Q 31: Poster: Quantum Optics and Photonics I

Time: Tuesday 17:00–19:00 Location: P OGs

Q 31.1 Tue 17:00 P OGs

Observation of Four-body Ring-exchange Interaction and Anyonic Fractional Statistics — •Han-Ning Dai[1,2,3], Bing Yang[1,2,3], Andreas Reingruber[2,5], Hui Sun[1,3], Xiao-Fan Xu[2], Yu-Ao Chen[1,3,4], Zhen-Sheng Yuan[1,2,3,4], and Jian-Wei Pan[1,2,3,4] — [1]Hefei National Laboratory for Physical Science at Microscal and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China — [2]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [3]CAS Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, University of Science and Technology of China, Hefei, Anhui, 230026, China — [4]CAS-Alibaba Quantum Computing Laboratory, Shanghai 201315, China — [5]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Erwin-Schroedinger-Strasse, Building 46, 67663 Kaiserslautern, Germany

We report the observation of four-body ring-exchange interactions and the topological properties of anyonic excitations within an ultracold atom system. A minimum toric code Hamiltonian in which the ring exchange is the dominant term, was implemented by engineering a Hubbard Hamiltonian that describes atomic spins in disconnected plaquette arrays formed by two orthogonal superlattices.

Q 31.2 Tue 17:00 P OGs

Observation of Quantum Criticality and Luttinger Liquid in One-dimensional Bose Gases — •Bing Yang[1,3], Yang-Yang Chen[2], Yong-Guang Zheng[1,3], Hui Sun[1,3], Han-Ning Dai[1,3], Xi-Wen Guan[2,4], Zhen-Sheng Yuan[1,3], and Jian-Wei Pan[1,3] — [1]Hefei National Laboratory for Physical Science at Microscal and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China — [2]State Key Laboratory of Magnetic Resonance and Atomic and Molecular Physics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Science, Wuhan 430071, Wuhan — [3]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [4]Department of Theoretical Physics, Research School of Physics and Engineering, Australian National University, Canberra ACT 0200, Australia

We report an observation of quantum criticality and the TLL in a system of ultracold 87Rb atoms within 1D tubes. The universal scaling laws are measured precisely and the characteristic critical temperatures are determined by the double-peak structure of specific heat, confirming the existence of three phases: classical gas, quantum critical region and the TLL. The Luttinger parameter estimated from the observed sound velocity approaches the measured Wilson ratio (WR), which reveals the collective nature of the TLL and the quantum fluctuations.

Q 31.3 Tue 17:00 P OGs

Universal many-body scattering matrix for strong sound-wave turbulence in a dilute Bose gas — •Isara Chantesana[1,2,3] and Thomas Gasenzer[1,3] — [1]Kirchhoff-Institut für Physik, Ruprect-Karls-Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Ruprect-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany — [3]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

Far-from equilibrium dynamics of a dilute Bose gas is studied by means of the two-particle irreducible effective action formalism. We investigate the properties of non-thermal fixed points predicted previously, which are related to non-perturbative strong wave turbulence solutions of the many-body dynamic equations. The key ingredient of our approach is a universal many-body scattering matrix in the infrared limit, independent of the details of the microscopic interactions, which is derived by a resummation of 2PI diagrams. The Boltzmann scattering integral is analyzed in order to find the scaling at the fixed points which correspond to scaling exponents of sound wave turbulence. The dynamics obtained depends on approximate conservation laws in momentum space, the scaling behaviour of the scattering matrix and the dimensionality.

Q 31.4 Tue 17:00 P OGs

Atom-cavity physics with a Bose-Einstein condensate in an ultra-narrow band resonator — •Jens Klinder[1], Christoph Georges[1], Jose Vargas[1], Hans Kessler[1], and Andreas Hemmerich[1,2] — [1]Institut für Laser-Physik, Universität Hamburg — [2]Wilczek Quantum Center, Zhejiang University of Technology

Bose-condensed atoms are trapped in a cavity operating in the ultimate quantum regime, when the Purcell factor exceeds unity and the frequency shift associated with scattering of a single photon exceeds the cavity bandwidth. We explore topics such as recoil resolved cavity sideband cooling [5], non-linear Bloch oscillations [4], matter wave superradiance [3], physics of the Dicke model [2] and the bosonic Hubbard model with infinite range retarded interactions [1].

[1] J. Klinder et al., PRL 115, 230403 (2015).
[2] J. Klinder et al., PNAS 112, 3290 (2015).
[3] H. Keßler et al., PRL 113, 070404 (2014).
[4] H. Keßler et al., NJP 18, 102001 (2016).
[5] M. Wolke et al., Science 337, 85-87 (2012).

