of the system is either in the dimer (spin Peierls) phase or in the spin liquid one. Applying a non-zero QZE the system breaks the degeneracy between 1/2 and 3/2 spin components, resulting in a phase transition into an effective pseudo-spin 1/2 isotropic Heisenberg antiferromagnet for a sufficiently large QZE. We characterize by means of DMRG calculations the ground state properties for the different regimes and determine the boundaries between the different phases. We characterize the transition between dimer phase and effective Heisenberg antiferromagnet by means of exact diagonalization techniques. We shall also discuss, by means of Gutzwiller Ansatz calculations for the particular case of spinor bosons, a resonance occuring between spin-changing collisions and QZE, which may lead to the destruction of the Mott-insulator phase.

Q 55.9 Th 16:00 Lichthof

Low-dimensional Bose-Fermi mixtures and atom chips — •Tim Langen, Michael Gring, Maximilian Kuhnert, Matthias Schreitel, David A. Smith, and Jörg Schmiedmayer — Institute for Atomic and Subatomic Physics, TU Wien, Stadionallee 2, A-1020 Vienna, Austria

We report on our novel experimental setup which aims for the creation of degenerate, low-dimensional Bose-Fermi mixtures on an atom chip. The apparatus is based on a two-species double-MOT system for bosonic ^{87}Rb and fermionic ^{40}K. Using two macroscopic magnetic traps, precooled atoms from the MOT are efficiently transfered onto the atom chip. There, we currently reach Bose-Einstein condensation with up to 10^5 atoms which we will use to rapidly cool the fermions into the degenerate regime [1]. The intrinsic tight confinement and high aspect ratio of the chip traps will then make it possible to prepare individual realizations of low-dimensional gases of bosons, fermions or mixtures of both. For the bosons, we present first results on the preparation, manipulation and probing of these many-body systems using radio-frequency dressed-state potentials [2] and matter-wave interferometry.

[1] Aubin et al., Nature Phys. 2, 384 (2006)
[2] T. Schumm et al., Nature Phys. 1, 57 (2005)

Q 55.10 Th 16:00 Lichthof

Multiband renormalization of Bose-Fermi mixtures in optical lattices — •Alexander Mering and Michael Fleischhauer — Fachbereich Physik and research center OPTIMAS, Technische Universität Kaiserslautern

The physics of ultracold mixtures of bosons and fermions in optical lattices is considered in the framework of the Bose-Fermi-Hubbard model. Starting from the derivation of the full multi-band model by including all couplings from the first Bloch band to all higher bands, we derive an effective single band Hamiltonian. This single band model obeys renormalized model parameters and allows for a consideration of the higher band effects onto the mixture. The most important contribution is shown to arize from inter- and intraspecies nonlinear corrections to the tunneling rate. Including further first-band corrections this approach finally allows to study the influence of the higher bands as well as the fermionic species onto the superfluid to Mott insulator transition of the bosons as recently studied in experiments.

Q 55.11 Th 16:00 Lichthof

"Photon"-assisted tunnelling of ultra-cold atoms — •Martin Esmann, Kirsten Stiebler, Bettina Gertjerenken, Niklas Teichmann, and Christoph Weiss — Institute of Physics, Carl von Ossietzky University, D-26111 Oldenburg, Germany

"Photon"-assisted tunnelling has recently been realised experimentally for a Bose-Einstein condensate in an optical lattice [1]. The focus of this poster are numerical and analytical calculations on the transfer of ultra-cold atoms between neighbouring wells in double-well lattices for which effects like fractional photon resonances are important [2]. Subwavelength lattices are also investigated.

[1] C. Sias, H. Lignier, Y. P. Singh, A. Zenesini, D. Ciampini, O. Morsch, and E. Arimondo, Phys. Rev. Lett. 100, 040404 (2008).

[2] N. Teichmann, M. Esmann, and C. Weiss, Phys. Rev. A 79, 063620 (2009).

Q 55.12 Th 16:00 Lichthof

Three-body bound states in a lattice — •Manuel Valiente[1,2], David Petrosyan[1], and Alejandro Saenz[2] — [1]IESL-FORTH, Heraklion, Greece — [2]Institut für Physik, Humboldt Universität zu Berlin, Berlin, Germany

We investigate the three-boson problem in a deep one-dimensional lattice with nearest neighbor hopping and pairwise on-site interaction. We find that, apart from the trivial bound states of three particles strongly co-localized on the same lattice site, there exist two other bound states essentially composed of a bound pair [1,2]– "dimer" – and a third particle – "monomer" – weakly bound to the pair [2]. The energy of such states can be above or below the continuum of dimer-monomer collisions. We explain these new exotic states in term of an effective model in the strong-coupling regime and find that the binding is induced by an exchange operator between the dimer and the monomer.

References [1] K. Winkler et al., Nature 441, 853 (2006) . [2] M. Valiente and D. Petrosyan, J. Phys. B 41, 161002 (2008); ibid. 42, 121001 (2009). [3] M. Valiente, D. Petrosyan and A. Saenz, Phys. Rev. A (in press); arXiv:0907.3111 .

Q 55.13 Th 16:00 Lichthof

Single site addressability in optical lattices — •Endres Manuel, Christof Weitenberg, Jacob Sherson, Marc Cheneau, Ralf Labouvie, Rosa Glöckner, Immanuel Bloch, and Stefan Kuhr — Max-Planck-Institut für Quantenoptik, Garching

Investigations of ultracold quantum gases in optical lattices are mostly restricted to access global information of the system. By contrast we are developing experimental techniques revealing the local distribution of the trapped gas. The main part of our experiment is an optical imaging system with a spatial resolution better than the lattice spacing of a near-infrared optical lattice. In addition the setup allows for manipulation of the atoms on a local scale.

Collecting the fluorescence light of the trapped atoms, will enable us to observe the local dynamics of the many-body system. With an additional strongly focused laser beam single sites of the optical lattice can be addressed. Possible applications of single site addressability are e.g. single q-bit rotations via local microwave-resonance or perturbation of the many-body system on a local scale.

So far we have taken in trap fluorescence images with a resolution of 700 nm using the 5S1/2 to 5P3/2 transition at 780nm and demonstrated the micro-manipulation of a few atoms with a tightly focused dipole trap. To extract one or a few slices and to remove the atoms that are out of the depth of focus we use microwave transitions in a magnetic field gradient.

Q 55.14 Th 16:00 Lichthof

Equilibrium and out-of-equilibrium properties of ultracold fermions in optical lattices — •Robert Jördens, Leticia Tarruell, Daniel Greif, Thomas Uehlinger, Niels Strohmaier, Henning Moritz, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

We present the results of a combined experimental and theoretical study of repulsively interacting ^{40}K atoms in the Hubbard model. Accurate measurements of the double occupancy provide direct access to the system's properties both in equilibrium and in the linear response regime. By calibrating the equilibrium double occupancy against theoretical models over a wide range of parameters we develop a reliable measure for the entropy in the lattice. We demonstrate the applicability of both high-temperature series and dynamical mean field theory to obtain quantitative agreement with the experimental data.

Additionally, we perform weak lattice modulation and monitor the increase of doublons with time. The observations are well captured by linear response theory and are sensitive to local spin ordering, which can be used to detect anti-ferromagnetic states. For long modulation times the system is driven into a far-from-equilibrium state with many additional doublons. We show that the dominant decay mechanism is a high-order scattering process and the doublon lifetime depends exponentially on the ratio of onsite interaction to tunneling energy.

Q 55.15 Th 16:00 Lichthof

Singlet-triplet oscillations with pairs of neutral atoms in an optical superlattice — •Stefan Trotzky[1], Yu-Ao Chen[1], Ute Schnorrberger[1], and Immanuel Bloch[1,2] — [1]Ludwig-Maximilians-Universität, Schellingstrasse 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans Kopfermann-Strasse 1, 85748 Garching

We show the creation, detection and manipulation of effective-spin triplet and singlet pairs with ultracold ^{87}Rb atoms in a bichromatic optical superlattice. The system is initialized with two atoms per lattice site being in two different Zeeman states $|F=1;m_F=-1\rangle \equiv |\downarrow\rangle$ and $|1;+1\rangle \equiv |\uparrow\rangle$. When splitting the lattice sites into symmetric double-wells by means of the superlattice, we create an array of entangled triplet pairs $|\uparrow,\downarrow\rangle + |\downarrow,\uparrow\rangle$. Subsequently, a magnetic-field gradient along the double-well axis is used to induce oscillation between the triplet and the singlet state $|\uparrow,\downarrow\rangle - |\downarrow,\uparrow\rangle$. We detect these singlet-triplet oscillations via the symmetry of the respective wavefunction after merging the double-wells. Our method provides a tool to probe local spin-order emerging in e.g. valence-bond solid type states as well as in Fermi-Hubbard systems at low temperature.

A superexchange coupling between adjacent double-wells is employed to implement a SWAP operation, stretching the entangled pairs over more than one double-well. This operation can be seen as a step towards the creation of a multi-particle entangled state in the optical lattice, which might serve as initial state for one-way quantum computational schemes.

Q 55.16 Th 16:00 Lichthof

Interacting Bose-Fermi Mixtures in Optical Lattices — •Simon Braun[1], Sebastian Will[1], Thorsten Best[2], Philipp Ronzheimer[1], Michael Schreiber[1], Ulrich Schneider[1], Tim Rom[1], Lucia Hackermüller[1], Kin-Chung Fong[1], Dirk-Sören Lühmann[3], and Immanuel Bloch[1] — [1]Ludwig-Maximilians-Universität München — [2]ALU Freiburg — [3]Universität Hamburg

Mixtures of ultracold quantum gases in optical lattices form novel quantum many-body systems, whose properties are governed by an intriguing interplay of quantum statistics, inter- and intraspecies interactions, as well as the relative atom numbers of the constituents.

In our setup, we cool bosonic ^{87}Rb and fermionic ^{40}K to simultaneous quantum degeneracy. We realize a Bose-Fermi Hubbard model (BFHM) by loading the atoms into the combined potential of a blue-detuned three-dimensional optical lattice and a red-detuned dipole trap. The interspecies interactions can be controlled using Feshbach resonances and Raman transitions between different Zeeman sublevels.

Our investigations of the many-body properties of the Bose-Fermi mixture revealed that attractive interspecies interactions cause a marked shift in the superfluid to Mott insulator transition due to self-trapping. In a detailed study of quantum phase diffusion of a BEC in a 3D optical lattice, we were able to measure the bosonic interaction energies with very high precision and observe the influence of a fermionic admixture on both the occupation number statistics and the BFHM parameters. Finally, we present routes towards the realization of polaron physics in atomic Bose-Fermi mixtures.

Q 55.17 Th 16:00 Lichthof

Collisional properties of metastable neon — •Thomas Feldker[1], Holger John[1], Jan Schütz[1], Norbert Herschbach[2], and Gerhard Birkl[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt — [2]QUEST Institute at PTB, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

We study the collisional interactions of metastable neon (Ne*) in the $^3P_2$ state in a magneto-optical trap and magnetic trap. The remarkable feature of Ne* is its extremely high internal energy which, on the one hand, enables sensitive detection using electron multipliers but, on the other hand, leads to very high two-body losses due to Penning ionization. The bad ratio of elastic to inelastic collisions hampers efficient evaporative cooling and, thus, achievement of quantum degeneracy.

We are therefor investigating possibilities to manipulate the collisional interactions. One objective is to prepare the atoms in certain superposition states of Zeeman sublevels using STIRAP which is proposed to significantly suppress inelastic collisions. Another approach is to exploit inter-isotopic collisions. We are able to trap two-isotope combinations of bosonic ^{20}Ne, bosonic ^{22}Ne, and fermionic ^{21}Ne and are exploring possible schemes for sympathetic cooling. We report on the status of the experiments.

