Q 30: Poster: Photonics, laser development and applications, ultrashort laser pulses, quantum effects

Time: Tuesday 16:30–18:30 Location: Spree-Palais

Q 30.1 Tue 16:30 Spree-Palais

Strongly interacting single photons in an ultra-cold Rydberg gas — •JOHANNES SCHMIDT — 5. Physikalisches Institut, Universität Stuttgart, Germany

Strong photon-photon coupling can be achieved in highly nonlinear media such as Rydberg atoms under the condition of electromagnetically induced transparency (EIT). Such a system enables the implementation of fundamental building blocks for photonic quantum information processing. More fundamentally, interacting Ryberg polaritons in a strongly correlated many-body system can be observed.

On this poster, we present our experimental apparatus to implement Rydberg-mediated few-photon nonlinearities in an high optical density medium (OD>200), consisting of ultracold Rb87 atoms in an optimized crossed optical dipole trap. We discuss how this setup can be used to implement a deterministic few-photon absorber and a few-photon switch. Recent results from these experiments are reported.

Q 30.2 Tue 16:30 Spree-Palais

Interfacing Superconducting Qubits and Single Optical Photons — •SUSANNE BLUM[1], CHRISTOPHER O'BRIEN[2], NIKOLAI LAUK[2], GIOVANNA MORIGI[1], and MICHAEL FLEISCHHAUER[2] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Technische Universität Kaiserslautern, Kaiserslautern, Germany

A proposal is presented which allows for interfacing single optical photons and superconducting qubits which have transition frequencies in the microwave regime. The idea is based on using either an atomic ensemble or a solid state quantum memory for storing an optical photon via a two-photon transition in a collective spin excitation. The spin excitation ca also be accessed directly by a microwave field. This transition is used to couple the excitation to a microwave resonator, which mediates the interaction of the collective spin state with the microwave qubit transition; completing the transfer from optical photon to microwave frequency qubit. The reverse process is also analyzed. The efficiency of different methods for transferring the excitation is discussed in relation to the specific realizations of the medium (atomic ensemble, NV-centers, and rare-earth doped crystals).

Q 30.3 Tue 16:30 Spree-Palais

Nondestructive measurement of the photon-number parity — •MAHMOOD SABOONI, ANDREAS REISERER, NORBERT KALB, BASTIAN HACKER, STEPHAN RITTER, and GERHARD REMPE — Max-Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Measuring the odd-even parity of the photon number plays an important role in the description of non-classical features of light. We present a novel approach towards this goal, which is based on the principles of cavity quantum electrodynamics. In our setup, a faint laser pulse is reflected off a resonant, single-sided cavity in which a single atom is trapped. When the atom is prepared in a state that does not couple to the resonator, the reflected light pulse will experience a phase shift of nπ, where n is the number of photons contained in the pulse. When the atom is prepared in a state that is strongly coupled to the cavity, there is no phase shift.

This conditional phase shift can be employed to detect the parity of the photon number when the atom is prepared in an equal superposition of the coupled and the uncoupled state: An odd number of photons in the impinging pulse will then lead to a phase flip of the atomic state, while there is no phase change when the photon number is even. Subsequent readout of the atomic phase thus allows discriminating between odd and even photon number parity. In the actual experiment we have probed the system with a weak laser pulses and then employed the parity measurement technique to nondestructively detect a single photon level probe.

Q 30.4 Tue 16:30 Spree-Palais

Coupling of a single NV center in diamond to a fiber-based microcavity — •ALEXANDER BOMMER[1], ROLAND ALBRECHT[1], CHRISTIAN DEUTSCH[2], JAKOB REICHEL[2], and CHRISTOPH BECHER[1] — [1]Fachrichtung 7.2, (Experimentalphysik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken — [2]Laboratoire Kastler Brossel, ENS/UPMC-Paris/CNRS, 24 rue Lhomond, 75005 Paris, France

The read-out of the spin state of a NV center in diamond would profit enormously from coupling the NV's optical transition to a microcavity. We here report on such a coupling to a fiber-based microcavity with a length $< 5\mu m$. The cavity consists of a plane mirror and a micro-mirror, which is fabricated on the facet of a single mode optical fiber. This fiber defines an output channel for the emitted photons. Nanodiamonds containing single NV centers are spin coated onto the plane mirror. Making use of the NV's broadened emission and thus entering a regime of phonon assisted cavity feeding, this setup provides a narrow-band and tunable single photon source over the whole NV emission spectrum at room temperature [1]. Theoretical simulations based on a master equation model predict that reducing the NV center's linewidth via cooling the nanodiamonds will allow to observe Purcell enhanced emission into the cavity mode. For our experimental parameters up to 65% of the emission could be channelled into the cavity. We show that such a fiber-based cavity works well at cryogenic temperatures. To reach necessary linewidths of about 10GHz we have to overcome spectral diffusion by using nanodiamonds containing less substitutional nitrogen. [1] R.Albrecht et al., PRL 110, 243602 (2013)

Q 30.5 Tue 16:30 Spree-Palais

Transformations of continuous-variable entangled states of light — •ONDŘEJ ČERNOTÍK[1,2] and JAROMÍR FIURÁŠEK[1] — [1]Department of Optics, Palacký University, 17. listopadu 12, 77146 Olomouc, Czech Republic — [2]Institute for Theoretical Physics, Leibniz University Hannover, Appelstraße 2, 30167 Hannover, Germany

Gaussian states and Gaussian transformations represent an interesting counterpart to two-level systems in quantum optics, on the one hand easily described using first and second moments of quadrature operators and on the other hand simple to implement experimentally using linear optics and optical parametric amplifiers. Here, we propose and analyse protocols for manipulation of entangled Gaussian states of light using local operations and classical communication. Firstly, we study entanglement concentration based on photon subtraction enhanced by local coherent displacements for states in the form of a single-mode squeezed vacuum state split on a beam splitter. We show that coherent displacements can enhance entanglement concentration based on photon subtraction.

Secondly, we study transformations of multipartite permutation invariant Gaussian states. We investigate how entanglement classification is changed by these transformations. In addition, as a figure of merit characterising the quality of the entanglement, we use fidelity of assisted quantum teleportation. We study two different strategies to achieve this objective. The first one is based on adding correlated noise to each mode while the other employs partial non-demolition measurements.

Q 30.6 Tue 16:30 Spree-Palais

Verifying Non-Gaussianity of up-converted single photons — •CHRISTOPH BAUNE[1], AXEL SCHÖNBECK[1], AIKO SAMBLOWSKI[1], JAROMÍR FIURÁŠEK[2], and ROMAN SCHNABEL[1] — [1]Albert-Einstein-Institut, Institut für Gravitationsphysik, Leibniz Universität Hannover, Callinstraße 38, D-30167 Hannover — [2]Department of Optics, Palacký University, 17. listopadu 12, 77146 Olomouc, Czech Republic

Non-classical states are crucial in many quantum metrology and quantum information processing tasks. Commonly, complete state information is required to proof that it cannot be described by convex mixtures of Gaussian states - a statement that the state is non-classical. We exploit a criterion proposed by Filip and Mišta [1] to up-converted single photons. Correlated photon pairs are produced at 810 nm and 1550 nm by means of non-degenerate down-conversion. The latter are up-converted to 532 nm and analyzed in a Hanbury Brown and Twiss setup. The quantum non-Gaussianity could be confirmed by the single photon and vacuum contribution of the state while higher photon number states could be neglected to a very good approximation. Our experiments show that quantum non-Gaussianity is maintained by means of frequency up-conversion.

[1] Filip, R. & Mišta, L. Detecting Quantum States with a Positive Wigner Function beyond Mixtures of Gaussian States. Phys. Rev. Lett. 106, 200401 (2011).

Q 30.7 Tue 16:30 Spree-Palais

Single-photon collection from a quantum dot with a parabolic mirror — •Vsevolod Salakhutdinov[1,2], Markus Sondermann[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Erlangen, Germany

Quantum dots are promising sources of single photons for quantum-computation applications. Here, we investigate CdSe/CdS dot-in-rod (DR) nano crystals, which have been shown to act as single-photon sources even at room-temperature [1]. One particular feature of these dots is their emission pattern which is close to the one of a linear dipole. However, enhancing the collection-efficiency for the emitted photons is still an open problem.

In this contribution we present an approach to enhance emission collection from these dots by means of a deep parabolic mirror covering almost the entire solid angle [2]. This setup is especially suited for linear-dipole emitters. The DR nano crystals are placed onto the flat surface of hemispheres and positioned in the focal region of the parabolic mirror. We discuss the achieved collection efficiency and assess possible improvements of the setup.

[1] F. Pisanello et al., Appl. Phys. Lett. 96, 033101 (2010)
[2] R. Maiwald et al., Phys. Rev. A 86 , 043431 (2012)

Q 30.8 Tue 16:30 Spree-Palais

FPGA based coincidence counter for quantum optics experiments — •Irati Alonso Calafell, Amir Moqanaki, and Philip Walther — University of Vienna, Vienna, Austria

Coincidence counting is a widely used technique in quantum optics for spotting photon correlations. We present a simple FPGA based coincidence counter which allows determining coincidences in a limitless number of detectors by an easy and cheap implementation. In addition, signals can be lengthened or shortened according to the required coincidence window and delayed to correct photon path mismatch. This poster describes the general picture of the coincidence counter as well as the concept of the code written in VHDL. Performance and reliability of the FPGA based coincidence counter has been tested and compared to a circuit based version.

Q 30.9 Tue 16:30 Spree-Palais

A cascaded monolithic Fabry-Pérot filter system for single photon quantum optics — •Christoph Berkemeier, Andreas Ahlrichs, Benjamin Sprenger, and Oliver Benson — AG Nano Optics, Institut für Physik, HU Berlin

A long-term stable filter system[1] has been set up with an effective free spectral range of several hundred GHz at a full width half maximum of 200 MHz. The filter system consists out of two monolithic Fabry-Pérot filters[2]. It has been used to filter a single mode of a cavity-enhanced parametric down-conversion source to test case its high resolution filtering capabilities. The comb-like frequency spectrum was accurately resolved and shown to be in high accordance with theory[3].

In a second experiment the indistinguishability of the filtered photon pairs was verified with the Hong-Ou-Mandel effect, which could be measured with a visibility of 96 %. This also shows that undesired birefringence, which is often encountered with monolithic cavities, can be avoided by stress-free mounting.

[1] Ahlrichs et al., Appl. Phys. Lett. 103, 241110 (2013)
[2] Palittapongarnpim et al., Rev. Sci. Instrum. 83, 066101 (2012)
[3] M. Scholz et al., Opt. Commun. 282, 3518 (2009)

Q 30.10 Tue 16:30 Spree-Palais

Reliable entanglement detection under coarse-grained measurements — •Lukasz Rudnicki[1,2], Daniel Tasca[3,5], Rafael Gomes[3,4], Fabricio Toscano[3], and Stephen Walborn[3] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs University of Freiburg, Albertstrasse 19, 79104 Freiburg, Germany — [2]Center for Theoretical Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02-668 Warsaw, Poland — [3]Instituto de Física, Universidade Federal do Rio de Janeiro, Caixa Postal 68528, Rio de Janeiro, Rio de Janeiro 21941-972, Brazil — [4]Instituto de Física, Universidade Federal de Goiás, 74.001-970 Goiânia, Goiás, Brazil — [5]SUPA, School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, United Kingdom

We present reliable entanglement witnesses for coarse-grained measurements on continuous variable systems. These witnesses include information about experimental coarse graining and never return a false positive conclusion for identification of entanglement. Even for the case of Gaussian states, new entanglement witnesses based on the Shannon entropy outperform those based on variances. We test our results experimentally using spatially entangled photon pairs.

Q 30.11 Tue 16:30 Spree-Palais

Prerequesites for continuous variable measurements on a type II PDC source — •Thomas Dirmeier[1,2], Nitin Jain[1,2], Georg Harder[3], Gerd Leuchs[1,2], Christoph Marquardt[1,2], and Christine Silberhorn[1,3] — [1]Max Planck Institut für die Physik des Lichts, Erlangen — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg — [3]Integrierte Quantenoptik, Universität Paderborn

Parametric down-conversion (PDC) sources are known to be a robust and versatile tool for the generation of photon pair states. It has been demonstrated that by using nonlinear waveguides and engineering their properties, pulsed type II PDC sources are able to produce entangled states, which are both spatially and spectrally single-mode [1]. Additionally, the single-mode nature of the produced states allows their efficient use in continuous variable quantum information experiments.

We present the progress made towards realizing the detection of the noise properties of the generated photon pairs via homodyne detection and discuss technical challenges and the applied solutions.

[1] G. Harder et. al., "An optimized photon pair source for quantum circuits," Opt. Express 21, 13975-13985 (2013)

Q 30.12 Tue 16:30 Spree-Palais

Entanglement distribution by separable states and quantum discord — •Daniela Schulze[1], Christina E. Vollmer[1], Tobias Eberle[1], Vitus Händchen[1], Jaromír Fiurášek[2], and Roman Schnabel[1] — [1]Albert-Einstein Institut, Institut für Gravitationsphysik, Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover, Germany — [2]Department of Optics, Palacký University, 17. listopadu 50, 77200 Olomouc, Czech Republic

Distribution of entanglement between two parties - Alice and Bob - is an essential step for most quantum information protocols. Surprisingly, it has been theoretically shown [1,2] that two distant systems can be entangled by sending a third system that is not entangled with either of them. We report on the experimental realization of a scheme for entanglement distribution by separable states on the basis of continuous variables [3]. We show that, as expected, our successful protocol requires a non-zero quantum discord.