Q 31.5 Tue 17:00 P OGs

Beyond mean-field dynamics of ultra-cold bosonic atoms in elongated traps — •Valentin Bolsinger[1,2], Sven Krönke[1,2], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Center for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We explore numerically the impact of dimensionality on the quantum dynamics of interacting bosons tunneling in a three dimensional double well including particle correlations. Such kind of numerical simulations are very challenging, due to (i) different participating length scales in modeling the short-range interactions in three dimensional traps and (ii) the exponential scaling of complexity with the number of atoms. Also a sketch of our numerical method is given, which is based on the recently developed ab-initio Multi-Layer Multi-Configurational Time- Dependent Hartee method for Bosons (ML-MCTDHB) [J. Chem. Phys. 139, 134103 (2013)], and which uses the fact that in elongated traps strong spatial correlations are suppressed due to the energy scales in the longitudinal and transversal direction. Our implementation has got a linear scaling in the number of grid points in contrast to other methods, using a product grid, with cubic scaling [arXiv:1608.04710].

Q 31.6 Tue 17:00 P OGs

Loading and in-situ fluorescence imaging of ultracold potassium in an optical trap — •Tobias Wintermantel, Henrik Hirzler, Alda Arias, Stephan Helmrich, Graham Lochead, and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Ultracold atoms provide a versatile toolbox to study many-body physics with full access to the underlying microscopic properties. We are currently setting up an experiment for potassium atoms confined to reduced dimensions to study the effect of long-range interactions introduced by Rydberg excitation.

We report on a major upgrade of the experimental apparatus to include gray molasses cooling and a quantum gas microscopy setup. Applying gray molasses cooling in a tight optical trap enhances the direct loading from a compressed magneto-optical trap. Low temperatures and high phase-space densities are reached combined with fast experimental cycle times of $\lesssim 1$ s. To image the atoms we placed an aspheric objective lens inside the vacuum chamber, which allows direct access to the spatial correlations between atoms. We present the first fluorescence images of potassium-39 atoms in the dipole trap using gray molasses.

Q 31.7 Tue 17:00 P OGs

Non-equilibrium dynamics of an F=1 spinor Bose-Einstein condensate — •Kevin Geier[1], Christian-Marcel Schmied[1], Sebastian Erne[2,3], and Thomas Gasenzer[1] — [1]Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany — [3]Vienna Center for Quantum Science and Technology, Atominstitut, TU Wien, Stadionallee 2, 1020 Wien,

Austria

We study the dynamics of an F=1 spinor Bose-Einstein condensate in one spatial dimension out of equilibrium by means of semi-classical simulations. Our main focus lies on sudden quenches within the paramagnetic phase, where the system is quenched near the critical point of a phase transition by varying an external magnetic field. The time evolution of the resulting non-equilibrium state including quantum effects is studied within the framework of the truncated Wigner approximation. To this end, the coupled Gross-Pitaevskii equations for the fundamental fields are solved numerically using higher-order time-splitting Fourier pseudospectral methods. We observe the formation of soliton-like excitations and study their link to the build-up of correlations in the system. By continuously tuning the interaction away from an integrable point of the system, we further investigate the effects of non-integrability on the observed dynamics. Our results are put into relation with the concept of non-thermal fixed points and critical phenomena.

Q 31.8 Tue 17:00 P OGs

Dynamics of a one-dimensional two-component Bose gas quenched to criticality. — •Martin Rabel, Markus Karl, and Thomas Gasenzer — Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany

We study the dynamics of a two-component Bose gas after a parameter quench into the proximity of a quantum critical point using analytical, real-time effective-action techniques. The relative degrees of freedom within the system can be described by a quasi-spin 1/2 model. This model is subject to a mean-field paramagnetic to ferromagnetic quantum phase transition. For the full model this corresponds to a transition from a miscible to an immiscible phase. The transition is investigated in a dynamical setup: The initial state is the ground-state configuration far away from criticality. Following a sudden quench to criticality the time evolution of the emerging spin fluctuations is analysed. In the one-dimensional system under investigation, the non-vanishing energy introduced by the quench leads to a finite correlation length during the induced time evolution. The finite critical correlation length is determined within a leading-order $1/N$ approximation. The obtained analytical results are compared with Truncated-Wigner numerical simulations.