Q 55.18 Th 16:00 Lichthof

A high-flux source of guided ultracold chromium atoms — •Valentin Viktorovich Volchkov, Anoush Aghajani-Talesh, Markus Falkenau, Axel Griesmaier, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut

A continuous source of cold atoms is a vital ingredient for realizing continuous atom lasers. The presented apparatus delivers a magnetically guided, ultracold beam of chromium atoms at a flux of 10^9 atom/s [1]. This beam is obtained by operating a MOT directly inside a magnetic guide. We discuss a proposal to continuously load a deep optical dipole trap from the atomic beam. To this end, a scheme of an atomic diode is presented: a magnetic field barrier within the optical dipole trap removes the kinetic energy of the atoms, while optical pumping into the lowest energy state removes the potential energy and traps the atom at the bottom of the combined trap. This mechanism will allow for continuous trapping and fast loading of the ODT. Recently, transverse laser cooling of the guided atoms has been demonstrated [2]. The resulting radial temperature yields, according to our simulations [3], a much higher loading efficiency of the trap.

[1] A Griesmaier et al. *J. Phys. B.* **42** 145306 (2009).
[2] A Aghajani-Talesh et al. *Submitted to New J. Phys.*
[3] A Aghajani-Talesh et al. *J. Phys. B.* **42** 245302 (2009).

Q 55.19 Th 16:00 Lichthof

Rb MOT system for an advanced lab course at the University of Heidelberg — Silvânia Alves de Carvalho, Marc Repp, Christoph S. Hofmann, Rico Pires, •Kristina Meyer, Dominic Litsch, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität, Philosophenweg 12, 69120 Heidelberg, Germany

We present an improved and compact setup of a Rb magneto-optical trap (MOT) experiment for an advanced student laboratory course. The Rb MOT will be used to introduce the students to topics such as Atomic Physics, laser cooling, spectroscopy and to the experimental techniques relevant in AMO Physics. This poster presents the apparatus and the characterization of the atom cloud (atom number, density, temperature and loading). We are currently working on implementing photoassociation spectroscopy near the dissociation threshold in this sample of cold atoms as an extension of the lab course. Instead of usual printed instructions, the lab manual will be available in the form of a wikipedia, which contains descriptions of the experiment and the topics presented.

Q 55.20 Th 16:00 Lichthof

Cooling caesium atoms in a bad, near-confocal cavity — •Arne Wickenbrock, Piyaphat Phoonthong, Nihal Wahab, and Ferruccio Renzoni — Department of Physics and Astronomy, Univerity College London, WC1 5BT London, UK

Particles in a macroscopic optical cavity have significantly altered optical properties [1]. The presence of the cavity changes the em-mode spectrum and hence scattering rates and spontaneous emission. Inside the cavity the mode density is strongly frequency dependent, which can be used to propose cooling schemes without a closed optical transition [2-4]. This might expand the range of ultracold particles to more complex structured atoms and molecules. We report on experiments conducted on a cold sample of caesium atoms placed in the centre of the optical resonator. Our apparatus includes a 12cm long near-confocal cavity with a finesse of 800.

In a first set of experiments the cavity resonance is positioned with respect to the cycling transition of caesium, while a laser pumps it for a certain time. Measuring the temperature of the expanding cloud in a time of flight measurement over the cavity-atom detuning reveals the effect of the resonator. [1]E.M. Purcell, Phys. Rev. 69, 681 [2]Horak P., Hechenblaikner G., Gheri K. M., Stecher H., Ritsch H., Phys. Rev. Lett.79, 4974 [3]Vuletic V., Chu S., Phys. Rev. Lett. 84, 3787 [4]P. Domokos and H. Ritsch, J. Opt. Soc. Am. B 20, 1089 (2003)

Q 55.21 Th 16:00 Lichthof

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

One can gain deeper insight into complex quantum dynamics via experimentally simulating the quantum behaviour of interest in another quantum system, where not all but the relevant parameters and interactions can be controlled and robust effects detected sufficiently well.

We report the trapping of a single ion in an optical dipole trap for a duration on the order of milliseconds. After the dipole trap is loaded by a regular Paul trap, the latter is turned off. Due to the sensitivity of the charged particle to voltages, the dipole forces required are orders of magnitudes above the ones required for atomic dipole traps. We found that we can achieve this by decreasing the detuning from resonance. However, this causes the increase of various heating effects like dipole heating and recoil heating, limiting the trapping duration. Therefore one has to find a trade-off between strong dipole forces and long trapping durations.

We aim to merge the advantages of quantum simulations with atoms and ions by confining them in the identical dipole trap/optical lattice. This renders it possible to investigate for instance atom-ion interactions or to form anharmonic potentials, a tool for scalable quantum simulations.

Q 55.22 Th 16:00 Lichthof

Microwave structures for electron guiding — •Johannes Hoffrogge and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München

We present microwave structures for the guiding of electrons in an alternating quadrupole field. These combine the electrode layout of a two dimensional planar Paul trap with that of a microwave transmission line. For longitudinal guide dimensions comparable to the wavelength of the driving field, the microwave guiding properties of these structures have to be considered. A normal mode decomposition of the trapping field shows that the latter consists of a superposition of two different eigenmodes of the electrode structure with differing propagation constants. For a typical structure driven at 10 GHz this leads to a dephasing by 5° after a propagation length of 7 cm. We investigate the consequences of this on the particle dynamics by numerical particle tracking and discuss strategies to minimize the effect.

At the moment, we are setting up a proof of principle experiment, where we will guide electrons in an electrically small structure at 1 GHz. Besides microwave measurements on test substrates, we present the characteristics of a low energy electron source and the current status of the experiment.

Q 55.23 Th 16:00 Lichthof

Design of a hexapole-compensated magneto-optical trap without external fields — •Stefan Jöllenbeck, Jan Mahnke, Jan Arlt, Carsten Klempt, and Wolfgang Ertmer — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

The production of Bose-Einstein condensates with a high repetition rate constitutes a large step towards atom interferometry with coherent matter waves. Our approach is to load atoms into a chain of magnetic traps generated by planar wire structures where they can be transported and cooled to quantum degeneracy. Magnetic offset fields used in a conventional magneto-optical wire trap disturb the parallel trapping of more than one cloud at a time. Here we present a new setup to generate a magnetic quadrupole field with nine planar wires placed outside our vacuum system. By minimizing the hexapole components of the magnetic field, a large effective trapping volume is obtained. We expect large trapping efficiencies for pre-cooled atoms provided by a two-dimensional magneto-optical trap. Such a mesoscopic trap with high particle numbers may serve as an ideal starting point for the production of many Bose-Einstein condensates in fast sequence.

Q 55.24 Th 16:00 Lichthof

Dynamics of a coherently driven atom in a high-finesse optical resonator — •Martin Eckstein, Wolfgang Alt, Stefan Brakhane, Tobias Kampschulte, Sebastian Reick, René Reimann, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn

In our experiment we transport a single cold caesium atom 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 [2]. We study the dynamics of a coherently driven two-level atom inside our cavity. The driving source consists of two phase locked diode lasers that connect the atomic states by a two-photon Raman process. We study the influence of the non-destructive measurement on the evolution of 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 55.25 Th 16:00 Lichthof

Coherent Processes in the Presence of Interparticle Interactions — •Hanna Schempp[1], Georg Günter[1], Christoph S. Hofmann[1], Nele Müller[1], Christian Giese[1], Sebastian D. Saliba[1], Brett D. DePaola[1], Sevilay Sevincli[2], Thomas Pohl[2], Thomas Amthor[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [2]Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

We report on coherent processes in ultracold Rydberg gases, namely Rabi oscillations between ground and Rydberg state [1], Rapid Adiabatic Passage [2] and Coherent Population Trapping (CPT). In the presence of interparticle interactions the coherence of these processes is reduced and correlations among the particles play a role. Van der Waals interactions between Rydberg atoms can precisely be adjusted by varying the atom density and the principal quantum number. Thus Rydberg atoms provide an excellent tool to systematically tune the interparticle interactions. We show experimental results on CPT with controlled interparticle interactions and present a many-body model that reproduces the measured features [3].

[1] M. Reetz-Lamour et al., Phys. Rev. Lett. 100, 253001 (2008)
[2] J. Deiglmayr et al., Opt. Comm. 264, 293 (2006)
[3] H. Schempp et al., submitted (2009)

Q 55.26 Th 16:00 Lichthof

Drift waves and instabilities in ultracold plasmas — •Cornelia Lechner, Christian Knapp, and Alexander Kendl — Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria

Ultracold quasi-neutral plasmas merge the physics of strongly coupled plasmas and of ultracold quantum gases. Recent experiments have been reported on first observations of ultracold plasma waves and instabilities, which are counterparts of well-known drift instabilities in hot plasmas (where they are e.g. responsible for turbulent transport losses in fusion experiments). However, not much attention has yet been devoted to the theory of ultracold plasma instabilities. Here, we present an analysis of possible theoretical approaches to ultracold plasmas, and discuss the influence of strong Coulomb coupling on the drift dynamics of such systems, especially concentrating on the case of a magnetized ultracold plasma.

Q 55.27 Th 16:00 Lichthof

Erzeugung und Nachweis von Bewegungs-Quantenzuständen einzelner kalter Ionen in einer Mikrofalle — •Gerhard Huber[1], Ulrich Poschinger[1], Markus Deiss[2], Frank Ziesel[1], Max Hettrich[1], Daniel Seyfried[1], Michaela Petrich[1] und Ferdinand Schmidt-Kaler[1] — [1]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm — [2]Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, 89081 Ulm

Kalte, in einer Paul-Falle gespeicherte Ionen sind ein ideales Modellsystem zur Untersuchung quantenthermodynamischer Phänomene [1]. Die experimentelle Umsetzung dieser Modellsysteme erfordert ein Höchstmaß an Kontrolle über die Bewegungsfreiheitsgrade einzelner Ionen, um die erforderlichen Quantenzustände zu präparieren und über externe, zeitabhängige Potentiale zu kontrollieren. Darüber hinaus kann der Bewegungszustand durch die Kopplung interner und externer Freiheitsgrade über Lichtfelder mit der Präzision einzelner Vibrationsquanten manipuliert werden [2]. Dazu führen wir Experimente in einer mikrostrukturierten linearen Paul-Falle durch. Insbesondere zeigen wir alle notwendigen Methoden der Zustandsdetektion von der Messung der Phononenverteilung bis hin zur vollständigen Zustandstomographie des Bewegungszustandes [3].

[1] G. Huber *et al.*, Phys. Rev. Lett. **101**, 070403 (2008)
[2] U. G. Poschinger *et al.*, J. Phys. B **42** 154013 (2009)
[3] D. Leibfried *et al.*, Phys. Rev. Lett. **77**, 4281 (1996)

Q 55.28 Th 16:00 Lichthof

Atom Trap Trace Analysis of Argon 39 — •Florian Ritterbusch[1], Joachim Welte[1], Matthias Henrich[1], Werner

Aeschbach-Hertig[2], and Markus K. Oberthaler[1] — [1]Kirchhoff-Institute, Heidelberg university — [2]Institute for environmental physics, Heidelberg university

We present our work towards the realization of Atom Trap Trace Analysis for ^{39}Ar, a promising novel method for dating water from the past 50 to 1000 years. This ultra-sensitive detection method for rare isotopes is based on laser cooling mechanisms. We report on the first experimental determination of the hyperfine spectrum of the relevant cooling transition. Furthermore, a high intensity, optically collimated beam of metastable argon atoms has been set up and fluorescence detection of single ^{40}Ar atoms in a magneto-optical trap is realized. Having achieved these essential steps an ATTA table-top apparatus now becomes feasible.