[1] T. S. Cubitt, F. Verstraete, W. Dür, J. I. Cirac, Phys. Rev. Lett. 91, 037902 (2003).
[2] L. Mišta, N. Korolkova, Phys. Rev. A 77, 050302 (2008).
[3] C. E. Vollmer, D. Schulze, T. Eberle, V. Händchen, J. Fiurášek, R. Schnabel, Phys. Rev. Lett. 111, 230505 (2013).

Q 30.13 Tue 16:30 Spree-Palais

Periodically poled Rb-exchanged waveguides in KTP — •Christof Eigner, Helge Rütz, Olga Driesner, Raimund Ricken, Hubertus Suche, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Due to their nonlinear optical and dispersive properties, periodically poled (PP)-KTP waveguides are very attractive for photon pair generation and nonlinear frequency conversion. Especially, Rb-K-ion exchanged waveguides have gained considerable attention due to low loss guiding in both, TE- and TM-polarization thus even allowing for type-II quasi-phasematching. However, the doping dependent ionic conductivity of Rb:KTP makes periodic poling a challenging task.

We will discuss the control of the field-assisted poling process by optical monitoring and show first results of periodically poled channel waveguides. And finally, linear and nonlinear optical characterizations of these guides will be presented.

Q 30.14 Tue 16:30 Spree-Palais

A flexible testbed for studies of collisions between fiber-optic soliton molecules — •Maria Lubs, Philipp Rohrmann, Alexander Hause, and Fedor Mitschke — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock

In fiber-optic data transmission systems using solitons in dispersion-managed (DM) fibers, multiple collisions between solitons in adjacent channels occur. Based on careful studies of such collisions ca. 15 years ago, detrimental effects can be avoided; solitons are now used in some commercial systems. Recently so-called soliton molecules – bound states of two or three (or potentially more) solitons in DM fibers – were suggested to further increase the data rate. Naturally, their behavior under collisions must also be investigated.

We introduce a testbed for such studies which is flexibly programmable, and avoids the need to use several laser sources. A pulse shaper (liquid crystal light modulator and two gratings) serves to carve two solitons or soliton molecules (as desired) at the same time from the same modelocked source, with center wavelength and timing differentials. These combinations are then sent down a fiber where collisions occur by virtue of fiber dispersion. By finetuning the wavelength differences, the location of the collision can be controlled. At the fiber end, the emerging pulse structures are analyzed using FROG.

We present preliminary experimental results, and outline how we plan to systematically investigate the impact of such collisions on solitons and soliton molecules. Experiments will be accompanied by numerical simulations.

Q 30.15 Tue 16:30 Spree-Palais

Modification of frequency-resolved optical gating setup improves signal-to-noise ratio — •Sven Kraft, Philipp Rohrmann, Alexander Hause und Fedor Mitschke — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock

Frequency-resolved optical gating (FROG) is one of the most popular techniques to assess the entire amplitude-and-phase structure of ultrashort light pulses. In this contribution we show that a modification can vastly improve the signal-to-noise ratio, thereby enabling measurements on weak pulses as they emerge from experiments, rather than strong pulses straight from the laser. In the standard version a camera is exposed line by line in sequence whereas noise accumulates in all lines, for the entire exposure time. We avoid the unnecessary noise accumulation by using a nanopositioning stage and a fast and sensitive line camera, operating under computer control for smooth operation.

Time to obtain a FROG trace is limited by the camera readout time; for a 512x512 pixel format our setup takes $\approx$ 470 ms. With extended exposure time sensitivity is increased. We tested this with a single line exposure time of 6 s on weak anti-phase double pulses with energies of $E \approx 350$ fJ and peak powers of only $P_0 \approx 590$ mW emerging from a fiber-optic transmission experiment. A full field reconstruction with acceptable noise was achieved.

In comparison to the standard FROG we find a significant signal-to-noise improvement of 35.9 dB. Moreover, the refined version is designed to make additional calibrations of scan linearity etc. unnecessary.

Q 30.16 Tue 16:30 Spree-Palais

Integration of photonic structures and thermal atomic vapors — •Ralf Ritter[1], Nico Gruhler[2], Wolfram Pernice[2], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Germany

The usage of atomic vapors in technological applications has become increasingly relevant over the past few years. They are utilized e.g. in atomic clocks, magnetometers, as frequency reference or to slow down and store light. Integrated devices, which combine photonic structures and thermal atomic vapors on a chip, could be an ideal basis for such purposes, as they provide efficient atom-light coupling on a miniaturized scale.

We will report on the status of our work on various photonic structures such as dielectric waveguides, directional couplers and interferometers combined with thermal cesium vapor.

Q 30.17 Tue 16:30 Spree-Palais

A narrowband Photon Pair Source based on Spontaneous Parametric Down-Conversion — •Matthias Bock, Andreas Lenhard, and Christoph Becher — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus E2.6, 66123 Saarbrücken

Narrowband photon pair sources have become an essential part in quantum networking and quantum repeaters with photons serving as flying qubits. In quantum repeaters one photon will be absorbed by a quantum node (e.g. trapped ions or atoms) while its partner is sent via a fiber communication link. Thus, one of the photons has to fit the atomic transition in center wavelength and linewidth while the other one should be in the low-loss telecom band. At the same time a high heralding efficiency is desirable.

We present such a pair source based on spontaneous parametric down-conversion (SPDC) in a single-resonant optical parametric oscillator (OPO) operating far below oscillation threshold. The OPO consists of a MgO-doped PPLT crystal and is widely tunable from 810nm to 955nm in the signal mode and from 1200nm to 1565nm in the idler mode. We show that the signal could be tuned to an atomic resonance (e.g. Cs or Ca^{+}) while the corresponding idler is located at telecom wavelengths. The resonator shapes the spectrum to a comb-like structure with lines separated by 1GHz and a FWHM of 44MHz. With an additional filter we cut out one single line of the OPO-spectrum and measure the spectral and temporal characteristics of the source including the signal-idler cross correlation and the heralding efficiency.

Q 30.18 Tue 16:30 Spree-Palais

Bandbreitenreduzierung der stimulierten Brillouin Streuung in Monomodefasern — •Stefan Preussler und Thomas Schneider — Institut für Hochfrequenztechnik, Hochschule für Telekommunikation Leipzig

Die stimulierte Brillouinstreuung (SBS) ist einer der dominierenden nichtlinearen Effekte in optischen Monomodefasern. Die SBS im Medium ist eine Wechselwirkung von zwei gegenläufigen Wellen, herbeigeführt durch eine akustische Welle. Dabei erzeugt eine schmalbandige Pumpwelle im Wellenleiter einen Gewinn bzw. Verlust für frequenzverschobene gegenläufige Signale. Der große Vorteil der SBS liegt in der geringen Bandbreite von 10-30 MHz in Monomodefasern. Viele Anwendungen wie z.B. die hochauflösende Spektroskopie optischer Signale, die Quasi-Licht-Speicherung, Mikrowellen Photonik, mm-Wellen Erzeugung und schmalbandige optische Filter profitieren von dieser einzigartigen Charakteristik. All diese Anwendungen würden von einer Verringerung der SBS Bandbreite profitieren. In den letzten Jahren wurden verschiedene Verfahren zur Reduzierung der Bandbreite entwickelt. Dazu gehören die Überlagerung des Gewinnes mit zwei Verlusten, der Einsatz einer spektralen Blende sowie die Verwendung eines mehrstufigen Systems. In diesem Beitrag werden die verschiedenen Ansätze zur Reduzierung der Bandbreite der SBS diskutiert und verglichen. Außerdem werden mögliche Anwendungsgebiete sowie Grenzen der einzelnen Methoden dargestellt.

Q 30.19 Tue 16:30 Spree-Palais

Supercontinuum generation in optical fibers: considerations about the spectral shape. — •Christoph Mahnke und Fedor Mitschke — Universität Rostock, Universitätsplatz 3, 18051 Rostock

In the process of supercontinuum generation in optical fibers the interplay of various nonlinear effects leads to a spectral broadening of the input field. Under certain conditions the resulting spectrum becomes independent from details of the field propagation and converges to a certain characteristic shape[1]. We observe a similar behavior in our experimental setup, where supercontinuum is generated by high-power picosecond laser pulses in a nonlinear microstructured fiber with two zero-dispersion wavelengths.

A recent theoretical approach endeavours to describe this observation by us and others through adaptation of the so called wave-turbulence theory from hydrodynamics [2-3]. This approach attempts to predict the characteristic spectral shape as dominated by the dispersion curve of the fiber. We will discuss whether this procedure can be applied to our experiment and compare experimental and numerical data to the predictions from the wave-turbulence theory.

[1] Martin-Lopez *et al.*, Opt. Express **9**, 6745 (2008)
[2] B. Barviau *et al.*, Opt. Lett. **33**, 2833 (2008)
[3] Kibler *et al.*, Opt. Fiber Techn. **18**, 257 (2012)

Q 30.20 Tue 16:30 Spree-Palais

Transverse Mode Coupling and Diffraction Loss in Fiber Based Micro Cavities — •Julia Benedikter[1], Thomas Hümmer[1,2], Raphael Franz[1], Matthias Mader[1,2], Theodor Hänsch[1,2], and David Hunger[1,2] — [1]Ludwig-Maximilians-Universität, Schellingstraße 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Fiber-based Fabry-Perot resonators provide very small mode volumes and high Finesse in a tunable and accessible geometry [1,2]. This makes them attractive for various applications ranging from cold atom and ion experiments to cavity optomechanics and cavity-enhanced single photon sources. In contrast to macroscopic cavities, the mirrors are not spherical, but rather have a Gaussian profile originating from the laser machining process used to shape the fiber surface. In consequence, Hermite-Gauss modes are no longer the eigenmodes of this system as their wave fronts do not match the mirror surface. This leads to modified mode shapes and transverse mode coupling occurs. Furthermore, the cavity mode can be of the same order of the mirror size, such that diffraction loss becomes an important issue.

We report on first measurements with cavities consisting of a fiber mirror and a macroscopic plane mirror showing clear signs of mode coupling and diffrcation loss, and present a method for calculating the cavity eigenmodes and diffraction loss [3].

[1] Hunger et al., NJP 12, 065038 (2010)
[2] Hunger et al., AIP Advances 2, 012119 (2012)
[6] Kleckner et al., PRA 81, 043814 (2010)

Q 30.21 Tue 16:30 Spree-Palais

A convergence study of different Rigorous Coupled Wave Analysis (RCWA) approaches to time-harmonic electromagnetic scattering problems with applications to nanooptical structures — •Philipp Gutsche[1], Thomas Judd[2], and Frank Schmidt[1] — [1]Zuse Institute Berlin, Takustraße 7, D-14195 Berlin, Germany — [2]Physikalisches Institut, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

Reliable numerical simulations of nano-optical structures are the key for design and pre-fabrication processes in diverse disciplines such as lithography in semiconductor industries, spectroscopy of biological molecules, optimization of quantum dot cavities for single-photon sources, and computation of atomic forces like the Casimir Effect.

For these purposes a variety of different methods, e.g. FDTD, FEM and RCWA, are in use. On the one hand, FDTD and FEM are investigated intensively - both in mathematics and numerical experiments - and their approximations and convergence properties are well known. On the other hand, there is a lack of these insights in RCWA. In spite of this, RCWA is commonly used to simulate a wide range of systems.

We review historical and modern contributions to convergence improvements with respect to RCWA from the early sugesstions to modern developments. We study the convergence rates of the open-source software S^4 and analyze the algorithmic properties in detail.

Furthermore, we compare RCWA and FEM simulations for different classes of problems including 1D-binary gratings and 2D-periodic photonic crystals.

Q 30.22 Tue 16:30 Spree-Palais

Graphene-Based Nanophotonic Devices Embedded In High-Quality Si_3N_4 Circuits — •Nico Gruhler[1], Christian Benz[1,3], Houk Jang[2], Jong-Hyun Ahn[2], Romain Danneau[1,3], and Wolfram Pernice[1] — [1]Institute of Nanotechnology, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany — [2]School of Electrical and Electronic Engineering, Yonsei University, Seoul 120-749, Korea — [3]Institute of Physics, Karlsruhe Institute of Technology, 76049 Karlsruhe, Germany

Si_3N_4 provides low material absorption even for visible wavelengths and is therefore a suitable material to take advantage of the broadband flat absorption of graphene. Using optimized e-beam lithography processes high quality Si_3N_4 nanophotonic circuits are realized. Large single-layer CVD graphene films are mechanically transferred onto a nanophotonic chip and via subsequent lithographic structuring many hybrid graphene-photonic devices are fabricated simultaneously. This waveguide-integration of graphene allows for prolonged light-matter interactions. MZIs with extinction ratio beyond 40dB and microring resonators with optical Q factors up to 1.6×10^6 are used for the characterization of the graphene-light interaction. This approach leeds to an absorption ceofficient of 0.067 dB/μm.

Q 30.23 Tue 16:30 Spree-Palais

Towards nonlinear optics and quantum sensing with cold atoms inside hollow-core fibres — •Maria Langbecker[1], Mohammad Noaman[1], Hannes Duncker[2], Ortwin Hellmig[2], Klaus Sengstock[2], and Patrick Windpassinger[1] — [1]Universität Mainz, QUANTUM, Institut für Physik, Staudingerweg 7, 55128 Mainz, Germany — [2]Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

In this poster we present an experiment for studying strong light-matter interactions using atoms confined inside a hollow-core fibre. For this, cold Rubidium atoms are guided inside a fibre by an off-resonant dipole trap. Then, by measuring the fluorescence of the guided atoms, the dynamics inside the fibre can be observed. In the past, guiding of atoms through a fibre has already been successfully demonstrated. Here, we present results for the first experiments concerning measurements of electromagnetically induced transparency and of the optical depth. For the future, we envision a diverse range of further studies towards nonlinear optics and quantum sensors.