Q 31.9 Tue 17:00 P OGs

Goldstone mode in the quench dynamics of an ultracold BCS Fermi gas: A full Bogoliubov-de Gennes approach — •Peter Kettmann[1], Simon Hannibal[1], Mihail Croitoru[2], Vollrath Martin Axt[3], and Tilmann Kuhn[1] — [1]Institute of Solid State Theory, University of Münster — [2]Condensed Matter Theory, University of Antwerp — [3]Theoretical Physics III, University of Bayreuth

Ultracold Fermi gases are a convenient system to probe and study the properties of phases like the BEC and the BCS phase and the crossover in between those regimes. In particular, ultracold Fermi gases can be used as a test bed to study the two fundamental dynamical modes –the Higgs and the Goldstone mode– which result from spontaneous symmetry breaking in these phases.

We investigate the Goldstone mode in the dynamics of a cigar-shaped cloud of ultracold ^{6}Li after an interaction quench on the BCS side of the BCS-BEC crossover. To this end, we numerically solve Heisenberg's equations of motion for the Bogoliubov single-particle excitations in the framework of the Bogoliubov-de Gennes (BdG) formalism. Extending previous studies, we use a full BdG approach instead of the truncated Anderson solution. This improves the validity in the strong-coupling regime and ensures a correct coupling of the Goldstone mode to the trapping potential.

We study the impact of this extension on the dynamics of the single-particle excitations and find an overall good qualitative agreement of both solutions. However, some significant deviations occur predominantly in the case of strong coupling.

Q 31.10 Tue 17:00 P OGs

Universal scaling and non-thermal fixed points in spin systems — •Stefanie Czischek[1], Halil Cakir[1], Markus Karl[1], Michael Kastner[2], Markus K. Oberthaler[1], and Thomas Gasenzer[1] — [1]Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institute of Theoretical Physics, University of Stellenbosch, Stellenbosch 7600, South Africa

We study the dynamical build-up of correlations after sudden quenches in spin systems using the discrete truncated Wigner approximation. In particular, we consider quenches from large external fields into the vicinity of a quantum critical point within the paramagnetic phase. We calculate correlation lengths and study their time evolution at different distances from the critical point. For the transverse-field Ising chain, we find that the discrete truncated Wigner approximation is in good agreement with exact analytical and numerical results. Our exact results show that the correlation function takes the form given by a generalized Gibbs ensemble already after short times and small relative distances, which is also found in the discrete truncated Wigner approximation. The agreement of both results for quenches into the vicinity of the critical point suggests that the discrete truncated Wigner approximation may be used to determine the correlation dynamics after quenches for spin systems which are not exactly solvable, in one and higher dimensions.

Q 31.11 Tue 17:00 P OGs

Probing Relaxation at the Many-Body Localization Transition with Ultracold Fermions in Optical Lattices — •Sebastian Scherg[1,2], Henrik Lüschen[1,2], Pranjal Bordia[1,2], Ulrich Schneider[1,2,3], and Immanuel Bloch[1,2] — [1]Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 München, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [3]Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom

The phenomenon of Many-Body Localization (MBL) describes a generic non-thermalizing phase in which quantum information can persist locally up to infinite times. This phase is separated from a phase obeying the Eigenstate Thermalization Hypothesis via a disorder driven, dynamical phase transition, which happens not only in the ground state but over an extended range of excited states. While the dynamical structure deep in the MBL phase is arguably well understood in one dimension, there is a paucity of results close to the critical point and in higher dimensions.

In this work, we report on the observation of MBL in one and two dimensions. We directly probe the transition points finding critically slow relaxation below the critical disorder strength in both 1D and 2D. The slow dynamics in 1D can be attributed to Griffiths type effects. We highlight the importance of interactions, which strongly govern the behavior around the critical point.

Q 31.12 Tue 17:00 P OGs

Sub-Doppler laser cooling of fermionic 40K atoms in gray optical molasses — •Max Hachmann, Robert Büchner, Raphael Eichberger, and Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg

Most experiments on quantum degenerate gases begin with a laser cooling phase that is followed by evaporative cooling in a conservative trap. The final quantum degeneracy strongly depends on the temperature at the end of the laser cooling phase and sub-Doppler cooling is often a key ingredient for initiating efficient evaporation. In our experiment for fermionic 40K a cooling cycle on the D2 transition for a bright optical molasses has been used. However, 40 K features a narrow hyperfine structure in the excited state of the D2 transition that hinders efficient sub-Doppler cooling by cooling to the red of this transition. The same is true for other isotopes of potassium and lithium. To overcome this limitation a gray molasses cooling scheme on the D1 transition at 770 nm can be implemented to produce cold and dense atomic samples. Here we report on the current progress of the experimental implementation.