Q 55.29 Th 16:00 Lichthof

Cold atoms inside a hollow core fiber - a novel medium for few-photon nonlinear optics — •Sebastian Hofferberth[1], Thibault Peyronal[2], Michal Bajcsy[2], Alexander Zibrov[2], Vladan Vuletic[1], and Mikhail Lukin[1] — [1]Harvard-MIT Center for Ultracold Atoms, Department of Physics, Harvard University, Cambridge, MA 02138 — [2]Harvard-MIT Center for Ultracold Atoms, Department of Physics, MIT, Cambridge, MA 02139

Typically, interactions of light beams in nonlinear media are very weak at low light levels. Strong interactions between few-photon pulses require a combination of large optical nonlinearity, long interaction time, low photon loss, and tight confinement of the light beams.

Here, we present an approach to overcome these issues that makes use of an optically dense medium containing a few hundred cold atoms trapped inside the hollow core of a photonic crystal fiber. We discuss recent experiments regarding few-photon optical nonlinearities and single atom detection inside the hollow core fiber.

Q 55.30 Th 16:00 Lichthof

Properties of ultracold ground state LiCs molecules — •Marc Repp[1], Johannes Deiglmayr[1,2], Anna Grochola[3], Olivier Dulieu[4], Roland Wester[2], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg — [2]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg — [3]Institute of Experimental Physics, University of Warsaw — [4]Laboratoire Aimé Cotton, CNRS, Orsay

Recently we achieved the formation of LiCs molecules in the lowest levels of the ground state by photoassociation (PA) [1]. These molecules are of particular interest due to their large permanent electric dipole moment. We will present a first experimental measurement of this dipole moment. We will further present the first trapping of ultracold LiCs molecules. The molecules are formed and trapped in a quasi electrostatic trap (QUEST) formed by single-focused CO_2 laser. We determine the lifetime of molecules in the trap to be τ=24(3) s, limited by collisions with background gas. Rate coefficients for inelastic collisions between LiCs molecules and cesium atoms in the QUEST are measured to be between β=1.1×10^{-10}cm^3/s and 2.4×10^{-10}cm^3/s, depending on the PA resonance used for the formation of the molecules.
[1] J. Deiglmayr *et al.*, Phys. Rev. Lett. 101, 133004 (2008).

Q 55.31 Th 16:00 Lichthof

Setup of a Li MOT for the study of ultracold molecule production — •Michael Köppinger, Frank Münchow, Florian Baumer, and Axel Görlitz — Institut für Experimentalphysik, HHU Düsseldorf, 40225 Düsseldorf

Quantum gases of ultracold polar molecules offer fascinating prospects for the realization of new forms of quantum matter with possible applications to quantum information and to precision measurements. Recently we have begun to study the photoassociative production of heteronuclear molecules in a mixture of ultracold Yb and Rb atoms and observed molecule production in the excited state.

While a mixture of Yb and Rb allows for the production of boson-boson and boson-fermion molecules, in a mixture of Yb and Li it would also be possible to explore the properties of fermion-fermion molecules. Therefore, we have started to set up a Li MOT in a compact test chamber which will eventually be merged with the Yb-Rb mixture. Here we report on the status of the experiment.

Q 55.32 Th 16:00 Lichthof

Active low- frequency vibration isolation for high precision atom interferometry — •Christian Freier, Alexander Senger, and Achim Peters — Humboldt Universität Berlin

The performance of high precision atom interferometers is often limited by Raman phase noise introduced by vibrations of the interferometers optical components. We present an active low frequency vibration isolation based on a commercial MinusK passive vibration isolation platform which isolates one key component, a retro-reflecting mirror, from environmental vibrations. The system combines an active system with the spring based negative-stiffness passive isolation of a MinusK vibration isolation platform. The active stage measures residual vibrations using a commercial weak-motion seismometer and feeds them back into a voice coil actuator to cancel them out. The passive vibration isolation only, with a resonant frequency of 0.5 Hz, reduces the amount of vibrations by a factor of 100-1000 from 10Hz to 100Hz. We characterize the performance of the platform with the active system enabled and show tests of interferometer fringes with and without active vibration isolation.

Q 55.33 Th 16:00 Lichthof

Degenerate Bose-Fermi Gases in Microgravity — •Christina Rode[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

Recent developments in atom optics allow for ultra precise and accurate measurements at the level of Heisenberg limited uncertainty. These measurements can be performed with ultra-cold quantum gases by extending their time of unperturbed evolution. The pioneering experiment QUANTUS has realized a Bose-Einstein condensate in microgravity and subsequently observed it's free evolution for up to 1 second. Our second generation experiment QUANTUS 2 will be more compact, allow for larger numbers of atoms and will enhance the time of microgravity to 9 seconds. ^{87}Rb and ^{40}K will be used as a Bose-Fermi mixture in order to perform matter wave interferometry in microgravity and to test the Weak Equivalence Principle in the quantum domain. This will be possible due to the mass independent confining potentials available in a microgravity environment. An up-to-date progress report of our activities and future prospects will be presented.

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 55.34 Th 16:00 Lichthof

Nanoscale scanning probe magnetometer with single spin sensitivity — •Friedemann Reinhard[1], Eike Oliver Schäfer-Nolte[1,2], Markus Ternes[2], Bernhard Grotz[1], Helmut Rathgen[1], Gopalakrishnan Balausbramanian[1], Julia Tisler[1], Klaus Kern[2], Fedor Jelezko[1], and Jörg Wrachtrup[1] — [1]Universität Stuttgart, 3. Physikalisches Institut — [2]Max-Planck-Institut für Festkörperforschung, Stuttgart

We present our work towards a scanning-probe magnetometer with subnanometre resolution, using the NV center in diamond as a magnetic field sensor. We will discuss technical aspects, such as the construction of dedicated AFMs for this application, as well as studies of the properties of NV centers close to the surface of diamond and in nanodiamonds.

Q 55.35 Th 16:00 Lichthof

Stabilization of the Advanced LIGO 200W laser — •Christina Krämer, Jan Hendrik Põld, Patrick Kwee, Hyunjoo Kim, Benno Willke, and Karsten Danzmann — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) und Institut für Gravitationsphysik der Leibniz Universität Hannover, Germany

The high power laser which will be operated in the interferometric gravitational wave detector Advanced LIGO has to fulfill strict requirements according to frequency and power stability as well as to the shape of the spatial beam profile. Therefore a demanding active and passive stabilization of this continuous wave 200W Nd:YAG laser at 1064nm is necessary. A key part of this stabilization is a ring cavity, which is used to suppress power noise at radio frequencies and improves the spatial beam quality. For the frequency stabilization the laser system is stabilized to a high finesse reference cavity. The power stability is achieved with a nested control loop to reach a relative power noise of $2 \cdot 10^{-9}\,\mathrm{Hz}^{-1/2}$ at the interferometer input.

In this contribution the concepts and preliminary results of the stabilization of the Advanced LIGO laser will be presented.

Q 55.36 Th 16:00 Lichthof

Controlling single-molecule dipole-dipole coupling by optical confinement in a $\lambda/2$-microresonator (exchanged with Q 67.1) — •Raphael Gutbrod, Sebastian Bär, Frank Schleifenbaum, Sébastien Peter, Kirstin Elgass, and Alfred J. Meixner — Institute of Physical and Theoretical Chemistry, University of Tübingen

Fluorescence resonance energy transfer (FRET) is a well-known photophysical phenomenon where the excited-state energy from the initially excited donor molecule is transferred to an acceptor molecule via dipole-dipole coupling. The rate of energy transfer depends upon the extent of spectral overlap of the donor emission spectrum with the acceptor absorption spectrum, the quantum yield of the donor, the relative orientation of the donor and acceptor transition dipoles and the distance between donor and acceptor and hence is often used as a molecular ruler in fluorescence microscopy in life-sciences. We present a novel approach to precisely tune the FRET efficiency by the local mode of a subwavelength Fabry-Pérot type microresonator. According to Fermi's golden rule, the spontaneous emission rate depends on the mode density of the electromagnetic field and can be modified in the microresonator. Thus, the fluorescence of the chromophores involved in the FRET-process is varied over a broad range. We demonstrate that a microresonator disentangles coupled FRET systems by gradually varying the energy transfer from donor to acceptor. It is possible to tune the energy transfer rate of a given FRET-pair without chemical or physical manipulation of the dye system by simply varying the mirror separation of the microresonator.

Q 55.37 Th 16:00 Lichthof

Quantum sensors with laser cooled ions — •Karsten Pyka, Norbert Herschbach, and Tanja E. Mehlstäubler — QUEST - Institut, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Time and frequency are the most accurately measurable quantities in physics today. In the cluster of excellence QUEST (Center for Quantum Engineering and Space-Time Research) atomic clocks are developed for new kinds of quantum sensors and tests of fundamental theories on a quantum-mechanical level. With an atomic clock with relative frequency inaccuracy of 10^{-18} new applications in geodetic measurements as well as navigation are accessible.

Today's standards in frequency measurement are defined by single-ion clocks and neutral atom optical lattice clocks, which have demonstrated the potential for ultra-high short term stability and ultra-high accuracy, respectively. Our group dedicates its work to the development of new trap geometries for the trapping, manipulation and spectroscopy of many ions to combine the advantages of both and overcome the problems of the current technologies.

We have set up a new experiment to trap ions in microfabricated trap structures. $^{172}Yb^+$-ions serve to test and characterize the new trap geometries as well as to sympathetically cool $^{115}In^+$-ions for spectroscopy. The first tested ion trap is made out of Rogers4350 printed circuit board, a high-precision ceramic chip trap is built in parallel. We present the status of our experiment together with FEM-simulations of the new trap designs.

Q 55.38 Th 16:00 Lichthof

Michelson interferometer with 3-port grating coupled arm resonators — •Maximilian Wimmer, Michael Britzger, Daniel Friedrich, Oliver Burmeister, Björn Hemb, 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

The signal to noise ratio in high precision interferometers such as gravitational wave detectors can be increased by maximizing the circulating laser power. In current laserinterferometric gravitational wave detectors partly transmissive optics are used as couplers and beamsplitters. In future detectors stronger light fields will increase thermal effects as the consequence of absorption of the transmitted part and this may lead to a limitation of the sensitivity. One possible solution for this problem is the change to all-reflective optics. Previous experiments have shown that the replacement of single interferometer elements is technically feasible. As the next step towards all-reflective interferometry we present the concept of an interferometer with arm cavities using so-called 3-port gratings as reflective cavity couplers.

Q 55.39 Th 16:00 Lichthof

A fiber-based femtosecond frequency comb for precision measurements in microgravity — •Andreas Resch, Claus Lämmerzahl, and Sven Herrmann — Center of Applied Space Technology and Microgravity (ZARM), Universität Bremen

We use a compact fiber-based femtosecond frequency comb in the microgravity environment of the Bremen drop tower at ZARM to explore possible applications in precision experiments, both earthbound and space-based. To this end we have acquired a frequency comb that was designed specifically for the use in a drop tower experiment.

The prospective application of this frequency comb is in an experiment that tests the universality of free fall from a differential measurement of a dual species atom interferometer. Due to the extended time of free fall available in the microgravity environment of the drop tower, and ultimately on board the International Space Station, the sensitivity of such an atom interferometer will be significantly enhanced as compared to earthbound laboratory experiments. The frequency comb will be used to establish a phase-link between the Raman lasers of the two atom interferometers and thus enable a precision measurement of the differential phase of the atom interferometers.

Here we present the current status of the experiment aiming tophase-link lasers at 780 nm and 767 nm in a drop tower experiment. We also discuss the perspectives for further microgravity applications of optical frequency combs. We acknowledge support by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50 WM 0842.