Q 30.24 Tue 16:30 Spree-Palais

Optical collection efficiency enhancement of shallow-implanted nitrogen vacancy centers in diamond by top-down fabricated nanopillars — •Seyed Ali Momenzadeh[1], Felipe Fávaro de Oliveira[1], Andreas Brunner[1], Andrej Denisenko[1], Sen Yang[1], Ilja Gerhardt[1,2], Friedemann Reinhard[1], and Jörg Wrachtrup[1,2] — [1]3. Physikalisches Institut, Universität Stuttgart, Stuttgart — [2]Max Planck Institute for Solid State Research, Stuttgart

The negatively charged nitrogen vacancy (NV) center in diamond is a single photon source with a variety of applications such as quantum information and nanoscale magnetometry. For all of these applications, optical collection efficiency remains a crucial challenge. Due to total internal reflection, most of the emitted photons cannot be collected by conventional detection optics. In the last few years, this problem has been tackled by different photonic structures such as engineered diamond nanopillar [1] and solid immersion lens (SIL) [2] containing NV centers. In this contribution, we present an optimized scheme for the fabrication of such nanopillars employing electron beam lithography and plasma etching. We thoroughly study shallow-implanted single NV centers (few nanometers beneath the diamond surface) embedded onto those nanopillars, as they are of high potential for future magnetometry applications. We find that these nanopillars enhance detected luminescence up to fivefold, even for shallow NV centers. In addition, we present benchmark measurements of the centers' coherence times. [1] Thomas M. Babinec et al. Nature Nanotechnology, 5, 195 - 199 (2010) [2] P. Siyushev et al. Applied Physics Letters 97, 241902 (2010)

Q 30.25 Tue 16:30 Spree-Palais

A Scanning Cavity Microscope — •Matthias Mader[1,2], Thomas Hümmer[1,2], Hanno Kaupp[1,2], Jakob Reichel[3], Theodor W. Hänsch[1,2], and David Hunger[1,2] — [1]Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799 München — [2]Max-Planck-Insitut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching — [3]Laboratoire Kastler-Brossel, ENS, CNRS, UPMC, 24 rue Lhomond, 75005 Paris

We present a novel tool for ultra sensitive and spatially resolved absorption spectroscopy on nanoscale objects. To boost sensitivity, multiple interactions of probe light with an object are realized by placing the sample inside a high finesse scanning optical microcavity. It is based on a laser machined and mirror-coated end facet of a single mode fiber and a plane mirror forming a fully tunable open access Fabry-Perot cavity [1, 2]. Scanning the sample placed on the plane mirror through the cavity mode yields a spatial map of absorptivity of the sample.

We show proof-of-principle experiments with individual gold nanospheres, demonstrating very sensitive absorption and dispersion measurements.

Our results open the perspective to use scanning cavity microscopy as a versatile tool for spectroscopy on weakly absorbing nanoparticles, for bio sensing, and single molecule detection.

[1] D. Hunger, T. Steinmetz, Y. Colombe, C.Deutsch, T. W. Hänsch and J. Reichel, New J. Phys. 12, pp. 065038(2010)
[2] D. Hunger, C. Deutsch, R. J. Barbour, R. J. Warburton and J. Reichel, AIP Advances 2, 012119 (2012)

Q 30.26 Tue 16:30 Spree-Palais

Coupling color centers in diamond to fiber based Fabry-Pérot microcavities — •A. Weissl[1,2], H. Kaupp[1,2], M. Mader[1,2], T. Hümmer[1,2], C. Deutsch[3], H.-C. Chang[4], J. Reichel[5], H. Fedder[6], T. W. Hänsch[1,2], and D. Hunger[1,2] — [1]Ludwig-Maximilians-Universität, 80799 München — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching — [3]Menlo Systems GmbH, 82152 Martinsried — [4]Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei 106, Taiwan — [5]Laboratoire Kastler-Brossel, ENS/UPMC-Paris 6/CNRS, F-7005 Paris, France — [6]Universität Stuttgart, 70569 Stuttgart

We study nitrogen-vacancy (NV) centers coupled to fiber-based Fabry-Pérot cavities. We apply an optical fiber with machined and coated end facet acting as high reflectivity mirror to build low loss optical resonators with free space access [1]. Analyzing optical spectra, we study the enhancement of the fluorescence of NV centers. We demonstrate the scaling behavior of the Purcell enhancement by varying the mode volume as well as the quality factor over a large range. Even though the life time does not change, ideal Purcell factors of several hundreds were observed [2]. In another approach we want to use a diamond nanocrystal large enough to provide nanoscale field confinement by itself in order to build ultra-small mode volume cavities. Embedding the crystal between a pair of silver layers, a Fabry-Pérot cavity mode can be defined with mode volumes down to $0.1(\lambda/n)^3$ resulting in large Purcell enhancement. [1] D. Hunger, AIP Advances 2, 012119 (2012) [2] H. Kaupp et al., PRA 88, 053812 (2013)

Q 30.27 Tue 16:30 Spree-Palais

Polymer DFB laser with hydrogel recognition layer for label-free biosensing — •Esmaeil Heydari[1,2], Jens Buller[1], Erik Wischerhoff[2], Sebastian Döring[1,2], Anna Sobolewska[2], Regina Rosenhauer[2], Andre Laschewsky[1,2], and Joachim Stumpe[1,2] — [1]University of Potsdam, Faculty of Science, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany — [2]Fraunhofer IAP, Geiselbergstr. 69, 14476 Potsdam, Germany

Over the last decades, different optical techniques have been developed for label-free biosensing due to the increasing demands for sensitive, high throughput and cost-effective biosensors. Label-free biosensors based on passive optical resonators such as microrings, microspheres, photonic crystals and plasmon resonances can provide high resolution or sensitivity for the detection of analyte molecules. However, active optical cavity biosensors have been attracted more attention due to their capability to produce their own resonance light while they exhibit superior characteristics in comparison to the passive counterparts. In this work, a polymer DFB laser with a hydrogel recognition layer was developed in order to realize an all-polymer active optical cavity sensor for high throughput and disposable label-free biosensing. This laser biosensor is a stack of three functional layers including a holographic grating with low refractive index as optical resonator, a semiconducting polymer layer with high refractive index as gain medium and a biofunctional hydrogel layer as a receptor unit. The avidin-biotin interaction was implemented as a primarily model in order to demonstrate the capability of this biosensor to perform label-free detection.

Q 30.28 Tue 16:30 Spree-Palais

Ultimate limits of Fabry-Perot microcavities — •Benedikt Schlederer[1,2], Mathias Mader[1,2], Theodor Wolfgang Hänsch[1,2], and David Hunger[1,2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck Institut für Quantenoptik, München

Fiber-based Fabry-Perot optical microcavities can be made from concave mirrors imprinted into the end-facet of optical fibers. They are a promising tool for many experiments, as they are tunable and are automatically fiber-coupled with very good efficiency. [1]

To maximize light matter interaction, the smallest possible cavity mode volume is desired in many cases. We report on simulations and improved CO2 laser fabrication directed to approach the limits of open acces Fabry-Perot type microcavities.

The experimental implementation is based on a CO2 laser which we use for a thermal ablation process. We control the laser with an AOM for pulsehaping and use automatized micropositioning to achieve precise alignment.

[1] Hunger et. al., NJP 12, 065038 (2010)
[2] Hunger et al., AIP Advances 2, 012119 (2012)

Q 30.29 Tue 16:30 Spree-Palais

Increasing quality through the surrounding: Whispering gallery mode resonators and their environment — •Richard Zeltner[1], Florian Sedlmeir[1,2,3], Gerd Leuchs[1,2], and Harald G. L. Schwefel[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Intitute for Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany — [3]SAOT, School of Advanced Optical Technologies, University of Erlangen-Nuremberg, Germany

Dielectric whispering gallery mode (WGM) resonators are based on the concept of total internal reflection at their dielectric interface. Their losses are only induced by residual material absorption and by surface scattering. Nevertheless, they have a very broad field of applications in modern physics such as laser stabilization and sensing of particles down to the nanometer scale. For most applications high Q factors are required. In crystalline WGM resonators record Q factors up to 10^{11} have been recorded which demand a sophisticated procedure of cutting, polishing, and cleaning of the resonator. To decrease the surface scattering loss of the resonator and therefore to achieve high Q factors with less or even without any polishing, we investigate the effect of the refractive index of the surrounding, as the scattering loss scales with the refractive index contrast. Furthermore, we report on the change in the length of the evanescent field in dependence of the refractive index contrast between medium and prism.

Q 30.30 Tue 16:30 Spree-Palais

Nanoparticle characterization by laser transmission microscopy — •Irene Neugebauer, Markus Selmke, and Frank Cichos — Fakultät für Physik und Geowissenschaften, Universität Leipzig, Deutschland

Optical transmission microscopy setups have been used to study small particles under tightly focused illumination. Detailed works about sensitive techniques like photothermal single particle microscopy and spatial modulation spectroscopy are available. The self-interference of the incidence beam with the scattered field here provides a contrast. The signal contains detailed information about the scatterer itself and the illuminating focused field point-spread-function. So far, there is no convenient framework for the precise description of such transmission signals of nanoparticles other than Rayleigh scatterers. We introduce a concise extension of the generalized Lorenz-Mie theory which allows us to characterize nanoparticles and focus fields by means of such transmission signals. We demonstrate the capability to robustly map out the illuminating point-spread-function and analyze the change of transmission while we use different apertures in the detection path.

Q 30.31 Tue 16:30 Spree-Palais

Direct Laser Writing of Singlemode Waveguides in SU-8 Photoresist for a Wavelength of 780nm — •Alexander Landowski, Michael Renner, Georg von Freymann, and Artur Widera — TU Kaiserslautern

Planar optical waveguides are essential for optical communication on a chip. Here we present the construction, characterization and simulation of polymer waveguide structures, fabricated by direct laser writing in a photoresist using a commercial system. We fabricated rectangular shaped single-mode waveguides with air-cladding and SU-8 core (MicroChem Corp.) on SiO_2 for a wavelength of 780nm. We have simulated the structure parameters in Lumerical FDTD (Finite Differential Time Domain) and we have characterized the written structures via raster electron microscopy and differential interference microscopy. We present optimal parameters for stable waveguides extending to approx. 7mm.

Q 30.32 Tue 16:30 Spree-Palais

Asymmetric backscattering of light in bottle microresonators — •Stefan Walser, Christian Junge, Jürgen Volz, and Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien - Atominstitut, Stadionallee 2, A-1020 Wien, Austria

Bottle microresonators are a novel type of whispering-gallery-mode (WGM) resonators [1], based on microfiber technology. Their properties, such as the near lossless coupling to tapered fiber couplers and full tunability, make them a powerful tool for a range of applications including, e.g., cavity quantum electrodynamics [2]. The evanescent field surrounding these resonators can interact with defects of the resonator surface or scatterers attached to it. This interaction leads to backscattering of the light from one running wave mode into the other which leads to a splitting of the cavity resonance. Remarkably, the backscattering rate can depend on the sense of rotation of the mode. In our experiments, we observe clearly different backscattering rates for the two propagation directions. Theoretical models suggest that the origin of this asymmetry arises from the interference of the scattered light from at least two perturbations on the surface. Using properly positioned additional scatterers such as gold nanoparticles or AFM tips, we want to experimentally study this effect, in order to precisely design the backscattering properties for future applications.

[1] M. Pöllinger et al., Phys. Ref. Let. **103**, 053901 (2009)
[2] C. Junge et al., Phys. Ref. Let. **110**, 213604 (2013)

Q 30.33 Tue 16:30 Spree-Palais

Analyzing Periodically Poled Crystals by Čerenkov-Type Second-Harmonic Generation Microscopy and Spectroscopy — •Julia Hanisch, Jörg Imbrock, and Cornelia Denz — Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster

Nonlinear photonic crystals (NPC) like periodically poled lithium niobate possess a modulated χ^2 nonlinearity in form of alternating ferroelectric domains. This modulation gives rise to new phase matching conditions which can be used for quasi phase-matched second-harmonic generation (SHG). We will present nonlinear optical techniques based on the so called Čerenkov-type SHG (ČSHG) to visualize ferroelectric domains in three dimensions and to determine the degree of disorder in NPCs. Efficient ČSHG occurs if the longitudinal phase mismatch is zero and the transverse phase mismatch is compensated for by reciprocal grating vectors of the NPC. In ČSHG spectroscopy the spectrum of reciprocal grating vectors is measured by SH detection. in the far field. Thus, we can determine the shape and mean diameter of ferroelectric domains in periodic and random NPCs [1]. ČSHG light is also emitted in form of two SHG spots at the Čerenkov angle when a focused fundamental laser beam hits a domain boundary. This effect is used in a ČSHG laser scanning microscope to record domain images [2].

References:
[1]*M. Ayoub, Ph. Roedig, K. Koynov, J. Imbrock, and C. Denz, Opt. Express 21, 8220 (2013)
[2]*Y. Sheng, A. Best, H.-J. Butt, W. Krolikowski, A. Arie, and K. Koynov, Opt. Express 18, 16539 (2010)

Q 30.34 Tue 16:30 Spree-Palais

Planare Optronische Systeme - Konzept, Umsetzung und erste Ergebnisse — •Sebastian Dikty[1] und Ludger Overmeyer[2] — [1]Hannoversches Zentrum für Opt. Technologien, Leibniz Universität Hannover — [2]Institut für Transport- und Automatisierungstechnik, Leibniz Universität Hannover

Das wissenschaftliche Ziel des interdisziplinären Sonderforschungsbereichs "Transregio 123 - Planare Optronsiche Systeme" (PlanOS) ist die Integration von innovativen sowie bereits erprobten optischen Technologien in eine einzelne, bis zu 100 μm starke Polymerfolie zu dem Zweck großflächige und flexible Sensornetzwerke realisieren zu können. Anders als in der Optoelektronik verstehen wir unter dem Begriff der Optronik einen weitgehenden Verzicht auf elektronische Bauteile. Dabei liegt der Schwerpunkt auf der optischen Messgrößenwandlung.