Q 31.13 Tue 17:00 P OGs

Fermi Surface Deformation in Dipolar Fermi Gases — •Vladimir Veljić[1], Antun Balaž[1], and Axel Pelster[2] — [1]Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research center OPTIMAS, Technical University of Kaiserslautern, Germany

In a recent time-of-flight (TOF) expansion experiment with ultracold polarized fermionic erbium atoms, TOF images show that the atomic cloud has an ellipsoidal shape, with an elongation in the direction of atomic dipoles [1]. The Hartree-Fock mean-field theory presented in Refs. [2,3], which was restricted to the orientation of dipoles along one of the harmonic trap axes, is generalized here for an arbitrary orientation of dipoles. Afterwards, using this approach we analyze the resulting Fermi surface deformation, calculate TOF dynamics, and solve the corresponding Boltzmann-Vlasov equation within the relaxation-time approximation in the vicinity of a new equilibrium configuration by using a suitable rescaling of the equilibrium distribution. The resulting ordinary differential equations of motion for the scaling parameters are solved numerically for experimentally relevant parameters at zero temperature. A comparison of our analytical and numerical results with the Innsbruck experimental results [1] is also presented.

[1] K. Aikawa, et al., Science **345**, 1484 (2014).
[2] F. Wächtler, A.R.P. Lima, and A. Pelster, `arXiv:1311.5100` (2013).
[3] V. Veljić, A. Balaž, and A. Pelster, `arXiv:1608.06448` (2016).

Q 31.14 Tue 17:00 P OGs

Towards second sound in a quasi two dimensional Fermi gas — •Daniel Hoffmann, Thomas Paintner, Wolfgang Limmer, and Johannes Hecker Denschlag — Universität Ulm, Institut für Quantenmaterie, Deutschland

Excitations in ultracold quantum gases have become a versatile tool to unveil fundamental thermodynamics. Especially the properties of superfluidity have been investigated extensively using local or global excitations. One phenomena which has recently been demonstrated in a quantum gas experiment is second sound excitation (see [1]). In this experiment entropy waves were excited in a suprafluid/normal fluid mixture and were detected by means of density modulation.

In the project presented here, we extend the work on second sound to quasi two dimensional gases. We use a degenerate Fermi gas of ^{6}Li loaded into a highly anisotropic trap, where the conditions of a quasi 2D Fermi gas can be fulfilled. To excite second sound, we use an intensity-modulated laser beam focused on the trap center to generate entropy waves. Detecting density modulations in the Fermi gas enables us to extract the second sound excitation. Our presentation shows first results towards second sound in a quasi 2D interacting Fermi gas.

[1]: Sidorenkov et al., Nature 498, 78-81 (2013)

Q 31.15 Tue 17:00 P OGs

Quench dynamics and equilibrium behavior in a spinless Fermi-Hubbard ladder with dipolar interactions — •Philipp Fabritius and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

We report on theoretical simulations of a spinless Fermi-Hubbard model on a two-leg ladder with anisotropic long-range dipolar interactions. Using a density-matrix renormalization group approach we obtain the quantum phase diagram. We also present results on the dynamical evolution of the system following a quantum quench from an insulating to an interlayer superfluid phase. These results have relevance for future experiments which aim to use quantum gas microscopy to reveal exotic superfluid and magnetic phases with ultracold atoms.

Q 31.16 Tue 17:00 P OGs

An experiment to initialize and study the Fermi-Hubbard model atom by atom — •Phillip Wieburg, Kai Morgener, Thomas Lompe, and Henning Moritz — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Investigating the Fermi-Hubbard model with cold atoms is typically done by evaporatively cooling an ultracold Fermi gas and loading it into a large optical lattice. In contrast, we plan to build up a Fermi-Hubbard system site by site using optical microtraps. Each microtrap will contain a single atom cooled to the vibrational ground state by Raman-sideband cooling. This technique combines fast experimental cycle times with single site addressability and detection and allows studying the fundamental processes governing the Fermi-Hubbard model in a bottom-up approach.

Here we report upon the commissioning of this new experiment, which is going to be able to cool a gas of 40K to quantum degeneracy as well as to directly lasercool single atoms into optical microtraps. We have already lasercooled 39K and 40K atoms and trapped them magnetically. Further cooling of the atoms will be performed using Raman-sideband cooling [1,2]. In order to image and to manipulate the atoms with high spatial resolution, our setup is equipped with a novel type achromatic imaging system located inside the vacuum chamber.

[1] A.M. Kaufman et al., Physical Review X 2 041014 (2012).
[2] L. W. Cheuk et al., Phys. Rev. Lett. 114, 193001 (2015).