Q 55.40 Th 16:00 Lichthof

Correction of Phase Damping Errors — •Benjamin Trendelkamp-Schroer, Julius Helm, and Walter T. Strunz — TU Dresden

We study a phase damping channel arising from a quantum optical experiment and focus on the question of how to correct phase errors. These errors allow for a complete correction if and only if the corresponding channel is of random unitary type, i.e., a convex combination of unitary transformations [1]. A successful correction, however, requires sound knowledge of both the system and its dynamics. In this context the role of random unitary versus quantum decoherence will be elucidated.

[1] M. Gregoratti and R.F. Werner, J. Mod. Opt. 50, 915 (2002)

Q 55.41 Th 16:00 Lichthof

Quantum key distribution with finite resources: calculating the min-entropy — •Sylvia Bratzik, Markus Mertz, Hermann Kampermann, Silvestre Abruzzo, and Dagmar Bruss — Heinrich-Heine-Universität, Universitätsstr.1, 40225 Düsseldorf

The min-entropy is an important quantity in quantum key distribution [1]. Recently, a connection between the min- entropy and the minimal-error discrimination problem was found [2]. We use this connection to evaluate the min-entropy for different quantum key distribution setups.

[1]R. Renner. Security of quantum key distribution. International Journal of Quantum Information, 6(1):1-127, 2008.

[2]R. König, R. Renner, and Ch. Schaffner. The operational meaning of min- and max-entropy. IEEE Trans. Inf. Th., 55(9), 2009.

Q 55.42 Th 16:00 Lichthof

Optimal Control of Adiabatic Quantum Search — •Johannes Nehrkorn — Institut für Quanteninformationsverarbeitung, Uni Ulm

The total time of an adiabatic computation depends on the speed by which the Hamiltonian of the system is varied. Cerf and Roland proposed an upper bound for this speed as a function of the instantaneous gap. Here, we propose a different approach, applicable for a much broader range of problems, where only an instantaneous condition is used to determine a maximum speed per timestep without any knowledge of the full instantaneous spectrum of the system. This approach is then tested on the search problem introduced by Roland and Cerf.

Q 55.43 Th 16:00 Lichthof

Optimising Quantum Control Algorithms: Tailored Balance between Sequential and Simultaneous Control Update — •Uwe Sander[1], Shai Machnes[2], Steffen Glaser[1], and Thomas Schulte-Herbrüggen[1] — [1]Department of Chemistry, Technical University of Munich, D-85747 Garching, Germany — [2]School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel

We compare the computational performance of the commonly used unconstrained optimal-control algorithms GRAPE (simultaneous update) and Krotov (sequential update), as well as several hybrid versions. Highly optimised code is used to study their behaviour in terms of computationally demanding operations like matrix multiplications and matrix exponentials. Test cases include unitary gate synthesis and state-to-state transfer for various system sizes, coupling types and topologies. The relative performance of each algorithm varies significantly with problem type and size (factors may be as large as ten). We give paradigmatic scenarios, where either GRAPE or hybrids that are midway or close to Krotov perform best.

Q 55.44 Th 16:00 Lichthof

Quantum Decoherence of Two Qubits — •Julius Helm and Walter T. Strunz — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

A widely accepted explanation of decoherence rests upon growing entanglement between the system and its environment. In practice, however, surprisingly often decoherence may equally well be described by random unitary dynamics without invoking a quantum environment at all. For a single qubit, for instance, pure decoherence (or phase damping) is always of random unitary type [1]. Here, we construct a simple example of true quantum decoherence of two qubits: we present a viable phase damping channel that cannot be understood in terms of random unitary dynamics [2]. We give a very intuitive geometrical measure for the positive distance of our channel to the convex set of random unitary channels, of which we find remarkable agreement with the norm distance based on the norm of complete boundedness [3].

[1] L. Landau and R.F. Streater, Lin. Alg. Appl. 193, 107 (1993).
[2] J. Helm and W.T. Strunz, Phys. Rev. A 80, 042108 (2009).
[3] V.I. Paulsen, Completely Bounded Maps and Operator Algebras (Cambridge University Press, Cambridge, U.K., 2002).

Q 55.45 Th 16:00 Lichthof

Towards quantum networks: integrating fiber cavities and ion traps — •Birgit Brandstätter[1,2], Tracy Northup[1], Maximilian Harlander[1], Piet Schmidt[1,3], and Rainer Blatt[1,4] — [1]Institute of Experimental Physics, University Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria — [2]Recipient of a DOC-fFORTE-fellowship of the Austrian Academy of Sciences at the Institute of Experimental Physics, University Innsbruck, A-6020 Innsbruck, Austria — [3]present address: QUEST Institute of Experimental Quantum Metrology, PTB, D-38116 Braunschweig, Germany — [4]Institute of Quantum Optics and Quantum Information, Austrian Academy of Sciences

Quantum networks, in which atoms at quantum nodes are linked by photonic channels, offer a compelling solution to the challenge of scalability in quantum computing. In these networks, optical cavities provide an interface between photons and atoms; however, the technical requirements for such cavities are demanding. We hope to utilize recent advances in mirrors fabricated on fiber facets in order to couple trapped calcium atoms to a high-finesse cavity with small mode volume. Our approach is twofold: first, we are investigating the perturbation of ions in a linear segmented trap by the presence of an optical fiber. This experiment provides a testbed for us to explore little-understood factors such as acceptable ion-fiber distances and the effects of fiber coatings. Second, we are developing and testing curved, coated fiber mirrors and designing an integrated ion-trap cavity setup.

Q 55.46 Th 16:00 Lichthof

Towards Cryogenic Surface Ion Traps — •Regina Lechner[1], Michael Niedermayr[1], Muir Kumph[1], Michael Brownnutt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Uni. Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, 6020 Innsbruck, Austria

Many future applications of quantum information processes such as quantum simulations and entanglement-enhanced precision measurements require a large number of qubits.

Arrays of miniaturised traps will form an ideal system for trapping large numbers of ionic qubits. Increased ion-heating rates in miniaturised traps due to charging of nearby surfaces can be mitigated by cooling the trap to cryogenic temperatures.

We present the characterisation of a gold-on-sapphire surface microtrap suitable for use at cryogenic temperatures. Furthermore, we discuss the experimental system including the cryostat and investigate the photoionisation loading of microtraps.

Q 55.47 Th 16:00 Lichthof

Entanglement dynamics of three-qubit states in noisy channels — •Michael Siomau[1] and Stephan Fritzsche[2,3] — [1]Max-Planck-Institut fuer Kernphysik, Postfach 103980, D-69117 Heidelberg, Germany — [2]Department of Physical Sciences, P.O.Box 3000, Fin-90014 University of Oulu, Finland — [3]Frankfurt Institute for Advanced Studies, D-60438 Frankfurt am Main, Germany

The implementation of schemes for quantum teleportation requires the quantification of entanglement for states that, in general, are mixed due to the interaction with the environment. We study the entanglement dynamics of three-qubit GHZ and W states under the influence of the environment. As noise models for the influence of the environment we use σ_z, σ_x and σ_y Pauli as well as the depolarizing channel [1]. The entanglement of the states is quantified with the lower bound to the three-qubit concurrence [2]. We show that the GHZ state preserves more entanglement than the W state in transmission through σ_x and σ_y Pauli and the depolarizing channels. For σ_z Pauli channel, in contrast, the W state preserves more entanglement than the GHZ state.

[1] E. Jung *et al.* Phys. Rev. A **78**, 012312 (2008).
[2] M. Li, S.-M. Fei, Z.-X. Wang, J. Phys. A **42**, 145303 (2009).

Q 55.48 Th 16:00 Lichthof

Beam Stabilization for Atmospheric Quantum Communication — •Claudia Dürr[1,3], Bettina Heim[1,2], Dominique Elser[1,2], Christoffer Wittmann[1,2], Denis Sych[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg — [3]University of Applied Sciences, Munich

We present a free space quantum communication system using continuous polarization states [1]. Weak coherent signal states are polarization-multiplexed with a bright local oscillator in order to perform homodyne measurements. Our atmospheric channel of length 1.6 km produces spatial beam fluctuations which could lead to detection losses [2]. Since losses can be detrimental for continuous-variable quantum states, we compensate for them by using active beam stabilization. For that purpose, the bright local oscillator generates a control signal on a position-sensitive-detector at the receiver. By using a network connection, we feed this signal back to the receiver in order to control the telescope's tilt.

[1] D. Elser et al., New J. Phys. 11, 045014 (2009)
[2] B. Heim et al., to appear in Appl. Phys. B

Q 55.49 Th 16:00 Lichthof

Experimente zur Typ-II Abwärtskonversion in periodisch gepolten Kristallen — •Sabine Euler, Michael Beier, Karen Siegenthaler, Mathias Sinther und Thomas Walther — IAP, TU Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt

In einem periodisch gepolten KTP-Kristall entstehen durch Abwärtskonversion aus einem Photon bei 404 nm in einem Typ-II Prozess zwei Photonen der Wellenlänge 808 nm und unterschiedlicher Polarisation. Wir präsentieren zwei Experimente basierend auf diesem Effekt: Zum einen eine heralded Ein-Photonenquelle, die in einer quantenkryptografischen Schlüsselaustauschstrecke eingesetzt werden soll. Zum anderen eine Zwei-Photonenquelle, die auf Rückkopplung eines der obengenannten Photonen basiert. Der aktuelle Stand der Projekte wird diskutiert.

Q 55.50 Th 16:00 Lichthof

Generation of two-dimensional cluster states using bimodal cavities — •Denis Gonta[1], Thomas Radtke[2], and Stephan Fritzsche[3,4] — [1]Max-Planck-Institut für Kernphysik, Postfach 103980, D-69029 Heidelberg — [2]Institut für Physik, Unversität Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [3]Department of Physical Sciences, P.O Box 3000, Fin-9014, University of Oulu, Finland — [4]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt

In the framework of microwave cavity QED, we propose two schemes to generate the two-dimensional 2×N and 3×N cluster states [1]. These states are produced between a chain of two-level Rydberg atoms in a deterministic way by using one or more bimodal cavities within the resonant atom-cavity interaction regime. In contrast to standard (single-mode) cavity schemes, such bimodal cavities possess two independent (orthogonally polarized) modes of the light field. We demonstrate that a 2×N cluster state can be generated efficiently with a single bimodal cavity, while two such cavities are needed to produce a 3×N cluster state. An extension of the scheme to generate two dimensional cluster states of arbitrary size is also possible.

[1] D. Gonta, T. Radtke, and S. Fritzsche, Phys. Rev. A **79**, 062319

(2009).

Q 55.51 Th 16:00 Lichthof

Towards a Loophole-free Test of Bell's Inequality with Entangled Pairs of Neutral Atoms — •Christoph Kurz[1], Julian Hofmann[1], Michael Krug[1], Florian Henkel[1], Wenjamin Rosenfeld[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität München, D-80799 München, Germany — [2]Max-Planck Institut für Quantenoptik, D-85748 Garching

Experimental tests of Bell's inequality allow to distinguish quantum mechanics from local hidden variable theories. Such tests are performed by measuring correlations of two entangled particles (e.g. spins of atoms). In order to constitute conclusive evidence, two conditions have to be satisfied. First, strict separation of the measurement events in the sense of special relativity is required ("locality loophole"). Second, almost all entangled pairs (for particles in a maximally entangled state the required one-side detector efficiency is 82.8%) have to be detected, which is hard to achieve experimentally ("detection loophole"). By using the recently demonstrated entanglement between single trapped atoms and single photons [1] it becomes possible to entangle two atoms at a large distance via entanglement swapping. Combining the high detection efficiency achieved with atoms with the space-like separation of the atomic state detection events, both loopholes can be closed within the same experiment [2]. In this contribution we present recent experimental progress which shows that such an experiment is feasible.