In unserem Beitrag möchten wir auf die Anwendungen dieser optronischen Systeme zur Messung von Temperatur, Druck und Dehnung bis hin zur Analytik von biochemischen Prozessen mittels Spektroskopie eingehen. Wir zeigen, welche Anforderungen neue Materialien mit optimierten mechanischen, optischen und thermischen Eigenschaften für die Produktion von Wellenleitern, Lichtquellen, Spektrometern und weiteren Sensoren haben müssen. Unsere Forschung konzentriert sich zudem auf neue Konzepte für die Signalgenerierung, -übertragung und Datenverarbeitung in Sensornetzwerken. Ein weiterer Schwerpunkt der Arbeiten von PlanOS ist die Umsetzung der Erkenntnisse in eine kosteneffektive, Ressourcen schonende Massenproduktion.

Q 30.35 Tue 16:30 Spree-Palais

Fabrication and Characterization of Photonic Structeres in diamond — •Hardy Schauffert[1], Luca Marseglia[2], Fedor Jelezko[1], and Christine Kranz[1] — [1]Universität Ulm — [2]Massachusetts Institute of Technology

We are presenting our latest results about "'Fabrication and Characterization of Photonic Structeres in diamond"'. Photonic Structeres are a promizing candiate for producing single-photon sources and enhancing read out times of single color centers in diamond. Herefor we designed and simulated photonic crystal cavities with resonances for silicon vacency center and archived quality factors of 60000 with a 2-dimensional hexagonal photonic stuctures and 500000 with a nanobeam design with small modul volumes and so possible structures for the strong coupling regime. In the next step we archived the production of thin clean diamond membran with thicknesses about 250 nm using focus ion beam milling and chemical treatment with an potassium nitrat-sulfuric acid mixture with shows a nice reducing of background emitting. We also want to show the remove of gallium deposition in the surface via plasma etching and postproduction tuning of the resonance frequency.

Q 30.36 Tue 16:30 Spree-Palais

Ein regenerativer Zweifarben-Ti:Sa Verstärker für ein Triplett-Solvatationsdynamik Experiment — •Vincenzo Talluto[1], Carl Böhmer[1], Thomas Walther[1] und Thomas Blochowicz[2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt — [2]Institut für Festkörperphysik, Technische Universität Darmstadt, Hochschulstr. 8, 64289 Darmstadt

Die Triplett-Solvatationsdynamik (TSD) ist eine optische Methode, mit der die molekulare Reorientierungsdynamik in unterkühlten Flüssigkeiten nahe des Glasübergangs untersucht werden kann. Der Flüssigkeit wird dazu ein Farbstoff beigemischt, welcher mit einem UV-Laserpuls angeregt wird. Ein Teil der Farbstoffmoleküle geht über in einen langlebigen Triplettzustand. Über den zeitlichen Verlauf der Phosphoreszenzwellenlänge kann die Relaxation der Solvatationshülle in einem Zeitbereich von 1 ms bis 1 s verfolgt werden. Der Vorteil dieser lokalen Methode gegenüber z. B. der dielektrischen Spektroskopie liegt u.a. darin, dass Glasbildner unter geometrischer Einschränkung genauer untersucht werden können. Für eine effektivere Anregung des Triplettzustands wird ein regenerativer Ti:Sa Verstärker aufgebaut. Er emittiert per Cavity Dumping gleichzeitig Pulse zweier Wellenlängen. Durch die Zwei-Photonen Anregung mittels SEP bzw. STIRAP soll der erfassbare Dynamikbereich zu kurzen Zeiten hin erweitert werden. Wir präsentieren den aktuellen Stand des Lasersystems und aktuelle TSD-Messungen mit einem kommerziellen Lasersystem.

Q 30.37 Tue 16:30 Spree-Palais

Ein Brillouin-LIDAR zur Messung von Temperaturprofilen im Ozean: Fortschritte am gepulsten Faserverstärker — •David Rupp, Andreas Rudolf und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Schlossgartenstraße 7, D-64289 Darmstadt

Wir entwickeln ein flugtaugliches LIDAR-System zur Messung von Wassertemperaturen im Ozean bis zu 100 m Tiefe. Es soll eine flexible Alternative zu kontaktbasierten Messverfahren bieten. Als Indikator dient spontane Brillouin-Streuung, die eine temperaturabhängige Spektralverschiebung zum eingestrahlten Laserlicht aufweist.

Die Anforderungen an die gepulste Laserstrahlquelle sind eine geringe spektrale Breite, eine Pulslänge im ns-Bereich und eine Pulsenergie von etwa 1 mJ. Dazu entwickeln und nutzen wir einen geseedeten Ytterbium-dotierten Faserverstärker mit anschließender Frequenzverdopplung. Die verwendete Wellenlänge wird durch unsere Detektionsmethode mit Hilfe eines Rubidium-Kantenfilters (ESFADOF) vorgegeben und liegt bei 543 nm.

Aus der vorverstärkten cw-Seed-Strahlung werden mittels elektrooptischer Modulatoren fourier-limierte 10ns-Pulse mit einer Wiederholrate von bis zu 5 kHz ausgeschnitten. Die weitere Verstärkung erfolgt in vier Yb-dotieren Fasern mit jeweils steigendem Kerndurchmesser. Bedingt durch die photonische Kristallstruktur der letzten beiden Stufen zeigen diese keinerlei Limitierung durch nichtlineare Effekte. Die derzeit erreichbare Pulsenergie liegt bei 0,5 mJ. Der aktuelle Stand und die geplante Weiterentwicklung werden präsentiert.

Q 30.38 Tue 16:30 Spree-Palais

Spektroskopische Eigenschaften von Sm^{3+}:$Y_3Al_5O_{12}$ im sichtbaren Spektralbereich — •Benedikt Niklas Stumpf[1], Daniel-Timo Marzahl[1], Fabian Reichert[1], Christian Kränkel[1,2] und Günter Huber[1,2] — [1]Institut für Laser-Physik, Universität Hamburg, Deutschland — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Deutschland

Das Sm^{3+}-Ion besitzt mehrere strahlende Übergänge im grünen bis tiefroten Spektralbereich und lässt sich mit blauviolettem Licht anregen. In unserem Labor wurden Sm^{3+}: $Y_3Al_5O_{12}$ (YAG) Kristalle mit verschiedenen Dotierungskonzentrationen von 0,1 at.% bis 6 at.% nach dem Czochralski-Verfahren gezüchtet und auf ihre spektroskopischen Eigenschaften hin untersucht. Der maximale Absorptionswirkungsquerschnitt beträgt $7,6 \cdot 10^{-20}$ cm^2 bei einer Wellenlänge von 405,5 nm und lässt sich dem Übergang $^6H_{5/2} \rightarrow {}^6P_{5/2}$ zuordnen. Dieser Übergang ist interessant für das Diodenpumpen von Sm^{3+}:YAG, da Laserdioden bei dieser Wellenlänge durch das Aufkommen der Blue-Ray-Technologie kommerziell verfügbar wurden. Die stärkste Emission findet auf dem Übergang $^4G_{5/2} \rightarrow {}^6H_{7/2}$ bei einer Wellenlänge von 617,8 nm mit einem Emissionswirkungsquerschnitt von $2,2 \cdot 10^{-21}$ cm^2 statt. Zur Zeit werden auch weitere Sm^{3+}-dotierte, oxidische Wirtskristalle untersucht am Institut für Laser-Physik untersucht.

Q 30.39 Tue 16:30 Spree-Palais

Single-mode Ti:sapphire laser with a Sagnac-Michelson standing-wave resonator — •Stefan Narr — Physikalisches Institut, Eberhard-Karls-Universitaet Tuebingen, Auf der Morgenstelle 14, D-72076 Tuebingen

The concept of a novel standing-wave laser resonator is presented. It allows for simultaneous operation of two independent single-mode laser oscillators. The Sagnac-Michelson type resonator consists of two subresonators which both contain the same laser crystal.

In this way the crystal's gain can be used with maximum efficiency. Both laser oscillators can be tuned independently within a range of several GHz. As only few intracavity elements are needed, the concept may allow for the construction of a compact and robust "twin beam laser".

Q 30.40 Tue 16:30 Spree-Palais

Construction and characterization of an amplified diode laser system for cold atom experiments — •Giulia Faraoni, Valentin Ivannikov, Silva Mezinska, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im

Neuenheimer Feld 226, 69120 Heidelberg, Germany

The necessity for high power laser beams in experiments with cold atoms requires the development of optical systems which allow the power amplification of laser light, with controlled optical properties (frequency, polarization, direction of the beam). Tapered Amplifier (TA) antireflection-coated laser diodes can fulfill this requirement when seeded by a suitable master oscillator. We have built a home-made TA diode system, based on the design by the Walraven group (University of Amsterdam) [1] to be used at wavelengths of 767 nm and 780 nm for experiments with ultracold atoms. The TAs are seeded by a continuous-wave external cavity diode laser (CW-ECDL) locked to an atomic spectroscopy resonance. The amplified light will be used for cooling and trapping Potassium or Rubidium atoms in a magneto-optical trap (MOT). We present the design and construction of our amplified laser system as well as a detailed characterization of its performance including power output, tunability and stability. Our lasers will be used in both Potassium and Rubidium experiments which aim at the study of strongly interacting Rydberg states in dense atomic gases.

[1] Paul Cleary, University of Amsterdam, PhD thesis (2012).

Q 30.41 Tue 16:30 Spree-Palais

Pulsed picosecond fiber amplifier at 1030nm — •Jochen Baaz, Tobias Beck, and Thomas Walther — Technische Universität Darmstadt, Institut für Angewandte Physik, Laser- und Quantenoptik, Schlossgartenstraße 7, 64289 Darmstadt

Laser cooling provides a fast and efficient way for high phase space densities in heavy ion beams with relativistic speeds in storage rings. Current laser systems employed use a scanning narrowband laser. An alternative approach would be a fourier limited pulsed laser producing a broad spectrum with a sharp cutoff in the blue part of the spectrum. This poster will report on our work towards the setup of such a system. We employ a grating stabilised external cavity diode laser running at 1029 nm. Its output is amplified up to 9W by a fiber amplifier. Subsequently a combination of AOM and EOMs will cut pulses with a duration of 80 ps to 4 ns which will be further amplified by two additional fiber amplifiers. The amplified pulsed will be converted to their fourth harmonic using nonlinear crystals.

Q 30.42 Tue 16:30 Spree-Palais

Modellierung des Regelsignals eines aktiv stabilisierten ECDLs — •Stefan Schürl, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, D-64289 Darmstadt

ECDLs (External Cavity Diode Laser) sind in der Lage eine hohe Durchstimmbarkeit der Emissionswellenlänge und eine geringe Linienbreite zu erreichen. Diese Eigenschaften machen sie zu hervorragenden Lasern für viele Bereiche wie z.B. der Sensorik oder der Präzisionsspektroskopie. Unterschiedliche Scanverfahren weisen allerdings verschiedene Limitierungen bei der Vermeidung von Modensprüngen auf.

Eine aktive Kontrolle des ECDLs überwindet diese Problematik [1]. Das Verfahren nutzt die periodische Abhängigkeit der Ausgangsleistung von Pumpstrom und externer Resonatorlänge. Für die experimentelle Realisierung des Verfahrens wird ein Regelsignal aus zwei orthogonalen Polarisationszuständen des ECDLs gewonnen. Zusätzlich erlaubt das Verfahren eine gezielte Änderung der Linienbreite durch Variation der Regelparameter.

In diesem Beitrag wird die Modellierung des Regelsignals basierend auf den ECDL-Ratengleichungen präsentiert.

[1] T. Führer, D. Stang, and T. Walther, „Actively controlled tuning of an external cavity diode laser by polarization spectroscopy,“ Optics express 17, 4991-6 (2009).

Q 30.43 Tue 16:30 Spree-Palais

Spatially resolved Stokes parameters of small-area Vertical-Cavity Surface-Emitting Lasers — •Andreas Molitor[1], Pierluigi Debernardi[2], Sebastien Hartmann[1], and Wolfgang Elsässer[1,3] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Darmstadt, Germany — [2]Istituto di Elettronica e di Ingegneria dell Informazione e delle Telecomunicazioni, Torino, Italy — [3]Center of Smart Interfaces, Technische Universität Darmstadt, Darmstadt, Germany

The polarization state of light is a fascinating phenomenon because of its versatility in many optical applications like ellipsometry, microscopy and 3D imaging. Beside these optical applications of polarized light, the polarization behavior of light directly emitted by optoelectronic devices has been investigated very recently. We have shown in [1], that the Stokes formalism is mandatory to uncover the full information of the state of polarization of the VCSEL's emitted light. Using now an extended experimental technique, we demonstrate here for the first time spatially resolved Stokes parameters of the fundamental transverse mode of a small-area surface-grating VCSEL, showing in spite of the surface-grating both a spatially non-uniform linear polarization distribution of the fundamental transverse as well as a non-zero amount of the circular polarization component showing an non-uniform interesting pattern as well. These findings are compared and explained by simulations using the 3D VCSEL ELectroMagnetic (VELM) code.

[1] A. Molitor, S. Hartmann, and W. Elsässer, Opt. Lett. 37, 4799 (2012).

Q 30.44 Tue 16:30 Spree-Palais

Micro-integrated semiconductor laser modules for precision quantum sensors in space — •Anja Kohfeldt[1], Ahmad Bawamia[1], Christian Kürbis[1], Erdenetsetseg Luvsandamdin[1], Max Schiemangk[1,2], Andreas Wicht[1,2], Götz Erbert[1], Achim Peters[1,2], and Günther Tränkle[1] — [1]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin, Germany

We report on the development of a very robust, energy-efficient, semiconductor based laser platform for the deployment of cold atom based quantum sensors in space. This platform is suitable for Master Oscillator Power Amplifier (MOPA) and Extended Cavity Diode Laser (ECDL) modules. The modules have a footprint not larger than $80 \times 25\,\mathrm{mm}^2$ and make use of either already space qualified or space qualifiable components and integration technologies.