Q 31.17 Tue 17:00 P OGs

Anomalous heating in ion traps: where does the noise originate? — •Carsten Henkel[1], Henning Kaufmann[2], and Ulrich Poschinger[2] — [1]Universität Potsdam — [2]Johannes-Gutenberg-Universität Mainz

Trapped ions that are laser-cooled to the ground state of a Paul trap provide a promising platform for quantum information processing and surface analysis. The ions are subject to fluctuating electric fields emanating from the surrounding electrodes which lead to a finite heating rate whose detailed behaviour is not yet fully understood (patch potentials, surface adsorbates, temperature and distance dependence ...)[1]. Building on a recent model with metallic electrodes covered by a thin lossy dielectric [2], we investigate the spatial distribution of the charge fluctuations that generate the electric field noise. We analyze for example the interference that is at the origin of the maximum of noise for films with a certain thickness [3, 4]. The aim is to mitigate anomalous heating with suitably coated electrodes that screen the dominant noise sources.

[1] M. Brownnutt, M. Kumph, P. Rabl, and R. Blatt, Rev. Mod. Phys. 87 (2015) 1419
[2] M. Kumph, C. Henkel, P. Rabl, M. Brownnutt, and R. Blatt, New J. Phys. 18 (2016) 023020
[3] S. Bauer, Am. J. Phys. 60 (1992) 257
[4] S. A. Biehs, D. Reddig, and M. Holthaus, Eur. Phys. J. B 55 (2007) 237; S. A. Biehs, Eur. Phys. J. B 58 (2007) 423

Q 31.18 Tue 17:00 P OGs

A hybrid atom-ion trap for ultracold Li and Yb$^+$ — •Jannis Joger[1], Henning Fürst[1], Norman Ewald[1], Thomas Secker[2], Thomas Feldker[1], and Rene Gerritsma[1] — [1]Institute of Physics, University of Amsterdam, Netherlands — [2]Institute for Coherence and Quantum Technology, TU Eindhoven, Netherlands

Our setup for realising a hybrid system of ultra-cold atoms and ions is presented. This setup allows studying the quantum dynamics of mixtures of fermionic atoms and ions. Recent experiments have shown that the time-dependent trapping field of the ions can cause heating in hybrid atom-ion systems [1]. One way to mitigate this problem is to employ ion-atom combinations with a large mass ratio [2]. The highest convenient mass ratio - for species that still allow for straightforward laser cooling - is achieved by using the combination ^{171}Yb$^+$ and ^{6}Li.

Combining ion trapping technology with ultra-cold lithium poses particular challenges that we address on this poster. We present numerical simulations showing that the s-wave limit may be reached in our setup, opening up the possibility of studying atom-ion Feshbach resonances [3] and show our first experimental results of atom-ion interactions.

[1] Z. Meir et al., arXiv:1603.01810 (2016)
[2] M. Cetina et al., Phys. Rev. Lett. 109, 253201 (2012).
[3] M. Tomza, C.P. Koch and R. Moszynski, Phys. Rev. A 91, 042706 (2015).

Q 31.19 Tue 17:00 P OGs

Laser cooling of Dysprosium — •Niels Petersen, Florian Mühlbauer, Carina Baumgärtner, Lena Maske, and Patrick Windpassinger — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Ultra-cold dipolar quantum gases enable the study of many-body physics with long-range, inhomogeneous interaction effects due to the anisotropic character of the dipole-dipole interaction. These systems are expected to show novel exotic quantum phases and phase transitions which can be studied with dysprosium atoms. Dysprosium is a rare-earth element with one of the largest ground-state magnetic moments (10 Bohr magnetons) in the periodic table. Therefore, the dipole-dipole interaction is not a small perturbation but becomes comparable in strength to the s-wave scattering. This influences significantly the physical properties of the trapped atomic sample, such as its shape and stability.

This poster presents the current status of our experimental setup to generate dysprosium quantum gases. We discuss the relevant properties of dysprosium and present our laser system and vacuum design. We present spectroscopic measurements of the relevant cooling transitions and show our progress towards laser cooling of dysprosium atoms in a magneto optical trap.

Q 31.20 Tue 17:00 P OGs

The role of particle (in-)distinguishability for many-particle dynamics in optical lattices — •Tobias Brünner, Gabriel Dufour, Alberto Rodriguez, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany

Much attention has been dedicated so far to the dynamical impact of interactions - which often can be associated with the progressive suppression of coherence phenomena. On the other hand, little is known on the fundamental role of the interacting particles* degree of mutual (in-)distinguishability in such experiments, while we have learnt from a new generation of photonic interference experiments and theory that controlling the degree of (in-)distinguishability unveils a panoply of novel many-particle interference phenomena. We import this program into the realm of controlled, interacting many-particle quantum systems, specifically for cold atoms in optical lattices, and identify statistical, experimentally readily accessible quantifiers to infer the particles* degree of distinguishability.