[1] J. Volz et al., Phys. Rev. Lett. **96**, 030404 (2006). [2] W. Rosenfeld et al., Adv. Sci. Lett. **2**, 469 (2009).

Q 55.52 Th 16:00 Lichthof

Optical nanofibers in ion-traps — •Jan Petersen[1], Rainer Blatt[2], Michael Brownnutt[2], and Arno Rauschenbeutel[1] — [1]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]Institut für Experimentalphysik, Unversität Innsbruck, 6020 Innsbruck, Austria

Atoms and molecules can be efficiently coupled to the intense evanescent light field around optical nanofibers. Such nanofibers are realised from standard optical fibers in a heat and pull process to produce a waist with a diameter of several 100 nm. Ion traps, on the other hand, are one of the most successful systems to entangle and manipulate single particles. Trapped ions can be confined for long durations and by tuning the electric trapping potentials one can adjust their position with a precision of a few nanometers.

We are planning to profit from the advantageous properties of both systems and set up an experiment, where an optical nanofiber is integrated in an ion trap. With this setup one could probe the evanescent light field with an ion and also use the optical nanofiber to efficiently excite the ions and to collect its fluorescence. As the ion will have to be placed in close vicinity of the nanofiber surface (around 100 nm), charging effects of the fiber surface are a serious issue. We present and discuss possibilities of coating the fibers to tackle these problems.

Financial support by the ERA-Net Research Network "Nanofibre Optical Interfaces, (NOIs)", the Volkswagen Foundation (Lichtenberg Professorship) and the ESF (EURYI Award) is gratefully acknowledged.

Q 55.53 Th 16:00 Lichthof

EIT storage for arbitrarily shaped low-intensity light pulses — •Gunnar Langfahl-Klabes[1], Peter Nisbet[1], Jerome Dilley[1], Genko Vasilev[2], Daniel Ljunggren[3], and Axel Kuhn[1] — [1]Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, UK — [2]Dept. of Phys., Sofia University, Bulgaria — [3]Dept. of Appl. Physics, KTH Stockholm, Sweden

Electromagnetically induced transparency (EIT) in hot atomic ensembles allows for the generation, delay, storage and retrieval of light pulses by precisely manipulating an control field that drives one of the branches in a Λ-type level scheme. Recent experiments extended the applicability to the few-photons and single photon level [1].

We aim to store and retrieve single photons which were generated by an atom-cavity-system a.k.a. photon pistol (cf. our other posters and talks) and check the retrieved photons for the preservation of their coherence properties.

The EIT process will utilise a Λ-type scheme connecting two Zeeman sub-levels of the hyperfine ground state $F = 1$ in ^{87}Rb.

We report on the latest status and characterization of our setup including a triple-shielded isotopically enriched ^{87}Rb vapour cell with Ne as buffer gas.

[1] Eisaman, M. *et al.* Nature **438**, 837 (2005)

Q 55.54 Th 16:00 Lichthof

Lossless atomic state detection using the Purcell effect — •Carolin Hahn, Jörg Bochmann, Martin Mücke, Christoph Guhl, Stephan Ritter, David Moehring, and Gerhard Rempe — MPI für Quantenoptik, 85748 Garching

One of the diVincenzo criteria for quantum computation is the efficient read-out of the state of the quantum bit (qubit). In single trapped neutral atoms, qubits are typically encoded in or mapped onto atomic hyperfine states. Detection of these hyperfine states often suffers from loss of the atom. Further, the speed and efficiency in schemes relying on spontaneous emission in free space is limited by the photon collection efficiency. Making use of the Purcell effect in an optical cavity, a controlled coupling between qubit and environment can be established, suitable for in an improved state detection scheme based on cavity-enhanced fluorescence. With this method we achieve a hyperfine state detection fidelity of 99.4% in 85 μs in our experiment with a single trapped ^{87}Rb atom. A result is obtained in every read-out attempt and, most importantly, the qubit can be interrogated many hundred times before the atom is lost from the trap. This presents an essential advancement for the speed and scalability of quantum information protocols based on neutral atoms. Our scheme is applicable to all systems with optically accessible qubits.

Q 55.55 Th 16:00 Lichthof

Quantum Information Processing with Atoms in Arrays of Dipole Potentials — •Malte Schlosser, Jens Kruse, Peter Schauss, Benedikt Baumgarten, Sascha Tichelmann, and Gerhard Birkl — Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt

Ultracold neutral atoms confined in two dimensional periodic potentials represent highly controllable quantum information systems with long coherence times. In our experiment, we use sets of optical micropotentials created by micro-fabricated lens arrays as the architecture for a scalable quantum processor. The microtrap array accesses the regime of collisional blockade, which allows us to probe single atoms in a site-selective fashion using advanced detection schemes with high efficiency and reliability. In addition to the stable and reproducible operation of the dipole trap array, employing microoptics ensures single site addressability. We are able to control each potential well separately utilizing a spatial light modulator. The combined system allows for the creation of arbitrary trap configurations as well as for flexible, site-specific, but also parallelized initialization and coherent manipulation of separated small ensembles or single ^{85}Rb atoms. We report on the experimental cancellation of the differential ac Stark shift of the hyperfine clock transition by optical means. The separation of internal and external dynamics results in a strong suppression of the dephasing of atoms occupying different vibrational levels and trapping sites, respectively. This scheme is extendable to all alkali elements where no standard "magic-wavelength" is available.

Q 55.56 Th 16:00 Lichthof

Operational multipartite entanglement classes for symmetric photonic qubit states — Nikolai Kiesel[1,2,3], •Witlef Wieczorek[1,2], Stephanie Krins[4], Thierry Bastin[4], Harald Weinfurter[1,2], and Enrique Solano[5,6] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Department für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [3]permanent address: Faculty of Physics, University of Vienna, Wien, Austria — [4]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Liège, Belgium — [5]Departamento de Química Física, Universidad del País Vasco, Bilbao, Spain — [6]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

We present experimental schemes that allow to study the entanglement classes of all symmetric states in multiqubit photonic systems. In addition to comparing the presented schemes in efficiency, we will highlight the relation between the entanglement properties of symmetric Dicke states and a recently proposed entanglement scheme for atoms [1]. In analogy to the latter, we obtain a one-to-one correspondence between well-defined sets of experimental parameters and multiqubit entanglement classes inside the symmetric subspace of the photonic system [2].

[1] T. Bastin, C. Thiel, J. von Zanthier, L. Lamata, E. Solano, and G. S. Agarwal, Phys. Rev. Lett. 102, 053601 (2009). [2] N.

Kiesel, W. Wieczorek, S. Krins, T. Bastin, H. Weinfurter, E. Solano, arXiv:0911.5112

Q 55.57 Th 16:00 Lichthof

A single photon source with diamond nanocrystals — •Juliane Hermelbracht[1], James Rabeau[3], Ariane Stiebeiner[4], Ruth Garcia Fernandez[4], Arno Rauschenbeutel[4], and Harald Weinfurter[1,2] — [1]FAkultät für Physik, Ludwig-Maximilians-Universität, München, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Macquarie University, Sydney, Australia — [4]Johannes-Gutenberg-Universität, Mainz, Germany

The development of reliable devices to generate single photons is crucial for applications in quantum cryptography, as well as for fundamental quantum optics experiments. With an optical emission centered around 650nm and a fluorescence lifetime of 11.6ns the nitrogen-vacancy (NV) color center in diamond seems well suited for implementing a single photon source which could be used in quantum cryptography experiments. The efficiency of the NV-center is, however, limited by the existence of a shelving level. Additionally the high refractive index of bulk diamond restricts the efficiency to collect the fluorescence light. A more convenient approach is the use of NV-center containing diamond nanocrystals, which - being much smaller than the wavelength of the fluorescence light - are not subject to refraction. Furthermore, diamond nanocrystals can be combined with a wide variety of microstructures and thus e.g. be incorporated into cavity-structures. We describe attempts to apply single NV-containing diamond nanocrystals to the waist of tapered optical fibers in order to manipulate the single photon emission characteristics.

Q 55.58 Th 16:00 Lichthof

Generation of strongly squeezed light in periodically poled KTP — •Sebastian Steinlechner, Jöran Bauchrowitz, Tobias Eberle, Henning Vahlbruch, and Roman Schnabel — Institut für Gravitationsphysik, Leibniz Universität Hannover und Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Callinstrasse 38, 30167 Hannover, Germany

Recent years saw a steady increase in the squeezing strength of continuous-wave light generated by parametric down-conversion. Losses have been reduced significantly by using monolithic nonlinear resonators made from magnesium-doped lithium niobate. However, high second-harmonic pump powers were needed to achieve strong squeezing in magnesium-doped lithium niobate, thus leading to thermal instabilities. Here we report on experimental results with a monolithic, periodically poled KTP resonator and present ultra-strong squeezing at 1064nm.

Q 55.59 Th 16:00 Lichthof

Geometric measure of entanglement compared to measures based on fidelity — •Alexander Streltsov — Heinrich-Heine-Universität Düsseldorf, Institut für Theoretische Physik III, Düsseldorf, Germany

One big problem in quantum information theory is the quantification of entanglement for multipartite mixed states. Different axiomatic and operational measures were proposed so far. In this work connections between the geometric measure of entanglement and measures based on the fidelity are established. Also a useful expression for fidelity is derived.

Q 55.60 Th 16:00 Lichthof

Barrier Control in Tunneling e^+-e^- Photoproduction — •Sebastian Meuren[1], Antonino Di Piazza[1], Erik Lötstedt[1], Alexander I. Milstein[1,2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]Budker Institute of Nuclear Physics, 630090 Novosibirsk, Russia

QED predicts that in the collision of a strong laser field and a relativistic nucleus, tunneling electron-positron pair production occurs. This process can be described as the tunneling of an electron from the filled, negative-energy Dirac see to a positive-energy state, under the influence of the external laser and nuclear fields. Since the tunneling barrier is very large (around 1 MeV, corresponding to twice the electron rest energy), this process has never been observed experimentally. In [1] we proposed to add to the above setup a weak, high-frequency laser field with a photon energy in the nucleus rest frame close to the pair production threshold. The absorption of one photon from this laser field significantly reduces the barrier to be still tunneled by the electron to go to the positive levels. In this way one can lower the required intensity of the strong laser field to observe the process. Our calculations show that tunneling electron-positron pair production can in principle be observed in the proposed scheme with currently available laser technology.

[1] A. Di Piazza, E. Lötstedt, A. I. Milstein and C. H. Keitel, Phys. Rev. Lett. **103**, 170403 (2009).

Q 55.61 Th 16:00 Lichthof

Quantum friction for particles near a metal — •Gregor Pieplow, Harald Haakh, Francesco Intravaia, and Carsten Henkel — Universität Potsdam, Germany

Quantum friction refers to the deceleration of a neutral or charged particle moving parallel to a half space filled by a dielectric or metal [1]. This was also investigated with plates moving parallel to each other at constant speed. The existence of this friction force has not yet been agreed upon for the zero temperature case [1,2]. QED calculations require the solution of the Maxwell equations with the respective boundary conditions. For realistic systems, symmetry breaking due to finite conductivity of the reflecting plane plays an important role and the role of longitudinal electric fields must be evaluated carefully. We discuss the consistency of previous approaches and their application to the zero temperature case. Our approach rigorously implements Lorentz covariance parallel to the surface.

[1] A.I. Volokitin, B.N.J. Persson, Rev. Mod. Phys. **79**, 1291 (2007).
[2] T. G. Philbin and U. Leonhardt, New J. Phys. **11**, 033035 (2009).