Designed for rubidium spectroscopy at 780 nm we will present a MOPA system achieving an optical output power $> 1\,\mathrm{W}$ and an intrinsic linewidth of $< 50\,\mathrm{kHz}$. Further, we outline the next steps of development that combine the MOPA and ECDL concepts with micro-integrated fibre-coupling in a hermetic housing and thus open up the prospect of satellite borne lasers for future applications such as interstellar navigation and relativistic geodesy.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under the grant numbers 50WM1141 and 50WM1240.

Q 30.45 Tue 16:30 Spree-Palais

Building a laser system with kHz linewidth for Rydberg EIT experiments — •Thomas Kerst, Vladislav Gavryusev, Hanna Schempp, Martin Robert-de-Saint-Vincent, Georg Günter, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Recent experiments have shown that light coupled to atoms in the Rydberg state can be used to realize effective photon-photon interactions [1]. Thus they can act as a single photon source with well-controllable properties [2]. Key element for this result is Electromagnetically Induced Transparency (EIT). The narrow EIT resonance width required for the realization of effective photon-photon interactions demands very narrow laser linewidths.

Here we present a commercial stabilization system based on a Fabry-Pérot cavity from Stable Laser Systems, which will allow to achieve linewidths of the order of few kHz for both 780nm and 960nm wavelengths. Key elements are the precise temperature stabilization of the high finesse cavity inside the vacuum housing as well as a very stable DDS based AOM system for frequency-locking [3].

[1] C. S. Hofmann et al. Phys. Rev. Lett. 110, 203601 (2013)
[2] M. M. Müller et al., Physical Review, A 87, 053412 (2013)
[3] H. Labuhn, Diploma thesis, Universität Heidelberg (2013)

Q 30.46 Tue 16:30 Spree-Palais

Kontinuierliches UV-Lasersystem bei 254 nm durch Frequenzvervierfachung eines Flüssigstickstoff-gekühlten Faserverstärkers bei 1015 nm — •Ruth Steinborn[1,2], Patrick Bachor[1,2], Thomas Diehl[1,2], Andreas Koglbauer[1,2], Matthias Stappel[1,2] und Jochen Walz[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz — [2]Helmholtz-Institut Mainz, Johannes Gutenberg-Universität Mainz, D-55099 Mainz

Durch Kühlung von Ytterbium-dotierten Glasfasern auf kryogene Temperaturen lässt sich die Absorption in der Faser im Wellenlängenbereich von 1000 nm bis 1050 nm deutlich reduzieren. Dieser Effekt wird ausgenutzt um einen Faserverstärker bei 1015 nm zu betreiben. Dazu wird von einem Diodenlasersystem erzeugtes Licht in einer auf 77 K gekühlten Ytterbium-Faser verstärkt. Das vorgestellte System erreicht zuverlässig und polarisationsstabil Ausgangsleistungen von über 10 W. Der Einfluss unterschiedlicher Fasertypen auf ASE-Entwicklung (amplified spontaneous emission) und Strahlqualität wurde untersucht.

Das verstärkte Licht wird in zwei Stufen auf 254 nm frequenzvervierfacht. Diese Wellenlänge entspricht dem $6^1S_0 \rightarrow 6^3P_1$-Übergang in Quecksilber.

Die erste Frequenzverdopplung mit einem periodisch gepolten Lithiumniobat-Kristall (PPLN) erreicht im Einfachdurchgang eine Ausgangsleistung von 2 W. Das so erzeugte grüne Licht soll in einem Überhöhungsresonator mit einem Cäsium-Lithiumborat (CLBO) frequenzverdoppelt werden.

Q 30.47 Tue 16:30 Spree-Palais

Nichtlineare Optik in einer Hohlfaser — •Thomas Diehl[1,2], Andreas Koglbauer[1,2], Patrick Bachor[1,2], Matthias Stappel[1,2], Ruth Steinborn[1,2] und Jochen Walz[1,2] — [1]Johannes Gutenberg-Universität Mainz, D-55099 Mainz — [2]Helmholtz-Institut Mainz, Johann-Joachim-Becher-Weg 36, 55128 Mainz

Vierwellenmischen in Metalldämpfen ist eine etablierte Methode zur Erzeugung kontinuierlicher vakuum-ultravioletter Laserlichtstrahlung. Für effizientes Summenfrequenzmischen müssen die fundamentalen Lichtfelder stark fokussiert in das nichtlineare Medium eingestrahlt werden. Dies führt dazu, dass die Wechselwirkungszone des Lichts mit dem Dampf auf die Größenordnung des konfokalen Parameters (ca. 1 mm) beschränkt ist. Durch die Verwendung einer Hohlfaser, innerhalb welcher der nichtlineare Prozess stattfindet, lässt sich die Wechselwirkungszone auf einige cm ausdehnen. Dadurch und durch den engen transversalen Einschluss der Atomen treten beim Vierwellenmischen zusätzliche Effekte auf: Bereits bei relativ geringen Dampfdichten konnte TALISE (two-photon absorption laser-induced stimulated emission) beobachtet werden, ein Prozess, für den üblicherweise die hohen Intensitäten von gepulsten Lichtquellen notwendig sind. Desweiteren gibt es Hinweise auf eine Zwei-Photonen induzierte LID (light induced drift) der Quecksilberatome in der Hohlfaser, was bisher experimentell noch nicht beobachtet wurde.
Die Erzeugung kontinuierlicher vakuum-ultravioletter Strahlung bei 121 nm in einer mit Quecksilberdampf gefüllten Hohlfaser konnte zum ersten Mal experimentell demonstriert werden.

Q 30.48 Tue 16:30 Spree-Palais

Investigation of Fluorescence Suppression in a Capillary Raman System — •Hendrik Seitz[1], Simone Rupp[1], Magnus Schlösser[1], Beate Bornschein[1], and Helmut H. Telle[2] — [1]Institute for Technical Physics, Tritium Laboratory Karlsruhe, Karlsruhe Institute of Technology, Germany — [2]Department of Physics, Swansea University, United Kingdom

Raman spectroscopy is a widely used tool for analyzing the composition of gas mixtures. It allows non-contact and inline multispecies gas measurements. A highly sensitive Raman system for detecting small amounts of gases can be realized by using a glass capillary with a silvered inner surface as the gas cell. The laser light is sent through the capillary which offers a long scattering region, while the highly reflective silvering makes it possible to collect a large fraction of the Raman-scattered light. Both the long scattering region and the effective Raman light collection lead to a high signal. A disadvantage of this approach, however, is the high fluorescence background. Fluorescence light is produced by laser light in glass, in this special case if the laser hits the capillary frontally or if laser light tunnels through the silvering into the glass. This poster discusses a new approach to suppress this fluorescence light for gaining even higher sensitivities: the glass capillary is replaced by a metal tube made of highly reflective metals, e.g. gold, silver or aluminium. An overview of the challenges connected to this approach is given, and the results of first comparison measurements between the metal tubes and the glass capillary are presented.

Q 30.49 Tue 16:30 Spree-Palais

Potassium Spectroscopy on a Sounding Rocket — •Kai Lampmann[1], Ortwin Hellmig[5], Achim Peters[2], Patrick Windpassinger[1,5], and The KALEXUS Team[1,2,3,4] — [1]Institut für Physik, Johannes Gutenberg-Universität, Mainz — [2]Institut für Physik, HU Berlin — [3]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin — [4]Institut für Quantenoptik, LU Hannover — [5]Institut für Laserphysik, U Hamburg

We present a laser spectroscopy system for the sounding rocket experiment KALEXUS. The KALEXUS experiment aims at demonstrating a completely autonomously operating laser spectroscopy system for quantum gas experiments in space. The whole system is designed to meet the stringent requirements of a sounding rocket launch and to provide redundancy for autonomous operation during the whole flight.

To this end, special monolithic Zerodur components are used for fiber coupling the laser light and within the spectroscopy module for guiding and overlapping the beams and mounting the spectroscopy cell including the heating necessary for potassium. Furthermore, a fiber based splitting module is set up to connect the different functional units of the system and to provide an offset frequency stabilization.

The KALEXUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number 50 WM 1345.

Q 30.50 Tue 16:30 Spree-Palais

Relative Intensity Noise Reduction of a Quantum Cascade Laser by Optical Feedback — •Carsten Juretzka[1], Stefan Breuer[1], Lukas Drzewietzki[1], Florian Michel[1], Mathieu Carras[2], and Wolfgang Elsässer[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Schloßgartenstr. 7, Darmstadt 64289, Germany — [2]III-V Lab, Campus Polytechnique, F-91767 Palaiseau Cedex, France

Quantum cascade lasers (QCL) are highly promising versatile mid-infrared sources for high-precision spectroscopy involving fundamental molecular absorption lines. The detection sensitivity is thereby limited by the noise of QCL and driving electronics. Here, we demonstrate the reduction of laser relative intensity noise (RIN) by applying an optical feedback technique that impacts the statistical noise properties of the QCL. The QCL in these experiment is a DFB structure emitting at 5.7 μm. Varying the feedback strength, feedback-phase and laser current, we identify a substantial reduction of RIN by -9.5 dB within a broad frequency range 200 kHz compared to the QCL without feedback. These results can be well explained by the concept of detuned loading [1]. Future work will cover the realization of synchronized wavelength-tuning and feedback-phase control. [1] C. Juretzka, S. Breuer, L. Drzewietzki, F. Schad, M. Carras and W. Elsäßer, 9.5 dB relative intensity noise reduction in quantum cascade laser by detuned loading, Electronics Letters, Volume 49, p. 1548-1550, 2013

Q 30.51 Tue 16:30 Spree-Palais

Ein Brillouin-Lidar zur Messung von Temperaturprofilen im Ozean: Bestimmung der spektralen Breite von Brillouin-Streuung in Abhängigkeit von Temperatur und Salzgehalt — •Pascal Lautz, David Rupp, Andreas Rudolf und Thomas Walther — Institut für Angewandte Physik, AG Laser und Quantenoptik, Technische Universität Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt

Als Alternative zu kontaktbasierten Messverfahren entwickelt unsere Arbeitsgruppe ein flugtaugliches Brillouin-LIDAR, mit dem sich Temperaturprofile des Ozeans erstellen lassen. Das Messprinzip beruht auf Detektion der spontanen Brillouin-Streuung im Wasser. Dabei ist sowohl die spektrale Verschiebung als auch die spektrale Breite der Brillouin-Streuung abhängig von der Temperatur des Wassers und ermöglichen somit eine laserbasierte Temperaturbestimmung aufgrund von zwei unabhängigen Messgrößen.

Die spektrale Linienbreite der Brillouin-Streuung im Wasser liegt in der Größenordnung von 1 GHz. Jedoch existieren bis heute dazu keine statistisch belastbaren Daten. Diese könnten eine noch genauere Kalibrierung des eingesetzten Detektors (ESFADOF-Kantenfilter) und gegebenenfalls die simultane Messung von Temperatur und Salinität ermöglichen. Wir entwickeln eine präzise Detektionseinheit, mit der sich die spektrale Breite der Brillouin-Streuung in Wasser als Funktion der Temperatur und der Salinität messen lässt.

Vorgestellt wird der aktuelle Stand und die geplante Weiterentwicklung.

Q 30.52 Tue 16:30 Spree-Palais

BOOST-Testing fundamental physics in space — •For the boost consortium[1,2], Alexander Milke[1], Deborah N. Aguilera[2], Norman Gürlebeck[1], Thilo Schuldt[2], and Claus Braxmaier[1,2] — [1]Center of Applied Space Technology and Microgravity (ZARM), University of Bremen, Germany — [2]German Aerospace Center (DLR), Bremen, Germany

We are presenting the small satellite mission BOOST (BOOst Symmetry Test). It aims for testing the foundations of special relativity by performing a modern Kennedy-Thorndike (KT) experiment. A potential violation of the boost invariance is measured by comparing two types of clocks, a highly stable optical resonator (length reference) with a molecular iodine clock (frequency reference). For realizing a small satellite compatible payload, the use of diode-laser technology is favorable and currently already under investigation with respect to other space experiments. A laser wavelength of 1016 nm is foreseen as its second harmonics accesses narrow linewidth transitions in molecular iodine. For the KT experiment, one laser is stabilized to a high finesse cavity and a second laser is frequency doubled to a wavelength of 508 nm and stabilized to a hyperfine transition in molecular iodine. Both lasers are directly compared in a beat measurement and analyzed with respect to a possible violation of boost invariance. By employing clocks with 1E-16 frequency stabilities at orbit time and by integration over 5000 orbits, a 1000-fold improvement in measuring the Kennedy-Thorndike coefficient is targeted, compared to the current best terrestrial test.

Q 30.53 Tue 16:30 Spree-Palais

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Q 30.54 Tue 16:30 Spree-Palais

Frequency stabilization and automatic alignment for the resonantly-enhanced Light-shining-through-a-wall experiment ALPS-II — •Robin Bähre[1] and The ALPS Collaboration[2] — [1]Max-Planck-Institute for Gravitational Physics, Hannover — [2]DESY, Hamburg

Searches for weakly interacting sub-eV particles (WISPs) with Light-shining-through-a-wall (LSW) experiments can be largely improved by resonant production and signal enhancement. However, efficient application of these techniques places demanding requirements on frequency matching and spatial alignment of the optical and axion modes. The LSW experiment ALPS-II implements a dichroic sensor scheme for mode frequency and pointing fluctuations. The sensor signals are used for automatic alignment and Pound-Drever-Hall stabilization of the resonator modes and thus enable the mutual alignment of the optical modes to ensure efficient overlap between both Eigenmodes. The poster will provide an optical setup, requirements on frequency and spatial stability of the cavity modes and how these can be achieved with control loops. We present results of our table-top prototype setup and show which steps are made towards a first optical WISP search with resonantly-enhanced regeneration and towards our final experiment stage with two 100 m cavities with a power build up of 5000 and 40000.