Q 31.21 Tue 17:00 P OGs

Quantum Hall physics with quantum walks in a synthetic magnetic field — •Muhammad Sajid, Dieter Meschede, and Andrea Alberti — Wegelerstr. 8 - 53115

Simulation of quantum transport with discrete-time quantum walks (DTQWs) have been realized in various experiments including ultracold neutral atoms in optical lattices [1]. For example, the behavior of charged particles in a periodic potential subject to an external electric field has been simulated with neutral atoms in spin-dependent one-dimensional optical lattices [2].

Here, we propose a scheme based on DTQWs to recreate integer quantum Hall (IQH) physics with pseudo-spin-1/2 particles. Quantum walks are particularly suited to study the limit of strong fields. We compute the bulk topological invariants, i.e. the Chern numbers of the bands, of DTQWs in a synthetic magnetic field. Further, we discuss an experimental proposal based on realistic experimental conditions, which uses neutral atoms to implement synthetic magnetic fields in a DTQW. Our experimental proposal permits to dial any synthetic magnetic field landscape, including those with sharp spatial boundaries, along which matter waves are expected to flow without dissipation into the bulk.

[1] M. Karski et al., Science 325, 174 (2009). [2] M. Genske et al., Phys. Rev. Lett. 110, 190601 (2013).

Q 31.22 Tue 17:00 P OGs

Imaging topologically protected transport in 2D optical lattices — •Falk-Richard Winkelmann, Stefan Brakhane, Alexander Knieps, Geol Moon, Gautam Ramola, Carsten Robens, Max Werninghaus, Wolfgang Alt, Dieter Meschede, and Andrea Alberti — Institut für Angewandte Physik - Uni Bonn

Discrete time quantum walks (DTQWs) of neutral atoms in 2D optical lattices provide a versatile platform to simulate topological phenomena arising in condensed matter and artificial gauge fields.

With our recently completed 2D quantum simulator we investigate topologically protected transport, using DTQWs in two dimensions [1].

We make use of polarization-synthesized lattice beams todeterministically transport neutral Cs atoms depending on their internal state. A high numerical aperture (NA = 0.92) objective lens enables us to image and address atoms with single site resolution [2].

We present how we plan to utilize aspatial light modulator to realize a spatially resolved coin operation, which will enable us to prepare topologically protected edge states between regions with different topological phases.

[1] Groh, et al. Robustness of topologically protected edge states in quantum walk experiments with neutral atoms. Phys. Rev. A, 94, Jul 2016. [2] Robens, et al. A high numerical aperture (na = 0.92) objective lens for imaging and addressing of cold atoms. arXiv:1611.02159, 2016.

Q 31.23 Tue 17:00 P OGs

Rydberg excitations of cold atoms inside a hollow-core fiber — •Maria Langbecker, Mohammad Noaman, Chantal Voss, Maik Selch, Florian Stuhlmann, and Patrick Windpassinger — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Cold atoms inside hollow-core fibers present a promising candidate to study strongly coupled light-matter systems. Combined with the long range Rydberg interaction which is controlled through an EIT process, a corresponding experimental setup should allow for the generation of a strong and tunable polariton interaction. Using this scheme, novel photonic states can be generated and studied with possible applications in quantum information and simulation.

This poster presents our experimental setup with laser cooled Rubidium atoms inside a hollow-core fiber. We explain the details of our transport procedure of the cold atoms into the fiber using an optical conveyor belt and show the first measurements of cold Rydberg excitations inside the fiber. In addition, we present the characterization of Kagomé-type hollow-core fibers whose properties allow for simultaneous atom guiding and two-photon Rydberg EIT excitation. Finally, we show our progress towards Rydberg quantum optics in a quasi-one-dimensional geometry.

Q 31.24 Tue 17:00 P OGs

Toward a photon-photon quantum logic gate based on Rydberg interactions — •Steffen Schmidt-Eberle, Daniel Tiarks, Thomas Stolz, Stephan Dürr, and Gerhard Rempe — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

The experimental realization of a photon-photon quantum logic gate based on a scheme which is not inherently probabilistic was a long-standing goal, which has been reached only recently, using a single atom in an optical resonator [1]. We pursue the same goal following a different approach in which the required strong interactions are generated by the gigantic van der Waals interaction between Rydberg atoms. A crucial ingredient needed for such a gate is an optical π phase shift generated by a single photon, which we demonstrated recently [2]. We now extended the scheme of Ref. [2] by storing an incoming photonic polarization qubit in a quantum memory consisting of an atomic ground state and a Rydberg state. We report on the implementation of this scheme in our experimental setup and quantitative studies of its performance.