Q 55.62 Th 16:00 Lichthof

Microwave cavity QED experiment with lower Rydberg atomic state — •Pierre Thoumany, Linas Urbonas, Theodor W. Hänsch, and Thomas Becker — Max Planck Institut für Quantenoptik, Garching, Deutschland

The one atom maser is a unique tool to study light matter interaction at the quantum level. The single mode of a superconductive microwave Nb cavity is interacting with a two level Rb85 Rydberg atomic system. This allows us to produce quantum state of light such as fock states. In a new approach we show the interaction of the cavity field with the lower atomic state of the two level atomic system.

Q 55.63 Th 16:00 Lichthof

Interpretation of Quantum Trajectories Arising from a Stochastic Description of Non-Markovian Open Quantum Systems — •Sven Krönke and Walter T. Strunz — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

By investigation of a simple non-Markovian open quantum system, we try to illuminate the conditions under which the quantum trajectories corresponding to a nonlinear stochastic Schroedinger equation [L. Diósi, N. Gisin and W. T. Strunz, Phys. Rev. A 58, 1699 (1998)] can be interpreted in terms of a continuous measurement scheme. In particular, we are interested in whether and under which circumstances such a scheme can be realised by only measuring the environment.

Q 55.64 Th 16:00 Lichthof

Short-time vs. long-time dynamics of entanglement in quantum lattice models — •Razmik Unanyan, Dominik Muth, and Michael Fleischhauer — Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern

We study the short-time evolution of the bipartite entanglement in quantum lattice systems with local interactions in terms of the purity of the reduced density matrix. A lower bound for the purity is derived in terms of the eigenvalue spread of the interaction Hamiltonian between the partitions. Starting from an initially separable state the purity decreases as $1-(t/\tau)^2$, i.e. quadratically in time, with a characteristic time scale τ that is inversly proportional to the boundary size of the subsystem, i.e., as an area–law. For larger times an exponential lower bound is derived corresponding to the well-known linear-in-time bound of the entanglement entropy. The validity of the derived lower bound is illustrated by comparison to the exact dynamics of a 1D spin lattice system as well as a pair of coupled spin ladders obtained from numerical simulations.

Q 55.65 Th 16:00 Lichthof

Crystallization of photons in optical lattices — •Sergey Grishkevich, Hessam Habibian, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken

Photons can interact with each other in a nonlinear medium. Such a medium could be realized using cold atoms loaded in an one-dimensional optical fibre. In this case the confinement enables the generation of large, tunable optical nonlinearities. In its extreme, the quantum light at the fiber output can behave as it were a gas of fermions [1]. Ultracold atoms in optical lattices (OL) may constitute an alternative system for realizing a similar medium. The OL resembles, in some sense, the periodicity of a crystal potential with interparticle distance of the order of the optical wavelength. In this case, the periodic distribution of atoms modulates the refractive index which may strongly modify the photonic properties.

We study light propagating through a crystal of atoms exhibiting a large Kerr nonlinearity. We show how photon blockade in such a medium, whose index of refraction can be modulated by the atomic spacial density as well as by an external field, may lead to a "crystallization" of photons. We focus on a simple 1D OL with atoms well localized at the lattice minima. For this system we develop a full quantum model for the light-matter interactions. These investigations open up the possibility for quantum simulation of matter Hamiltonians using optical systems. Such a system is also supposed to be of great interest for applications in metrology and for quantum information purposes.

[1] D. E. Chang et al., Nature Physics 4, 884 (2008)

Q 55.66 Th 16:00 Lichthof

Cavity-EIT with single atoms — •Martin Mücke, Eden Figueroa, Joerg Bochmann, Carolin Hahn, Celso Jorge Villas-Boas, Stephan Ritter, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Coherent dark states, such as electromagnetically induced transparency (EIT), can be used to control nonlinear effects for light fields [1]. So far, these phenomena have been studied in media involving a macroscopic number of atoms. In order to scale down these systems to the single quantum level of matter (single atoms) and light (single photons) one has to enhance the matter-light interaction. We report on a new experiment where we use a high finesse optical cavity in which an exactly defined number of atoms can be coupled to the mode of the cavity. We discuss prospects for cavity-based EIT with single atoms and will present its first experimental observation.

[1] M. Fleischhauer, A. Imamoglu and J.P. Marangos, Rev. Mod. Phys. **77**, 633 (2005)

Q 55.67 Th 16:00 Lichthof

Artificial magnetic fields for stationary light — •Johannes Otterbach[1], Julius Ruseckas[2], Razmik Unanyan[1], Gediminas Juzeliunas[2], and Michael Fleischhauer[1] — [1]Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Theoretical Physics and Astronomy, Vilnius University, 01108 Vilnius, Lithuania

The creation and control of effective gauge potentials for electrically neutral particles, such as cold atoms, has attracted lots of interest recently. Here we show how to create a homogeneous magnetic fields for light-matter quasi-particles, so-called dark-state polaritons (DSP). These particles arise in the Raman interaction of a weak probe field with a coherently driven atomic ensemble and form the basis of phenomena such as slow and stopped light. In the limit of a large pulse length they behave as effective Schrödinger particles with an externally controllable mass and velocity. Confinement to lower dimensions is easily done by using standard resonator or wave-guide techniques. By uniformly rotating the medium, an artificial gauge field is created. We show that in this scheme Landau levels with degeneracies well above 100 can be achieved. Thus the system is well suited to study such effects as the action of a Lorentz force on neutral particles or the bosonic analog of the fractional quantum Hall effect.

Q 55.68 Th 16:00 Lichthof

Zeta-States in Phase Space — •Cornelia Feiler, Rüdiger Mack, and Wolfgang P. Schleich — Institute for Quantum Physics, Ulm University

> Wenn ich nach einem tausendjährigen Schlaf aufwachen würde, wäre meine erste Frage: „Wurde die Riemann-Hypothese bewiesen?“
>
> D. Hilbert - Zur Hypothese von Bernhard Riemann

The Riemann hypothesis is a conjecture about the distribution of the so called non-trivial zeros of the Riemann ζ-function which is strongly connected with the distribution of primes [1]. Prime numbers, on the other hand, play a crucial role for example in cryptography or factorization.

We aproach the questions about the behavior of the ζ-function in the whole complex plane from a physical point of view. We construct so-called Zeta-states which contain properties connected to the Riemann ζ-function $\zeta(s)$. For example, the imaginary part t of the argument $s = \sigma + it$ should be proportional to the time if we consider the time-evolution of the Zeta-state. Other properties, like the functional equation, and their influence on the phase space functions of these states are considered.

[1] E. C. Titchmarsh. *The Theory of the Riemann Zeta-Function.* Oxford, Charlendon Press, 1967.

Q 55.69 Th 16:00 Lichthof

Motional effects on the efficiency of excitation transfer — •Ali Asadian[1], Markus Tiersch[1], Jianming Cai[1], Gian Giacomo Guerreschi[1], Hans Briegel[1], and Sandu Popescu[2] — [1]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, und Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, Innsbruck, Austria — [2]Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, UK.

Energy transfer plays a vital role in many natural and technological processes. In this work we study the effects of classical motion on the electronic excitation transfer through a chain of interacting molecules. Our investigation demonstrates that for various types of oscillations, in a suitable range of frequencies, the efficiency of the energy transfer is significantly enhanced. This enhancement is a signature of the collaborative interplay between the coherent evolution of the excitation and the classical motion of the molecules. This effect has no analogue in the classical incoherent energy transfer. In addition, we discuss control techniques to optimize the excitation transfer along the chain.

Q 55.70 Th 16:00 Lichthof

Tunable upconversion Pr,Yb:ZBLAN fiber laser from 601 nm to 625 nm — •Benjamin Hermberg, Ortwin Hellmig, Klaus Sengstock, and Valeri Baev — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Compact coherent light sources at different wavelengths in the visible can be realized with an upconvertion Pr/Yb-doped ZBLAN fiber laser. Selective dielectric mirrors placed to both ends of the fiber are usually used for the selection of the required emission wavelength, e.g. 492, 520, 535, 605, 612, 635, or 717 nm. Since the separation between some of the emission lines is smaller than the spectral broadening of the gain, continuous wavelength tuning between neighboring transitions is possible [1]. We have realized a broadband spectral tuning between 605, 612 and 635 nm transitions with a specially designed nonuniform narrowband spectral filter placed in the open part of the cavity. A spectral filter made out of 19 dielectric layers is highly transparent at the desired wavelength and highly reflecting at small detunings. This requirement is very important because of strong variations of the laser gain. An additional 50% cavity loss is achieved at 0.5 nm detuning. Transmission maximum of the filter can be spectrally shifted over 50 nm by its translation perpendicular to the optical axis. The tuning range demonstrated in this experiment extends from 601 to 625 nm, which is 3 times larger than the tuning achieved with a Bragg grating [1].

1. M Zeller, H. G. Limberger, and T. Lasser, IEEE Photonics Technology Letters 15, 194 (2003).

Q 55.71 Th 16:00 Lichthof

Femtosekunden-Laser geschriebener Kanalwellenleiterlaser in Nd:YAG mit 1,3 W Ausgangsleistung — •Jörg Siebenmorgen, Thomas Calmano, Ortwin Hellmig, Klaus Petermann und Günter Huber — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Mit fs-Laserpulsen einer Pulsdauer von 140 fs wurden Spurpaare bestehend aus zwei parallelen Zerstörspuren in Nd(1%)- bzw. Nd(0,55%)-dotierte YAG-Kristalle geschrieben. Aufgrund spannungsinduzierter Doppelbrechung konnte Wellenleitung in einem Kanal im Zentrum der Doppelspuren beobachtet werden. Die Brechungsindexänderung betrug etwa 10^{-3}.

Die geringsten Leitungsverluste der Wellenleiterkanäle von 1,2 dB/cm bei einer Wellenlänge von 1063 nm traten zwischen Doppelspuren auf, die einen Abstand von ca. 25 μm hatten.

Unter Verwendung eines Ti:Saphir-Lasers als Pumpquelle konnte Lasertätigkeit des Nd(1%):YAG Wellenleiters bei einer Wellenlänge von 1064 nm für vier verschiedene Auskoppelgrade zwischen 50% und 99% gezeigt werden. Die Ausgangsleistung betrug 1,3 W bei einem Auskoppelgrad von 95%. Dies ist die bisher höchste erzielte Leistung eines fs-strukturierten Wellenleiterlasers. Der differenzielle Wirkungsgrad betrug 59%.

Ein Vergleich der Nd(1%)- und Nd(0,55%)-dotierten Wellenleiterlaser ergab ähnliche Wirkungsgrade.

Q 55.72 Th 16:00 Lichthof

A new laser source for trapping Lithium — •Ulrich Eismann[1], Frédéric Chevy[1], Fabrice Gerbier[1], Gérard Trénec[2], Jacques Vigué[2], and Christophe Salomon[1] — [1]Laboratoire Kastler Brossel, CNRS UMR 8552, UPMC, École Normale Supérieure, 24 rue Lhomond, 75231 Paris, France — [2]Laboratoire Collisions Agrégats Réactivité, CNRS UMR 5589 - Université Paul Sabatier Toulouse 3, Route de Narbonne, 31062 Toulouse Cedex, France

We present a powerful new laser setup for light-induced manipulation of Lithium atoms which is currently being developed within the framework of the Fermix experiment at ENS.

The design is based on a diode-pumped solid state Nd:YVO_4 ring laser, operating on the $^4F_{3/2} \rightarrow {}^4I_{13/2}$ transition near 1342 nm. The infrared light is subsequently frequency doubled to the Lithium-6 D2 resonance at 670.977 nm in an enhancement cavity using periodically poled Potassium Titanyl Phosphate (ppKTP). Hereby, a special locking technique is applied.

The results obtained so far indicate a higher performance in terms of power, spatial mode quality and simplicity compared to the existing laser sources in the same wavelength range.