Q 30.55 Tue 16:30 Spree-Palais

Yb:Lu_2O_3 thin disk laser for intracavity cw-alignment of molecules — •Bastian Deppe[1,2], Kolja Beil[1], Günter Huber[1,2], Jochen Küpper[1,2,3], and Christian Kränkel[1,2] — [1]Department of Physics, University of Hamburg — [2]Center for Ultrafast Imaging, University of Hamburg — [3]Center for Free-Electron Laser Science, DESY, Hamburg

We are setting up a cw thin disk laser resonator with an intracavity power exceeding 150 kW in fundamental TEM_{00} mode with well-defined, linear or elliptical, polarization. This allows for focal intensities of more than 10^{10} W/cm^2, sufficient for the adiabatic alignment of molecules due to the interaction of their polarizability anisotropy with the field of the cavity mode. Recently, 196 kW of pulsed average power have been demonstrated in an enhancement cavity [ASSL 2013, JTh5A.3]. This demonstrates that dieelectric coatings can sustain the high intracavity powers. The higher lasing efficiency of Yb:Lu_2O_3, compared to Yb:YAG, at very low output coupling rates reveals the higher optical quality of Yb:Lu_2O_3 and its better suitability for our purpose. We will present our results on scaling the intracavity power into the 100 kW regime with an 450 W diode-pumped thin disk laser in multi-mode operation in a short linear resonator. In addition, thermo-optical measurements of the laser disk will be shown for Yb:Lu_2O_3 allowing for detailed investigations regarding the resonator design and optimization of the gain material.

Q 30.56 Tue 16:30 Spree-Palais

Ätz- und Abformprozesse zur Herstellung strahlungsresistenter DOE — •Jana Schmitt[1], Christian Bischoff[2], Andreas Meier[1], Ulrich Rädel[2], Friedemann Völklein[1] und Michael Wolz[3] — [1]IMtech, Hochschule Rhein Main, Rüsselsheim — [2]TOPAG Lasertechnik, Darmstadt — [3]GD Optical Competence, Sinn

Diffraktiv Optische Elemente, die für die Laserstrahlformung und -teilung eingesetzt werden, müssen strahlungsresistent sein. Für ihre Herstellung ist die Verwendung von Glassubstraten unerlässlich. Deren Mikrostrukturierung wird zum einen fotolithographisch durchgeführt. Als Ätzprozesse stehen Reactive Ion Etching (RIE) und Ion Beam Etching (IBE) zur Verfügung. Zum anderen wird ein Heißprägeverfahren entwickelt, das die Abformung von DOEs in Glas und somit die kostengünstige Kleinserienfertigung ermöglicht. Dabei wird ein Stempelwerkzeug fotolithografisch strukturiert, das dann in einem Hochtemperaturprozess abgeformt werden kann.

Es wird gezeigt, dass die Strukturierungsverfahren großen Einfluss auf die entstehenden DOEs und Stempelwerkzeuge haben. Die Strukturprofile der fertigen Elemente dokumentieren, dass jedes Verfahren die gewünschte Geometrie anders überträgt. Auch die entstehenden Oberflächenstrukturen unterscheiden sich bei RIE, IBE und Prägeverfahren signifikant, wie anhand von AFM- und REM-Aufnahmen deutlich wird. Zudem sind für den RIE- und IBE Prozess präzise Ätzratenbestimmungen entscheidend, da sie die Tiefe der Strukturen bestimmen, die nur um wenige Nanometer vom Soll abweichen darf.

Q 30.57 Tue 16:30 Spree-Palais

A 20 kHz carrier-envelope phase-stabilized non-collinear optical parametric chirped-pulse amplifier — •Daniel Nürenberg, Jiaan Zheng, Wataru Kobayashi, and Helmut Zacharias — Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

Parametric amplification is an ideal tool for sensitive carrier-envelope phase (CEP) stable pulses, because of the lower thermal deposition in the gain medium and thus lower thermal fluctuations compared to conventional laser amplification. Our 20 kHz non-collinear optical parametric chirped-pulse amplifier (OPCPA) delivers 10 fs long pulses with an energy of 125 μJ each [1,2]. The system is equipped with a CEP-stabilized Ti:sapphire seed oscillator. We measure the relative CEP of the amplified pulses with an f-2f interferometer. For short-term operation it is sufficient to stabilize only the seed laser. To reach long term CEP-stability we tested different methods for a slow feedback-loop and finally use a feedback to the locking-electronics of the seed-oscillator.

[1] J. Zheng *et al.* Proc. SPIE 8699 (2013), 86990U-1
[2] J. Zheng *et al.*:"Visualization of high-order dispersions for few-cycle pulse compression" accepted for Appl. Phys. B (2013)

Q 30.58 Tue 16:30 Spree-Palais

Changing the spatial beam profile of shaped femtosecond pulses on an ultrafast time scale — •Tom Bolze and Patrick Nuernberger — Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg

Femtosecond pulse shaping is routinely employed to selectively change the amplitude, the spectral phase, and the polarisation state of the laser pulses. However, only a few studies have adressed the aspect of modifying the spatial beam profile within a single laser pulse.

We present a concept to shape the spatial intensity distribution of a femtosecond laser pulse on the ultrafast timescale. To this end, the laser beam is sent through a Mach-Zehnder-type interferometer. In one arm, a spiral phase plate generates a pulse with a Laguerre-Gaussian (LG) spatial beam profile, and additionally a glass rod imprints a large positive chirp. The laser pulse in the other interferometer arm receives the same amount of chirp, but with opposite sign, by a femtosecond pulse shaper. However, its spatial intensity distribution remains the fundamental Hermite-Gaussian (HG) mode. After the interferometer, the LG pulse and the HG pulse are recombined and interfere. This leads to a corkscrew-like motion of the spatial intensity distribution, spiraling around the beam axis on the time scale of the pulse's duration.

Q 30.59 Tue 16:30 Spree-Palais

Resonantly enhanced high-order harmonic generation in plasmas. — •Michael Wöstmann[1], Henrik Witte[1], Helmut Zacharias[1], and Rashid Ganeev[2] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Institute of Ion-Plasma and Laser Technologies, Tashkent 100125, Uzbekistan

Results from high-harmonic generation from laser ablated plasmas from different materials are presented. These include materials that show resonant enhancement of a certain harmonic. An amplified Ti:sapphire laser system with pulse durations of about 40 fs and pulse energies of up to 5 mJ at a repetition rate of 1 kHz is used for harmonic generation. The plasma is generated by part of the uncompressed radiation from the same laser focused onto a rotating solid state target. Additionally, the compressed pulse has been applied for plasma generation as well. In both cases the delay between the plasma generating pulse and the high harmonic generating pulse was investigated dependent on the material used. Altogether eight different target materials have been studied, namely Al, C, Ag, In, Sn, Cu, Zn and brass. Studies include the development of the harmonics intensity on the polarization of the driving laser, the tuning of the fundamental wavelength, especially in presence of a resonantly enhanced harmonic, and the application of an alloy in comparison to the pure materials.

Q 30.60 Tue 16:30 Spree-Palais

Influence of band structures in strong-field phenomena in solids — •Takuya Higuchi and Peter Hommelhoff — Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen

Advances in phase-stabilized pulsed lasers have opened an avenue to field-induced nonlinear optical phenomena, such as field ionisation and higher-harmonic generation. The scope of these strong-field phenomena has been mainly focused on gaseous media, and is extended to solids more recently. A notable difference of crystalline solids from individual gas atoms or molecules is the existence of periodicity due to the lattices, where electrons form band structures in the reciprocal space. The role of this periodicity in perturbative light-matter interactions has been well explored, however, can differ quite much in such strong field phenomena and waits for deeper understanding. For example, Bragg reflection at the Brillouin zone boundaries and formation of Wannier-Stark localized states are known to play important roles, where the wave-number dependence of the energies of the electron bands are essential. However, the energies of the bands are not the only parameters that depend on the wave number. In this contribution, we highlight the influence of the wave-number dependence in dipole matrix elements between electron bands on the strong-field phenomena, mainly comparing models for direct- and indirect-band-gap materials. The relationships among Wannier-Stark localization, Zener tunneling, and higher harmonic generations are discussed.

Q 30.61 Tue 16:30 Spree-Palais

Direct writing of waveguides in polymers with a fs laser — •Welm Pätzold[1], Bernhard Kreipe[1], Moritz Emons[1], Carsten Reinhardt[2], Boris Chichkov[2], and Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover — [2]Laserzentrum Hannover e.V., 30419 Hannover

Current advances in the micromachining of waveguides in polymers with fs laser radiation are presented. A laser beam is focused into a fully crosslinked polymer sample to reach intensities for multi-photon absorption. After cooling of the localizes plasma a permanent structural change remains. The goal is to achieve an increase in refractive index that can act as a Type I waveguide. An alternative approach is the formation of Type II waveguides where the light is guided inbetween multiple modified areas.

This method of direct material modification can create virtually arbitrary 3D-paths within a bulk material and is insensitive to the surrounding environment. In the future it shall be used to create photonic structures like e.g. couplers or beam splitters on polymer foils.

Q 30.62 Tue 16:30 Spree-Palais

Dispersionsscan zur Pulscharakterisierung mittels Erzeugung der dritten Harmonischen an Dünnfilmschichten — •Mathias Hoffmann[1], Tamas Nagy[1,2], Thomas Willemsen[3], Marco Jupé[3], Detlev Ristau[1,3] und Uwe Morgner[1,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Laser-Laboratorium Göttingen e.V., Hans-Adolf-Krebs-Weg 1, 37077 Göttingen — [3]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

In vielen Anwendungen der Ultrakurzzeit-Physik werden Pulse mit wenigen optischen Zyklen benutzt. Für die präzise Charakterisierung gibt es diverse Verfahren wie z.B. SPIDER, FROG, MIIPS und auch den Dispersionsscan (D-Scan), der kürzlich von Miranda et. al. [1] entwickelt wurde. Dieses Verfahren basiert auf der Messung eines frequenzkonvertierten Signals (z.B. SHG, THG) in Abhängigkeit der Dispersion, die die erzeugende Strahlung vor der Konversion erfährt. Ist die eingebrachte Dispersion bekannt, so kann aus den harmonischen Spektren die Pulsdauer bestimmt werden. Wir verwenden hier zur Pulscharakterisierung die dritte Harmonische (um 266 nm) erzeugt an verschiedenen Dünnschichtfilmen, sodass die Charakterisierung von Spektren mit Bandbreiten von mehr als einer Oktave prinzipiell möglich ist. In diesem Beitrag zeigen wir aktuelle Ergebnisse hinsichtlich des Einflusses des verwendeten nichtlinearen Mediums auf die rekonstruierte Pulsdauer und Pulsform.

[1] Miranda et. al., Opt. Exp. 20, 18798-18743 (2012)

Q 30.63 Tue 16:30 Spree-Palais

A split-and-delay unit for the European XFEL — •Sebastian Roling[1], Liubov Samoylova[2], Stefan Braun[3], Frank Siewert[4], Björn Siemer[1], Harald Sinn[2], Frank Wahlert[1], Michael Wöstmann[1], and Helmut Zacharias[1] — [1]Physikalisches Institut WWU Münster, 48149 Münster, Germany — [2]European XFEL GmbH, 22761 Hamburg, Germany — [3]Fraunhofer IWS, 01277 Dresden, Germany — [4]HZB, 12489 Berlin, Germany

For the European XFEL an x-ray split- and delay-unit (SDU) is built covering photon energies from 5 keV up to 20 keV. This SDU will enable time-resolved x-ray pump / x-ray probe experiments as well as sequential diffractive imaging on a femtosecond to picosecond time scale. Further, direct measurements of the temporal coherence properties will be possible by making use of a linear autocorrelation. The set-up is based on geometric wavefront beam splitting, which has successfully been implemented at an autocorrelator at FLASH. The x-ray FEL pulses will be split by a sharp edge of a silicon mirror coated with Mo/B4C and W/B4C multilayers. Both partial beams will then pass variable delay lines. For different wavelengths the angle of incidence onto the multilayer mirrors is adjusted in order to match the Bragg condition. For a photon energy of hν = 20 keV a grazing angle of $\theta = 0.57^\circ$ has to be set, while for hν = 5 keV the angle amounts to $\theta = 2.3^\circ$. Because of the different incidence angles, the path lengths of the beams will differ as a function of wavelength. Hence, maximum delays between 2.5 ps at hν = 20 keV and up to 36 ps at hν = 5 keV will be possible.

Q 30.64 Tue 16:30 Spree-Palais

Photon path representation for multiphoton states — •Nils Griebe and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt, 64289

We develop a method for calculating the time evolution of several initially excited two level atoms inside a cavity or in free space. Our method is a generalization of the known photonic path representation for only one initial excitation and as such well suited for dealing with multimode scenarios. Similar to the case of only one initial excitation our method generates a series of terms. In an approach similar to the Feynman diagrams each of these terms can be uniquely connected to a descriptive diagram. These diagrams correspond to photon paths which contain spontaneous decay, absorption and stimulated emission processes.