[1] B. Hacker et al. Nature 536, 193 (2016).
[2] D. Tiarks et al. Science Advances 2, e1600036 (2016).

Q 31.25 Tue 17:00 P OGs

Probing many-body states of interacting Rydberg atoms via fluorescence imaging. — •Henrik Hirzler, Tobias Wintermantel, Stephan Helmrich, Alda Arias, Graham Lochead, and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Trapped ultracold atoms excited to Rydberg states provide a widely controllable platform for strongly-interacting many-body physics. We recently showed that the competition between driving fields, dissipation and interactions leads to several interesting dynamical regimes which exhibit scaling behavior [1]. We expect this is associated with the emergence of strong spatial correlations between the excited atoms. To probe these correlations we will optically down-pump the excited Rydberg atoms and then measure their fluorescence using a high-resolution imaging system, consisting of a high-NA objective lens and a high quantum efficiency camera. We will report progress towards spatially resolving correlations induced by Rydberg-Rydberg interactions down to single atom level.

[1] Helmrich, S et al. "Scaling of a long-range interacting quantum spin system driven out of equilibrium", arXiv:1605.08609, 2016

Q 31.26 Tue 17:00 P OGs

Simulation of 3D atomic Bragg beam splitters — •Antje Neumann and Reinhold Walser — Institut für Angewandte Physik TU-Darmstadt, Darmstadt, Germany

Atoms are the ultimate quantum sensors. In the configuration of an atom interferometer they provide the opportunity of high-precision rotation and acceleration sensing. Potential applications are inertial navigation, geological exploration and fundamental physics. In the QUANTUS free-fall experiments atom interferometry is the central method as well.

Like in optical systems, matter wave devices like traps, beam splitters and mirrors require specifications and ubiquitous imperfections need to be quantified. In particular, we study the response and aberrations due to spatio-temporal laser beam envelopes, wave front curvatures and spontaneous emission of a Bragg beam splitter. We present results of numerical and analytical studies of the velocity dependence of the complex reflectivities of the beam splitter. Finally, this is applied to obtain the diffraction efficiency of a Bragg beam splitter for thermal and Bose-condensed atomic ensembles.

Q 31.27 Tue 17:00 P OGs

Atomic lensing with aberrations — •Wolfgang Zeller[1], Albert Roura[1], Wolfgang P. Schleich[1], and the QUANTUS TEAM[1,2,3,4,5,6,7,8] — [1]Institut für Quantenphysik, Universität Ulm — [2]Institut für Quantenoptik, LU Hannover — [3]ZARM, Universität Bremen — [4]Institut für Physik, HU Berlin — [5]Institut für Physik, JGU Mainz — [6]Institut für angewandte Physik, TU Darmstadt —

[7]MUARC, University of Birmingham, UK — [8]Lab. Kastler Brossel, E. N. S., France

The field of light-pulse atom interferometers has made an enormous progress in precision with a wealth of applications since the first experiments 25 years ago. Improving the resolution by means of longer interferometer times is, however, accompanied by a loss in the signal-to-noise ratio because of the decreasing density of the cloud. Although atomic lensing (also known as delta-kick cooling) can mitigate this problem (see Ref. [1], for instance), we illustrate that possible "lens aberrations" caused by potential anharmonicities can give rise to non-trivial features of the atomic cloud [2]. In particular, we investigate their relevance in the context of recent QUANTUS and future high-precision experiments.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant number 50WM1556.

[1] H. Müntinga et al., *Physical Review Letters* **11**, 093602 (2013).
[2] W. Zeller, A. Roura and W. P. Schleich, *in preparation.*

Q 31.28 Tue 17:00 P OGs

Geometric Phases in Light-Pulse Atom Interferometry — •Stephan Kleinert, Wolfgang P. Schleich, and the QUANTUS Team — Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQ^{ST}), Universität Ulm

In the presence of a time-dependent Hamiltonian, a quantum state accumulates, apart from a dynamical phase, a geometric phase which solely depends on the topology of the projective Hilbert space.

We investigate the topological effects of the internal as well as the external degrees of freedom in atom interferometers. Within the general framework of the representation-free description of light-pulse atom interferometry [1] we separate the geometric phase from the dynamical phase contributions and propose an interferometer pulse sequence that measures the geometric phase.