Q 55.73 Th 16:00 Lichthof

High-power solid state laser system at 589 nm — Axel Friedenauer, •Manfred Hager, Bernhard Ernstberger, and Wilhelm Kaenders — TOPTICA Photonics AG, Gräfelfing, Germany

A novel scheme is presented which allows for generating high-power diffraction-limited laser radiation in the yellow spectral region. An extended cavity diode laser (ECDL) emitting at a wavelength of 1178 nm serves as a master oscillator and provides seed signals for two PM fibre Raman amplifiers. The output of these amplifiers is coherently combined and resonantly frequency-doubled to obtain more than 30 W of narrow-band tunable output power to resonantly address the sodium D2 transition at 589 nm.

The results have been obtained in collaboration with MPBC and ESO.

Q 55.74 Th 16:00 Lichthof

Aufbau eines kompakten Dioden-Lasersystems bei 435,9 nm — •Florian Schad, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Zur Anregung des Übergangs $^3P_1$ nach $^3S_1$ in neutralen Quecksilberatomen wird Laserlicht der Wellenlänge 435,9 nm benötigt. Dieser Übergang wird zum optischen Pumpen der metastabilen Niveaus verwendet.

Zur effizienten Frequenzverdopplung kommt ein Leistungsüberhöhungsresonator in bow-tie Konfiguration zum Einsatz, der auf einen ECDL (External Cavity Diode Laser) bei 871 nm gelockt wird. Als nichtlineares Medium wird ein LBO-Kristall unter kritischer Phasenanpassung verwendet. Die Stabilisierung erfolgt nach dem Pound-Drever-Hall-Verfahren, bei dem Seitenbänder mittels Strommodulation erzeugt werden. Durch Überlagerung des heraustretenden und des direkt reflektierten Lichtes vom Resonator kann ein geeignetes Fehlersignal erzeugt werden.

Desweiteren soll der gesamte optische Aufbau kompakt gehalten werden und nicht mehr als die Grösse eines DIN A4 Blattes beanspruchen. Erste Ergebnisse des Projekts werden vorgestellt.

Q 55.75 Th 16:00 Lichthof

Continuous-wave Lyman-α generation by four-wave-mixing in mercury — •Andreas Koglbauer, Martin Scheid, Daniel Kolbe, Ruth Steinborn, Sven Richter, and Jochen Walz — Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz

For future precision measurements on anti-hydrogen, laser-cooling of the magnetically trapped atoms down to a milli-Kelvin range is essential. We present the generation of Lyman-α-light on the cooling-transition at 121.56 nm wavelength by sum-frequency four-wave-mixing (FWM) in mercury-vapor using solid-state fundamental laser systems. In addition to the enhancement utilizing the two-photon $6^1S - 7^1S$ resonance, the tuning range of our fundamental laser system enabled us to investigate the influence of the $6^1S - 6^3P$ resonance on the FWM-process. This also gave rise to the observation of two-photon absorption laser induced stimulated emission (TALISE) on the $6^1P - 7^1S$ transition at 1014 nm.

At slightly shorter wavelength than Lyman-α, the mixing process can use a triple one-photon resonant scheme. This gives a 10^4-fold increase of the nonlinear susceptibility and a total vacuum UV power of 6 μW.

The current status of new projects like Lyman-α generation in a three-color resonator and in hollow-core fibers is presented.

Q 55.76 Th 16:00 Lichthof

Effects of counter-directional mode coupling in a cw PP LN SRO with ring resonator — Sergey Vasilyev[1], Stephan Schiller[1], •Hans-Emanuel Gollnick[1], Alexander Nevsky[1], Arnaud Grisard[2], and Juan Jiménez[3] — [1]Heinrich-Heine Universität, Düsseldorf, Germany — [2]Thales Research and Technology, Palaiseau Cedex, France — [3]Universidad de Valladolid, Valladolid, Spain

The effects of coupling between clockwise and counterclockwise modes in a ring resonator with QPM nonlinear crystals are observed and investigated. We consider back reflection from the QPM grating as an important cause of the counter-directional mode coupling. We used computer simulation to demonstrate that the non-phase-matched back reflection from the QPM grating can be considerably enhanced due to grating imperfections. We developed an analytical model and evaluated parameters of the SRO in presence of the coupling. This is a parasitic effect, and results in increase of the SRO threshold. On the other hand, the asymmetry of coupled clockwise and counterclockwise modes can be used for active stabilization of the cavity. Described effects were observed experimentally. Measured properties are in good agreement with our analysis.

Q 55.77 Th 16:00 Lichthof

Detektor zum Nachweis von Hg für ein EPR-Experiment — •Tobias Beck, Alexander Bertz und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schloßgartenstraße 7

Ein Detektor, basierend auf resonanter Ionisationsspektroskopie, wird vorgestellt. Dieser ermöglicht es, mit Hilfe von Channel-Electron- Multipliers Quecksilberatome sowie -dimere nachzuweisen. Zur Ionisation wird ein regeneratives Titan:Saphir-Verstärkersystem verwendet, welches ns-Pulse bei 789 nm und 761 nm simultan emittiert. Mittels Frequenzkonversion wird Strahlung bei 253, 7 nm sowie 197, 3 nm erzeugt. Durch die zweistufige Anregung in einen autoionisierenden Zustand ist die Ionisation besonders effizient. Die geladenen Teilchen werden durch Ring-Elektroden in die CEMs fokussiert. Präsentiert wird der aktuelle Stand der Entwicklung.

Q 55.78 Th 16:00 Lichthof

Optical AC Coupling - Ein neues Konzept für Leistungsstabilisierungen von Lasern — •Patrick Kwee, Benno Willke und Karsten Danzmann — Albert-Einstein-Institut Hannover

Optische Präzisionsexperimente, wie z.B. interferometrische Gravitationswellendetektoren, benötigen häufig eine Laserquelle mit sehr hoher Leistungsstabilität. Traditionell werden Photodioden als Leistungsdetektoren verwendet, um die Laserleistung mithilfe eines Regelkreises aktiv zu stabilisieren. Dabei wird die erreichbare Stabilität durch die Empfindlichkeit des Photodetektors limitiert. Die optische AC Kopplung verwendet einen Photodetektor in Reflektion eines optischen Resonators, um dessen Empfindlichkeit um etwa eine Größenordnung zu erhöhen. Dadurch können Leistungsstabilitäten erzielt werden, die bislang unerreichbar schienen. Ergebnisse einer durch Quantenrauschen limitierten Leistungsstabilisierung eines Nd:YAG Lasers bei 1064 nm werden vorgestellt. Eine Analyse des theoretischen Stabilitätslimits und begrenzender Rauschkopplungen werden präsentiert.

Q 55.79 Th 16:00 Lichthof

Study of nonlinear effects produced by organic molecules adsorbed on subwavelength diameter optical fibres — •Konstantin Karapetyan, Cristian Dan, Ulrich Wiedemann, Dimitri Pritzkau, Wolfgang Alt, and Dieter Meschede — In-

stitut für Angewandte Physik, Wegelerstr. 8, 53115 Bonn

Optical fibres with a diameter smaller than the wavelength of light offer interesting perspective for strong light-matter interaction without using a cavity. Light propagating in such fibres has a strong evanescent component, which can be coupled to molecules close to or adsorbed on the surface of the fibre. Thus, linear (e.g. absorption, fluorescence) and nonlinear (e.g. two photon absorption/fluorescence, second and third harmonic generation) effects can be used to characterize and control the molecules. In this work we study the effects produced on the propagation of light in subwavelength diameter fibres by organic molecules deposited on the surface.

Q 55.80 Th 16:00 Lichthof

Chlorophyll fluorescence measurements with single cells of the photosynthetic model organism *Chlamydomonas reinhardtii* — •Andreas Garz[1], Stefanie Schlede[2], Heiko Lokstein[2], and Ralf Menzel[1] — [1]Institut für Physik und Astronomie/Photonik — [2]Institut für Biochemie und Biologie/Pflanzenphysiologie, Universität Potsdam, Karl-Liebknecht-Str. 24/25, 14476 Potsdam

A comprehensive systems biology analysis of photosynthesis and its regulation in response to selected environmental factors and at different growth stages in a model algal system, *Chlamydomonas reinhardtii*, and the integration of the obtained insight with research on model higher plants and crop plant species are the aims of the interdisciplinary collaborative Potsdam-Golm (Germany) network GoFORSYS.

Our particular field of interests in this regard is the study of the regulation of photosynthesis in response to environmental factors and at different developmental stages, also at the level of single cells using the principle of puls-amplitude-modulated fluorometry to measure photosynthetic parameters such as photochemical and non-photochemical quenching. The data will be used to gain deeper insight into photosynthesis, its regulation and photoprotective mechanisms by application of systemic modelling.

The employed setup is based on an inverse confocal microscope. For manipulation of single cells during the measurements a home-made optical trap is used. Furthermore, the cells can be manipulated in specifically designed micofluidic assemblies (in the range of twenty microns).

Q 55.81 Th 16:00 Lichthof

THz generation via optical rectification in GaAs and GaP — •Jan-Philipp Negel, Robin Hegenbarth, Andy Steinmann, Bernd Metzger, Felix Hoos, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

We develop a compact, high-power and low-cost THz source using optical rectification in GaAs and GaP. We use a home-built 5 W, 230 fs, 1025 nm, 44 MHz Yb:KGW laser as well as a commercial 3 W, sub-500 fs, 1035 nm, 37 MHz fiber laser as the pump source for optical rectification in GaP. Alternatively, GaAs with a much higher electro-optic coefficient is used. In order to avoid two-photon absorption in the GaAs, which would lead to a high THz absorption in the crystal, we use an OPO having a tunable signal wavelength up to 1.9 μm. We expect broadband, ultrashort THz radiation centered around 1 THz and output powers of a few μW. We demonstrate scaling up of the power even further.

Q 55.82 Th 16:00 Lichthof

Realization of a scanning microscope for nonlinear microscopy — •Sebastian Beer[1,2], Petra Gross[1], Carsten Cleff[1], Lisa Kleinschmidt[1], and Carsten Fallnich[1] — [1]Institut für Angewandte Physik, Westfälische Wilhelms-Universität, Corrensstr. 2, 48149 Münster — [2]Fachhochschule Gießen-Friedberg, Wiesenstr. 14, 35390 Gießen

During the last decade, research in biology and the life sciences has inspired and led to major achievements in nonlinear microscopy. This includes the improvement of resolution beyond the diffraction limit as well as advances in and application of different nonlinear microscopy methods like two-photon excited fluorescence, harmonic generation or coherent anti-Stokes Raman scattering (CARS). Typically, these methods require scanning of the focus across the sample.

We have developed a multimodal scanning microscope, where not the focus, but the sample is scanned in order to disturb the focus as little as possible. The easy access to all building blocks and the resulting flexibility made an experimental setup more attractive than a commercial, but expensive microscope. Using a piezo-driven three axis stage, the specimen can be scanned by 150 μm in each direction. We present practical considerations and technical details which one has to keep in mind when constructing a high performance scanning microscope. We also show first results obtained by two-photon excited fluorescence-, second harmonic generation-, and CARS-microscopy, which demonstrate that our microscope is highly suitable for multimodal nonlinear microscopy.