Q 30.65 Tue 16:30 Spree-Palais

Waveguide Quantum Electrodynamics - Nonlinear Physics at the Few-Photon Level — •Michael Schneider[1], Tobias Sproll[1], Christoph Martens[1], Peter Schmitteckert[2], and Kurt Busch[1,3]

— [1]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany — [2]Institut für Nanotechnologie, Karlsruher Institut für Technologie (KIT), 76344 Eggenstein-Leopoldshafen, Germany — [3]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik und Photonik, Newtonstr. 15, 12489 Berlin, Germany

The transport of few photons in 1D structures coupled to a fermionic impurity gives rise to a set of non-linear effects, induced by an effective interaction due to Pauli blocking such as photon bunching and the formation of atom-photon bound states.
We analyze a specific example of such systems, namely a 1-D waveguide coupled to a 2-level system, for the case of one and two-photon transport. Therefore we have developed a general theoretical framework, which contains analytic approaches originating in methods of quantum field theory, like path integrals and Feynman diagrams as well as powerful numerical tools based on solving the time-dependent Schrödinger equation.
Owing its generality, our approach is also applicable to more involved setups, including disorder and dissipation as well as more complicated impurities such as driven and undriven 3-level systems.

Q 30.66 Tue 16:30 Spree-Palais

On the fluctuations of the Casimir-Polder force — •Oliver Urban, Stefan Scheel, and Johannes Fiedler — Universität Rostock

One particular consequence of quantum vacuum fluctuation of the electromagnetic field is the Casimir-Polder interaction, which occurs between polarisable particles near a magnetodielectric medium. The existence of this force has been predicted as early as 1948 [1], with the first experimental demonstration using sodium atoms in 1993 [2]. Casimir-Polder forces can be viewed as quantum averages of the quantum Lorentz force [3]. By the fact that this interaction is generated by vacuum fluctuations, the associated force itself fluctuates, so it can be decomposed into an average and a fluctuating component. With a view towards applications of Casimir-Polder potentials as part of a trapping potential for ultracold atoms close to surfaces, such fluctuations could lead to heating and trap loss. We present the first steps towards an understanding of these higher-order fluctuations of the quantized electromagnetic field [4,5].

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Q 30.67 Tue 16:30 Spree-Palais

Super-Adiabatic Transfer in Three-level Systems — •Luigi Giannelli[1,2] and Ennio Arimondo[1,3] — [1]Dipartimento di Fisica, Università di Pisa, Largo Pontecorvo 3, 56127 Pisa, Italy — [2]Theoretische Physik, Universität des Saarlandes, Campus E2.6, D 66123 Saarbrücken, Germany — [3]INO-CNR, Università di Pisa, Largo Pontecorvo 3, 56127 Pisa, Italy

Superadiabatic quantum driving allows for a perfect adiabatic transfer between an initial and a final quantum state by applying an auxiliary Hamiltonian which cancels non-adiabatic transitions.

We apply this theoretical method to the transfer of population in a three-level system, either in cascade or Lambda configuration. As a reference, we consider stimulated Raman adiabatic passage with different laser pulses and determine the superadiabatic correction for each scheme. The fidelity and the transfer time for the schemes are compared.

Moreover, we discuss the robustness of the three-level superadiabatic transfer with respect to changes in driving parameters, and compare the benefits with the challenges in the implementation.

Q 30.68 Tue 16:30 Spree-Palais

Experimental scheme to investigate nonclassicality and nonlocality of light fields of disparate sources using spatial correlation functions — •Johannes Hölzl[1,2], Ralph Wiegner[1], Girish S. Agarwal[3], and Joachim von Zanthier[1,2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen, Deutschland — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen , Deutschland — [3]Department of Physics, Oklahoma State University, Stillwater, OK 74078-3072, USA

We present an experimental scheme for a detection-efficient measurement of spatial two-photon correlations functions of light fields produced by statistically independent disparate sources. By using one single photon emitter, e.g., a spontaneous parametric down conversion source, and controlling the intensity of a second classical source the visibility of the correlation function can exceed the limit where classical Cauchy-Schwarz- and local-realistic Bell-type inequalities are violated.

Q 30.69 Tue 16:30 Spree-Palais

A new source of pseudothermal light — •Thomas Mehringer[1,2], Steffen Oppel[1,2], and Joachim von Zanthier[1,2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen

In the last years various multiphoton interference experiments have been performed using thermal light sources [1,2]. So far, the standard method to generate pseudothermal light relies on a coherent laser beam illuminating a rotating ground glass disk [3,4]. Here we propose a new method to produce pseudothermal light based on a common multimode fiber. If excited by a coherent laser the light of the many modes of the fiber interferes in the far field behind the fiber creating the same speckle pattern and photon statistics as the standard pseudothermal source. Making use of the flexibility of the new device we present multiphoton interferences with up to four pseudothermal light sources.

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Q 30.70 Tue 16:30 Spree-Palais

Light characteristics of quantum dot SLEDs — •Franziska Friedrich and Reinhold Walser — Institute of Applied Physics, TU Darmstadt, Germany

Light emitting quantum dot SLED shows unusual behavior: a broad spectral width of some THz and simultaneously second order coherence of 1.33 at a temperature of 190K [1]. This “hybrid coherent” light arises at the transition of spontaneous to stimulated emission, the range of amplified spontaneous emission (ASE), and has been observed experimentally [2]. The novel light states are interesting objects for fundamental physics on one hand and could find applications in medical diagnostics (OCT) on the other hand.
To understand the physics of the phenomenon of hybrid coherence, we have developed a laser model describing the characteristics of the semiconductor device as well as its observed correlation properties [3]. In particular we have considered N driven quantum dot systems embedded in a cylindrical waveguide of high refractive index surrounded by two beam splitters. In this presentation we will be presenting our semiclassical analysis of the coupled Maxwell-Bloch equations.

[1] M. Blazek et al., Optics Express **17**, 16 (2009)
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[3] F. Friedrich, MSc thesis ”Hybrid coherent light: modeling quantum dot superluminescent diodes” (TU Darmstadt) (2013)

Q 30.71 Tue 16:30 Spree-Palais

Generalised N-photon Hong-Ou-Mandel interference effect in free space — •Simon Mährlein[1,2], Steffen Oppel[1], Ralph Wiegner[1], Joachim von Zanthier[1,2], and Girish S. Agarwal[3,2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen, Germany — [3]Department of Physics, Oklahoma State University, Stillwater, Oklahoma 74078-3072, USA

We propose a simple setup for the realisation of a generalised Hong-Ou-Mandel interferometer. The scheme takes advantage of N input modes evolving in free space and post selection of N output modes via photon detection in the far field. In this way N input modes are symmetrically mixed with N output modes corresponding to the positions of the N detectors. A particularly interesting result is obtained if N single photons are used as input states. By interference of multiphoton quantum paths a generalized Hong-Ou-Mandel dip with total destructive interference is observed for the right choice of detector positions - the so-called “magic positions”.

Q 30.72 Tue 16:30 Spree-Palais

Quantum interference and spontaneous decay — •Andreas Alexander Buchheit and Giovanna Morigi — Universität des Saarlandes, Saarbrücken, Deutschland

We consider a three level transition, composed by two excited states which couple to a common ground state by means of two optical dipole transitions. We first consider that the levels are arranged in a so-called cascade configuration and determine the condition on the decay rate of the intermediate state and on the strength of the pumping field for which coherent-population trapping is observed. We then consider a V-type of transition, where the dipole transitions coupling with the common ground state are parallel. This configuration has been discussed in [1] and is expected to exhibit interference in the spontaneous decay due to cross-damping terms in the master equation. We present a detailed derivation of the master equation and analyze the conditions under which this effect could be experimentally measured in the setup of [2].

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Q 30.73 Tue 16:30 Spree-Palais

Composite bosons: Entangled parts, bosonic whole — •Malte Tichy[1], Peter Alexander Bouvrie[2], and Klaus Mølmer[1] — [1]Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark — [2]Departamento de Física Atómica, Molecular y Nuclear and Instituto Carlos I de Física Teórica y Computacional, Universidad de Granada, E-18071 Granada, Spain

Most bosons in nature are composites made of more elementary bosons and fermions. Still, from hadrons to ultracold molecules, these composites behave very similarly to elementary bosons, because the statistics of the underlying constituents is negligible. The deviation from ideal bosonic behavior is quantified by the normalization ratio of the quantum state of N composites. Using tools from quantum information science, the normalization ratio for two-boson and two-fermion composites can be bounded efficiently in terms of entanglement measures [1,2]. Using these results, we predict an abrupt transition between ordinary and exaggerated bosonic behavior in a condensate of two-boson composites [1], and show how the entanglement between the parts becomes observable in the collective interference pattern of the bosonic whole [3].

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Q 30.74 Tue 16:30 Spree-Palais

Generating Mesoscopic Bell States via Collisions of Distinguishable Quantum Bright Solitons — Bettina Gertjerenken[1], Thomas Billam[2], Caroline Blackley[3], Ruth Le Sueur[3], Lev Khaykovich[4], Simon Cornish[5], and •Christoph Weiss[5] — [1]Carl von Ossietzky Universität, Oldenburg, Germany — [2]Department of Physics, University of Otago, Dunedin, New Zealand — [3]Department of Chemistry, JQC Durham-Newcastle, Durham University, Durham, United Kingdom — [4]Department of Physics, Bar-Ilan University, Ramat-Gan, Israel — [5]Department of Physics, JQC Durham-Newcastle, Durham University, Durham, United Kingdom

We investigate numerically the collisions of two distinguishable quantum matter-wave bright solitons in a one-dimensional harmonic trap. We show that such collisions can be used to generate mesoscopic Bell states that can reliably be distinguished from statistical mixtures. Calculation of the relevant s-wave scattering lengths predicts that such states could potentially be realized in quantum-degenerate mixtures of 85Rb and 133Cs. In addition to fully quantum simulations for two distinguishable two-particle solitons, we use a mean-field description supplemented by a stochastic treatment of quantum fluctuations in the soliton's center of mass: we demonstrate the validity of this approach by comparison to a mathematically rigorous effective potential treatment of the quantum many-particle problem.

[1] B. Gertjerenken *et al.*, Phys. Rev. Lett. **111** 100406 (2013)

Q 30.75 Tue 16:30 Spree-Palais

Ion chains as quantum reservoirs — •Thomás Fogarty[1,2,3], B. G. Taketani[1], E. Kajari[1], A. Wolf[1], Th. Busch[3], and G. Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany — [2]Physics Department, University College Cork, Cork, Ireland — [3]Quantum Systems Unit, Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan

We characterise ion chains as quantum reservoirs, which can mediate entanglement between two objects coupled with the vibrational modes of the chain. The systems which become entangled are the transverse vibrations of two heavy impurity defects, embedded in the ion chain, which couple with the chain axial modes by means of an external optical potential. General scaling properties are verified for large chains, where we demonstrate that entanglement is a stationary feature and does not depend on the finite size of the physical system. We present in detail the effect of the initial squeezing on the entanglement generated and how the entanglement also scales with the distance between the impurities. Finally we analyse the dynamics for small chains, composed of tens of ions, for experimentally relevant parameters such as the initial temperature of the chain.

Q 30.76 Tue 16:30 Spree-Palais

Influence of dipole-dipole interactions on decoherence-free states — •François Damanet and John Martin — Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Bât. B15, B-4000 Liège, Belgium

Decoherence, known as the consequence of the coupling of any quantum system to its environment, causes information loss in the system and represents a major problem in the physical realization of quantum computers [1]. Decoherence-Free States (DFS) are considered as a possible solution to this problem. A set of trapped cold atoms placed in a DFS state will be immune against decoherence due to spontaneous emission. However, because of dipole-dipole interactions between atoms, induced dephasing effects are likely to destroy the coherence and drive the system out of its DFS [1-2]. In this work, we study numerically the dynamics of a set of two-level atoms initially in a DFS with respect to dissipative processes by solving the master equation including both dissipative dynamics and dipole dipole interactions. We focus our attention on the influence of dipolar coupling on the radiated energy rate and coherence of the system as in [3]. In particular, by averaging over many realizations of close randomly distributed atomic positions, we show the formation of a superradiant-like pulse and we study its properties as a function of the dipolar coupling strength.

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Q 30.77 Tue 16:30 Spree-Palais

Pointer state motion of a particle in a gas environment — •Lutz Sörgel and Klaus Hornberger — Fakultät für Physik, Universität Duisburg-Essen

A quantum test particle interacting with an ideal gas environment via collisions is a paradigmatic system for understanding the quantum-to-classical transition of particle motion. To describe the general effect of the collisions, in particular, friction and thermalization, the quantum linear Boltzmann equation [1] can be used. Two limiting cases are considered here: the limit of collisional decoherence (i.e. the marker particle is very massive) and the Brownian motion limit of many weak collisions. The pointer states for both cases are identified as the solitonic solutions of the nonlinear equation of motion associated with a particular unraveling of the master equations. Their equations of motion are determined and turn out to be the classical trajectories in phase space.

[1] B. Vacchini, K. Hornberger, Phys. Rep. 478 (2009)

Q 30.78 Tue 16:30 Spree-Palais

Entanglement dynamics of two-level systems under decoherence — •Joachim Fischbach and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

While being one of the most intriguing effects in quantum physics, entanglement is also notoriously susceptible to the effects of noise. Thus we are interested in understanding the dynamics of entanglement under the influence of decoherence. In our work we study entanglement properties of two-level systems coupled to a cavity, altogether located in a noisy environment. In particular we examine the ultra-strong coupling regime between two-level systems and cavity as well as the possibility of creating entanglement via a dissipative state preparation.

Q 30.79 Tue 16:30 Spree-Palais

Diffractionless image propagation and frequency conversion via four-wave mixing exploiting the thermal motion of atoms — •Lida Zhang and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

A setup to frequency-convert an arbitrary image encoded in the spatial profile of a probe field onto a signal field using four-wave mixing in a thermal atom vapor is proposed[1]. The atomic motion is exploited to cancel diffraction of both signal and probe fields simultaneously. We show that an incoherent probe field can be used to enhance the transverse momentum bandwidth which can be propagated without diffraction, such that smaller structures with higher spatial resolution can be transmitted. It furthermore compensate linear absorption with non-linear gain, to improve the four-wave mixing performance since the propagation dynamics of the various field intensities is favourably modified.