Q 55.83 Th 16:00 Lichthof

Brightness measurement of laser-triggered electrons from field emission tips — •Hanno Kaupp, Max Eisele, Markus Schenk, Michael Krüger, Johannes Hoffrogge, John Breuer, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München, Germany

We have set up a source of laser triggered electrons emitted from sharp metal tips. Currently our group investigates the nature of the diverse emission processes possible [1]. Here we present a method to measure the brightness of laser-triggered electrons emitted from these sources. We employ a method based on Fresnel diffraction that occurs at a sharp edge in close proximity of the tip and observe the far-field diffraction pattern with a micro channel plate detector [2]. This is of high interest for future applications of ultrafast tip-based electron sources. We also focus on the development of alternative field emitters. Materials like gold offer laser-induced plasmon resonances which can greatly enhance the field at the tip apex. Modifications of tip geometry and material are presented and we report on the current status of our experiments. [1] See contributions by Markus Schenk et al. and Michael Krüger et al. [2] N. de Jonge et al., Nature 420, 393-395 (2002)

Q 55.84 Th 16:00 Lichthof

Laser Proton Acceleration with a 150 TW laser system — •Stephan Kraft, Karl Zeil, Josefine Metzkes, Tom Richter, Stefan Bock, Uwe Helbig, Thomas Cowan, and Ulrich Schramm — Forschungszentrum Dresden Rossendorf, Bautzener Landstraße 400, 01328 Dresden

Recent success in laser-driven particle acceleration has increased interest in laser-generated accelerator-quality beams. At the Forschungszentrum Dresden - Rossendorf effords are made to produce and charaterize ion beams suitable for applications. During the last two years the 150 TW laser system DRACO as well as a target site have been commisioned and first experiments on ion acceleration have been performed.

In order to investigate the influence of laser accelerated protons on a cell sample a cell irridation site equioped with an energy filtering system has been setup. In this poster we want to present the experimental setup for proton acceleration as first results on energy scaling.

Q 55.85 Th 16:00 Lichthof

Direct Observation of Structural Dynamics in Graphite Using Ultrafast Electron Diffraction — •Christian Gerbig, Cristian Sarpe-Tudoran, Matthias Wollenhaupt, and Thomas Baumert — University of Kassel, Institute of Physics and Center of Interdisciplinary Nanostructure Science and Technology (CINSaT), D-34132 Kassel, Germany

In the recent past Ultrafast Electron Diffraction (UED) has become one of the most promising techniques to directly provide insights into fundamental physical and chemical dynamics at the microscopic level and on the pico- to subpicosecond timescale [1].
With its nature to form a wide range of bonding networks (sp, sp2, sp3) carbon is well-suited to investigate bond and lattice dynamics. So far time-resolved electron crystallography has been used to study structural dynamics of graphite sub-surfaces providing new insights in processes involving lattice vibrations [2] and coherent lattice motions [3]. In this contribution we present first results on the direct observation of optically induced structural dynamics in graphite *bulk* material using UED. In addition, we show improvements and a new approach of our setup, leading to a better spatial and temporal resolution with the prospect to directly resolve coherent shearing phonons in graphite.

[1] M. Chergui & A. H. Zewail, Chem. Phys. Chem. **10**, 28 (2009)
[2] A. H. Zewail and coworkers, Phys. Rev. Lett. **100**, 035501 (2008)
[3] R. K. Raman *et al.*, Phys. Rev. Lett. **101**, 077401 (2008)

Q 55.86 Th 16:00 Lichthof

OCT and CARS imaging with an ultrashort pulse Ti:sapphire laser — •Claudia Hoffmann[1], Angelika Unterhuber[2], Boris

Považay[2], Thomas Binhammer[1], Wolfgang Drexler[2], and Uwe Morgner[1] — [1]Institute of Quantum Optics, Leibniz University Hanover, Germany — [2]Biomedical Imaging Group, School of Optometry and Vision Sciences, Cardiff University, Cardiff, UK

Optical coherence tomography (OCT) is an emerging non-invasive in vivo biomedical imaging modality capable of performing real time, three-dimensional visualization of tissue morphology at micrometer scale resolution. Coherent Anti-Stokes Raman Scattering (CARS) is a nonlinear spectroscopic technique which provides molecular information due to a four wave mixing process. In combination with a microscope, CARS enables chemical selective imaging by scanning the sample with resolutions in the micrometer range.

We present measurements of the same sample with both techniques by using ultrashort pulse Ti:sapphire lasers.

Q 55.87 Th 16:00 Lichthof

Selectively closed liquid-filled photonic crystal fibers — •Timo Gissibl, Marius Vieweg, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Germany

In the past few years periodic and nonlinear systems have been subject of many efforts in optics. Therefore many researchers aim to develop all-optical tunable devices. We use glue to close selectively the holes of photonic crystal fibers. Afterwards we use these selectively closed fibers by filling the unblocked holes with highly-nonlinear fluids. With this method we have the possibility to close microstructured fibers with any desired pattern and produce in this way tunable liquid-filled photonic crystal fibers for both supercontinuum generation and nonlinear light propagation in two-dimensional discrete systems.

Q 55.88 Th 16:00 Lichthof

Numerische Berechnungsverfahren zur Simulation von Brillouin-basierten Slow-Light Systemen — •Andrzej Wiatrek, Ronny Henker, Kambiz Jamshidi, Stefan Preussler und Thomas Schneider — Institut für Hochfrequenztechnik, Hochschule für Telekommunikation Leipzig, Germany

Die gezielte Veränderung der Ausbreitungsgeschwindigkeit optischer Pulse, auch bekannt als Slow-Light, hat in den letzten Jahren viel Aufsehen erregt. Neben der sehr offensichtlichen Anwendungsmöglichkeit als optischer Pufferspeicher in der Telekommunikation eröffnen sich weitere Anwendungsfelder in der zeitlich aufgelösten Spektroskopie, der nichtlinearen Optik und der Signalverarbeitung. Der nichtlineare optische Effekt der stimulierten Brillouin-Streuung (SBS) gilt vor allem in faserbasierten Slow-Light Systemen als sehr vielversprechend, weil eher geringe Pumpleistungen zu hohen Verzögerungszeiten führen und der Effekt im gesamten Transparenzbereich aller Fasern auftritt.

Der Prozess der Verstärkung und Verzögerung der optischen Pulse mittels SBS wird durch ein Gleichungssystem gekoppelter Differentialgleichungen beschrieben. Das aufgrund der Gegenläufigkeit der Wellen entstehende Randwertproblem wird mittels Schießverfahren auf ein Anfangswertproblem zurückgeführt. Die Sättigung des SBS-Prozesses verhindert eine weitere Vereinfachung des Gleichungssystems, jedoch führt sie zu einer signifikanten Pulskompression bei gleichzeitiger Verzögerung der Pulse. In diesem Beitrag werden Runge-Kutta und Split-Step-Fourier Methode zur numerischen Simulation eines gesättigten SBS Slow-Light Systems intensiv untersucht und verglichen.

Q 55.89 Th 16:00 Lichthof

Simulation eines optischen Regenerators für mehrstufige optische Modulationsformate — •Martin Hierold[1], Tobias Röthlingshöfer[1,2,3], Klaus Sponsel[1,2], Georgy Onishchukov[2,3], Bernhard Schmauss[1,3] und Gerd Leuchs[1,2,3] — [1]Universität Erlangen — [2]Max-Planck-Institut für die Physik des Lichts — [3]Graduate School in Advanced Optical Technologies

Bei der Weiterentwicklung optischer Übertragungssysteme finden sich zunehmend mehrstufige optische Modulationsverfahren im Fokus der Untersuchungen, inbesondere zur Erhöhung der spektralen Effizienz. Die Akkumulation von Phasen- und Amplitudenrauschen ist bei diesen jedoch auf Grund der geringen Distanz der Signalzustände im Phasenraum besonders kritisch. Bei der Verwendung einer Phasenkodierung führt dabei das nichtlineare Phasenrauschen durch nichtlineare Effekte in Übertragungsfasern, wie die Erzeugung von nichtlinearem Phasenrauschen aus Amplitudenrauschen durch die Selbstphasenmodulation, zu starken Beeinträchtigungen. Mithilfe eines modifizierten nichtlinearen Faser-Sagnac Interferometers, des nichtlinearen verstärkenden Schleifenspiegels (NALM) kann eine phasenerhaltende Verringerung des Amplitudenrauschens auch bei mehrstufigen Modulationsformaten erricht werden. Durch eine Optimierung der verschiedenen Parameter eines NALM, wie das Teilugnsverhältnis, die Verstärkung und das Profil des nachgeschalteten optischen Bandpassfiltes, kann der NALM für Eingangssignale mit verschieden starkem Eingangsrauschen angepasst werden. Hierbei ist auch eine Optimierung für Modulationsformate mit nicht äquidistanten Amplitudenniveaus möglich.

Q 55.90 Th 16:00 Lichthof

On the brink of causality: Wave propagation in Gödel's Universe — •Michael Samaniego, Endre Kajari, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, 89069 Ulm, Germany

In 1949 Kurt Gödel presented a cosmological solution of Einstein's field equations, the so-called Gödel Universe, which is stationary, homogeneous, but anisotropic. A particularly interesting feature of Gödel's Universe is the existence of closed timelike world lines, which allow for time travel. Thus, a well-posed Cauchy initial value problem is only possible when we restrict ourselves to a specific spacetime region in Gödel's Universe. In this work, we examine a special type of wave propagation in Gödel's Universe based on a well-posed Cauchy initial value problem for the Klein-Gordon equation.

Q 55.91 Th 16:00 Lichthof

Optical Properties of the Insulator-On-Silicon-On-Insulator Material System — •Daniel Pergande and Ralf B. Wehrspohn — Martin-Luther-Universität Halle-Wittenberg, 06099 Halle

In the last years great efforts lead to a strong miniaturization of optical components by means of realization of devices within the silicon-on-insulator (SOI) platform which is completely compatible to CMOS technology. The very high refractive index contrast between the Si core (n=3.5) and the oxide cladding (n=1.45) and air (n=1), respectively, leads to a high confinement of light inside a waveguide. To meet the demands of next generation networks an appropriate material system which provides equably propagation of TE and TM-polarization is essential. In addition, to realize photonic crystal (PhC) based polarization sensitive devices a fully symmetrical material system is needed to avoid polarization mixing. For most of the (symmetric) SOI-based structures no transmission for TM-polarized light was reported or for TM-polarization a large deviation between theory and experiment was observed.

We present polarization-dependent optical transmission properties of a completely symmetric SOI-based material system. In contrast to typical SOI structures here an insulator-on-silicon-on-insulator (IOSOI) material system has been fabricated, which features an additional silica top layer. The group index dispersions and absorption coefficients of ridge waveguides will be presented. Furthermore, PhC waveguides were characterized and we present measurements to determine the amount of polarization crosstalk.

Q 55.92 Th 16:00 Lichthof

Optomechanical coupling of ultracold atoms and a membrane — •Maria Korppi, Stephan Camerer, David Hunger, Theodor W. Hänsch, and Philipp Treutlein — Max-Planck-Institut für Quantenoptik und Ludwig-Maximilians-Universität München

We report the progress of our experiment which aims at coupling a single mechanical mode of a high-Q membrane-oscillator to the motion of laser-cooled atoms in an optical lattice. The optical lattice is formed by retroreflection of a laserbeam from the oscillator surface. When the trap frequency of the atoms is matched to the eigenfrequency of the membrane, the coupling leads to resonant energy transfer between the two systems. This should allow to observe the back-action of the atoms onto the membrane. In the long term, such coupling mechanism could be exploited in developing hybrid quantum systems between atoms and solid-state devices.

Q 55.93 Th 16:00 Lichthof

Measuring non-Markovian dynamics using optomechanical systems — •Alexey Trubarov[2], Konrad Kieling[1], Simon Gröblacher[2], Markus Aspelmeyer[2], and Jens Eisert[1] — [1]Universität Potsdam — [2]Universität Wien

We consider a system consisting of a micromechanical harmonic oscillator coupled to a thermal bath. Usually, for reasons of simplicity, the assumption is made that this heat bath is ohmic, i.e. is described by a linear spectral density. However, depending on the geometry of the specific mechanical oscillator at hand, this assumption does not have to be fulfilled. We show that the spectral density of the heat bath of the oscillator*s environment can be extracted from the dynamics of the mechanical system and we present first experimental results.