[1] L. Zhang and J. Evers, arXiv:1309.0615 [quant-ph]

Q 30.80 Tue 16:30 Spree-Palais

Light scattering at an NV center in an optical cavity — •Ralf Betzholz, Marc Bienert, and Giovanna Morigi — Universität des Saarlandes, Saarbrücken, Germany

We study a system consisting of a single nitrogen-vacancy (NV) center in diamond situated in an optical resonator. In particular we investigate the light scattering at such a system when it is weakly driven by a laser. Since the NV center is embedded in a diamond crystal the interaction of the electronic degree of freedom to bulk phonons has to be taken into account in the description. Starting from a master equation approach we present absorption spectra as well as spectra of the NV centers fluorescence and the cavity output. By means of these spectra we discuss the influence of the coupling to bulk phonons on the light scattering at the composite system. Moreover, we investigate how the cavity parameters modify the spectral properties of the emitted light by comparison to the free space emission of an NV center.

Q 30.81 Tue 16:30 Spree-Palais

Collective Emission from Interacting Two-Level Atoms on a Lattice — •Paolo Longo and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We investigate the collective emission from interacting two-level atoms on a one-dimensional lattice.

In particular, we focus on the regime of an extended sample, which can be realized in prototypic, basic quantum-optical systems ranging from cold atoms trapped in an optical lattice [1] over photonic realizations based on coupled resonators [2] to synchrotron-based x-ray experiments with thin-film cavities [3,4]. This diversity demands for a generic description that captures the essential physical mechanisms (such as aspects of coherence and interactions) independent of the actual physical realization. We propose such a generic description and study its properties based on the dissipative few-excitation eigenstates (including scattering states and bound states) as well as the physical implications with regard to the signatures that emerge when the system is probed optically.

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[2] M. I. Makin *et al.*, Phys. Rev. A **80**, 043842 (2009).
[3] R. Röhlsberger *et al.*, Science **328**, 1248 (2010).
[4] K. P. Heeg *et al.*, Phys. Rev. Lett. **111**, 073601 (2013).

Q 30.82 Tue 16:30 Spree-Palais

Field control of single x-ray photons in nuclear forward scattering — •xiangjin kong, wen-te liao, and adriana pálffy — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Recent experimental developments of coherent light sources such as the X-ray Free Electron Laser (XFEL) have opened the x-ray parameter regime for fascinating coherent control concepts originally developed in quantum optics. Thus, new fields such as x-ray quantum optics [1] and even nuclear quantum optics emerge as nuclei with low-lying collective states can be resonantly addressed with x-ray light.

Here, the field control of single x-ray photons in nuclear forward scattering, i.e., in the resonant coherent scattering of light off nuclei, is investigated theoretically [2]. First, the simultaneous coherent propagation of two pulses through a nuclear sample is addressed. We find that the signal of a weak pulse can be enhanced or suppressed by a stronger pulse simultaneously propagating through the sample in counter-propagating geometry. Second, the effect of a time-dependent hyperfine splitting is investigated and we put forward a scheme that allows parts of the spectrum to be shifted forward in time. This may become a valuable technique if single x-ray photon wavepackets are to become the information carriers in future photonic circuits.

[1] B. W. Adams *et al.*, J. Mod. Opt. 60, 2 (2013).
[2] X. Kong, W.-T. Liao and A. Pálffy, arXiv:1310.6235v1 (2013).

Q 30.83 Tue 16:30 Spree-Palais

Negative azimuthal force of nanofiber-guided light on a particle — •Fam Le Kien and Arno Rauschenbeutel — VCQ, TU~Wien – Atominstitut, Stadionallee 2, 1020 Wien, Austria

It is well known that radiation pressure due to the momentum flux in a light beam tends to push illuminated objects along the direction of propagation. Recent studies have shown that small particles can be pulled by so-called tractor light beams against the photon stream even when the beam intensity is uniform along the propagation axis. Such a pulling force occurs when the projection of the total incident photon momentum along the propagation direction is small and the forward scattering is dominant.

In this work, we study the Poynting vector and the force of the evanescent wave of a quasicircularly polarized guided light field in a nanofiber on a dielectric spherical particle. We show that the orbital parts of the axial and azimuthal components of the Poynting vector are always positive while the spin parts can be either positive or negative. The presence of the spin part of the axial Poynting vector component is related to the presence of the longitudinal component of the guided light field. It is the source of the negative axial Poynting vector obtained for high-contrast optical nanofibers. We find that, for appropriate values of the size parameter of the particle, the azimuthal component of the force is directed oppositely to the circulation direction of the energy flow around the nanofiber. The occurrence of such a negative azimuthal force indicates that the particle undergoes a negative torque.

Q 30.84 Tue 16:30 Spree-Palais

Bipartite entanglement through a random media — •manutea candé — lpmmc, cnrs, Grenoble, France

In our theoretical work, we study quantum and classical aspects of two-photon interference in light transmission through disordered media. We show that disorder is the main factor that suppresses the interference, whatever the quantum state of the incident light. Secondarily, the two-photon interference is affected by the quantum nature of light (i.e., the well-defined number of photons in the two-photon entangled and Fock states as compared to the coherent state). And finally, entanglement is a resource that allows one to prepare two-photon states with special symmetries with respect to the interchange of the photons and, in particular, the states with bosonic and fermionic symmetries.

We are also interested in the quantification of the entanglement after the propagation through the disorder. Because the amount of entanglement can be related to the Schmidt decomposition of the state, we are using random matrix theory and statistical physics to get access to the distribution of the eigenvalues of the reduced density matrix. The first results we obtain show a strong dependence of the entanglement entropy with the size of the transmission matrix. Properties of the output state are also related to the statistics of the random matrix used to describe the disordered media.

Q 30.85 Tue 16:30 Spree-Palais

Excitation and tunneling in the harmonic and anharmonic limit of the Morse potential — •Harald Losert, Karl Vogel, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We study the behavior of a particle in the Morse potential under the influence of external fields. We haven chosen this model system since the eigenvalues, eigenfunctions and dipole matrix elements can be calculated analytically. Moreover, the tunability of the spacing of the energy levels opens up the transition from the harmonic to the anharmonic limit. Hence, this model system allows an analytical as well as an efficient numerical investigation of a variety of problems.

In particular, we apply an oscillating external field and study the excitation of eigenstates and wave packets in the anharmonic and close-to-harmonic case. Furthermore, a constant external field tilts the Morse potential and enables quantum tunneling. We compare and interpret the tunneling processes of various states in such a metastable potential.

Q 30.86 Tue 16:30 Spree-Palais

Dispersion force control via surface mode excitation —

•Harald R. Haakh[1,3], Francesco Intravaia[2,3], and Carsten Henkel[3] — [1]Max Planck Institut für die Physik des Lichts, Erlangen — [2]Humboldt Universität zu Berlin — [3]Universität Potsdam

Dispersion interactions like the Van der Waals or Casimir-Polder arise from the fluctuations of matter and electromagnetic fields and result in typically attractive forces that play an important role in micro and nanoscale physics[1]. Control over these effects is of high technological relevance to avoid the jamming of movable parts in micro or nanomechanical systems (MEMS/NEMS). We discuss the Casimir interaction between two parallel plane surfaces and analyze the role of different types of electromagnetic field modes. Surface plasmons on metals[2] or surface polaritons on magneto-dielectric composites[3] play a key role in reaching repulsive regimes. Tailored surface mode spectra and their selective excitation to situations out of thermal equilibrium may therefore pave a way towards Casimir force control.

References:
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[3] Haakh, Intravaia, Henkel, Phys. Rev. A **82**, 012507 (2010).
[4] Haakh, Intravaia, Phys. Rev. A **88**, 052503 (2013).

Q 30.87 Tue 16:30 Spree-Palais

Dynamical Casimir-Polder interaction between an atom and surface plasmons — •Harald R. Haakh[1,2], Carsten Henkel[2], Salvatore Spagnolo[3], Lucia Rizzuto[3], and Roberto Passante[3] — [1]Max Planck Institut für die Physik des Lichts, Erlangen — [2]Universität Potsdam — [3]Università degli Studi di Palermo, Palermo, Italy.

We investigate the time-dependent Casimir-Polder potential between a polarizable two-level atom and a surface after a sudden change a system parameter, generalizing previous work[1,2] to arbitrary materials. Similar to the static Casimir-Polder interaction, surface mode excitations play a central role in the interaction[3]. For an initially bare ground-state atom, the time-dependent Casimir-Polder energy reveals how the atom is "being dressed" by virtual photons and surface plasmons. A second scenario considers the dynamics after an externally induced change in the atomic level structure or transition dipoles. We analyze in particular how the time evolution of the interaction energy depends on the optical properties of the surface, in particular on the dispersion relation of surface plasmon polaritons and discuss the mechanism behind the equilibration[4].

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[2] Messina, Vasile, Passante, Phys. Rev. A **82**, 062501 (2010).
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[4] Haakh, Henkel, Spagnolo, Rizzuto, Passante, arXiv:1312.2407

Q 30.88 Tue 16:30 Spree-Palais

Interaction-free measurements with free electrons — •Sebastian Thomas, Jakob Hammer, Dominik Ehberger, and Peter Hommelhoff — Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 1, 91058 Erlangen

In quantum mechanics, it is possible to determine the position of an object without disturbing it in any way. This phenomenon is called an "interaction-free measurement". It was experimentally verified using single photons [1]. Recently, an interaction-free measurement setup has been proposed with electrons instead of photons [2]. This could make it possible to design a new type of electron microscope, in which samples receive a greatly reduced radiation dose. We consider different approaches towards the realization of an interaction-free measurement. In particular, we discuss possible designs of an electron beam splitter. Additionally, we examine the effect of semitransparent samples in interaction-free measurements. We compare the performance of interaction-free gray-value measurements in the proposed setup to classical transmission measurements and to an ideal quantum measurement scheme [3].

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[2] W. Putnam, M. Yanik, Phys. Rev. A 80, 040902 (2009)
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Q 30.89 Tue 16:30 Spree-Palais

Macroscopicity of quantum experiments — •Stefan Nimmrichter and Klaus Hornberger — Universität Duisburg-Essen, Fakultät für Physik, 47048 Duisburg

We present a measure for the macroscopicity reached in quantum superposition experiments. It is based on the observable consequences of a hypothetical breakdown of the superposition principle on macroscopic scales [1]. By specifying the mathematical form of a broad generic class of such breakdown mechanisms, we can quantify and compare how much they are ruled out by quantum superposition experiments. We discuss applications and possible extensions of the method to different experimental fields, as well as its relation to the concept of macroscopic realism and objective collapse [2,3].

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[3] A. Bassi et al, RMP 85, 471 (2013)

Q 30.90 Tue 16:30 Spree-Palais

Anisotropy compensation — •Andrea Cavanna[1], Angela Perez[1], Felix Just[1], Maria Chekhova[1,2,3], and Gerd Leuchs[1,2,3] — [1]Max Planck Institute for the Science of Light Günther-Scharowsky-Str. 1 Building 24 91058 Erlangen — [2]University of Erlangen-Nürnberg, Staudtstrasse 7/B2, 91058 Erlangen, Germany — [3]Department of Physics, M.V.Lomonosov Moscow State University, Leninskie Gory, 119991 Moscow, Russia

We demonstrate a method to compensate for the effect of the anisotropy in the spatial distribution of the radiation generated by parametric down-conversion (PDC) in bulk crystals. In order to achieve this task, a single nonlinear crystal is replaced by two consecutive crystals with opposite walk-off directions. We implement a simple numerical model to calculate the spatial distribution and correlations of PDC light in the low-gain regime, which takes the anisotropy of the crystals into account. Experimental results are presented which prove the validity of both the model and the method.

Q 30.91 Tue 16:30 Spree-Palais

Absolute calibration of a Hybrid Photon Detector camera — •Felix Just[1], Andrea Cavanna[1], Mykhaylo Filipenko[2], Thilo Michel[2], John Vallerga[4], Jeff DeFazio[5], Anton S. Tremsin[4], Jerome A. Alozy[6], Michael Campbell[6], Timo Tick[7], Gisela Anton[2], Maria V. Chekhova[1,3,8], and Gerd Leuchs[1,3] — [1]Max Planck Institute for the Science of Light Günther-Scharowsky-Str. 1 Building 24 91058 Erlangen — [2]Friedrich-Alexander University of Erlangen-Nürnberg Erlangen Centre for Astroparticle Physics Erwin-Rommel-Str. 1 91058 Erlangen — [3]University of Erlangen-Nürnberg, Staudtstrasse 7/B2, 91058 Erlangen, Germany — [4]Experimental Astrophysics Group, Space Sciences Laboratory, University of California Berkeley, CA 94720, USA — [5]PHOTONIS USA Pennsylvania, Inc. 1000 New Holland Avenue Lancaster - PA 17601-5688 - USA — [6]CERN Geneva, Switzerland — [7]IBM Zurich Research Laboratory Säumerstr. 4 8803 Rüschlikon — [8]Department of Physics, M.V.Lomonosov Moscow State University, Leninskie Gory, 119991 Moscow, Russia

The Hybrid Photon Detector is the first device of its kind and is capable of single photon detection with high spatial (6 μm) and temporal (20ns) resolution. We measure the quantum efficiency of this novel device using the Klyshko calibration method utilising the correlations of photon pairs emitted by parametric down-conversion source. This well-known method can be considered absolute, because it does not rely on any standards or references. We also suggest some intriguing applications for such a device in quantum optics.