The QUANTUS project is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economics and Energy (BMWi) under grant number 50WM1556.

[1] S. Kleinert, et al., *Representation-free description of light-pulse atom interferometry including non-inertial effects*, Physics Reports 605, 1 (2015).

Q 31.29 Tue 17:00 P OGs

Elements of a guided electron based quantum electron microscope — •Robert Zimmermann, Philipp Weber, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

This poster reports on the manipulation of free electrons using microwave electric fields applied to micro-structured chips. The working principle is the same as for the Paul trap, i.e. a microwave potential applied to electrodes causes an oscillating electric field by which the electrons can be guided [1]. Based on the first designs of a planar quadrupole guide [2][3] and of an electron beam splitter [4], we discuss the improved confinement from using two electrode chips. Lastly, the design of an electron resonator and its first experimental results are presented. In contrast to conventional electron optics, the transverse confinement naturally provides discretized motional quantum states that govern the electron motion. The goal is to employ these quantum states to show interaction-free measurements [5] with free electrons, which would pave the way for the development of the quantum electron microscope [6].

[1] W. Paul, Rev. Mod. Phys. 62, 531 (1990) [2] J. Hoffrogge, R. Fröhlich, M. A. Kasevich and P. Hommelhoff; Phys. Rev. Lett. 106, 193001 (2011) [3] J. Hoffrogge and P. Hommelhoff; New J. Phys. 13, 095012 (2011) [4] J. Hammer, et al.; Phys. Rev. Lett. 114, 254801 (2015) [5] P. Kwiat, et al.; Phys. Rev. Lett. 74, 4763 (1995) [6] W. P. Putnam and M. F. Yanik; Phys. Rev. a 80, 040902(R) (2009)

Q 31.30 Tue 17:00 P OGs

The moiré fieldmeter: an atom optics tool for electric and magnetic field measurements — •Andrea Demetrio[1], Pierre Lansonneur[2], Simon Müller[1], Patrick Nedelec[2], and Markus K. Oberthaler[1] — [1]Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg (DE) — [2]Institut de Physique Nucleaire de Lyon, Bâtiment Paul Dirac, 4 rue E. Fermi, 69622 Villeurbanne (FR)

We report on the development of a fieldmeter which employs the moiré effect to determine the magnitude of electric and magnetic fields in the experimental region.

The device is composed by three material gratings with micrometric periodicity. A diffused beam of particles going through the gratings forms a pattern with the same periodicity as the gratings themselves. A force acting on the particles causes a shift of this pattern, which is proportional to the acceleration perpendicular to the orientation of the slits. Comparing this shift for different ions, the intensity of the external fields can be measured. With the use of three ion species with different charge-to-mass ratios, it is possible to decouple the effects of magnetic and electric fields.

Here we show the use of this device in the scope of the ATLIX project (Antiproton Talbot-Lau Interferometry eXperiment) as a way to ensure that the fields inside the experimental region are below the critical limits which would hinder its realization. The data have been taken with the use of a ECR ion source in Heidelberg, where a prototype of the experiment is currently being built.

Q 31.31 Tue 17:00 P OGs

Nuclear spin register in diamond and their application — •Thomas Unden[1], Zhenyu Wang[2], Jorge Casanova[2], Boris Naydenov[1], Alex Retzker[3], Martin B. Plenio[2], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm — [2]Institut für Theoretische Physik, Universität Ulm — [3]Racah Institute of Physics, Hebrew University of Jerusalem

Nuclear spin register in diamond open several ways towards the understanding of future quantum technology. Using a single, cotrollable electron spin nearby, our nuclear register is controllable and can be used for quantum information tasks like quantum error correction as well as improved metrology.

Q 31.32 Tue 17:00 P OGs

Atom-chip interferometry with Bose-Einstein condensates — •Matthias Gersemann[1], Sven Abend[1], Martina Gebbe[2], Holger Ahlers[1], Hauke Müntinga[2], Christian Schubert[1], Wolfgang Ertmer[1], Claus Lämmerzahl[2], Ernst M. Rasel[1], and the QUANTUS team[1,2,3,4,5,6] — [1]Institut für Quantenoptik, LU Hannover — [2]ZARM, Uni Bremen — [3]Institut für Physik, HU zu Berlin — [4]Institut für Quantenphysik, Uni Ulm — [5]Institut für Angewandte Physik, TU Darmstadt — [6]Institut für Physik, JGU Mainz

The small spatial and momentum width of ultracold atoms such as Bose-Einstein condensates (BEC) makes them very well suited for high precision atom interferometry. In our atom-chip setup we generate a ^{87}Rb BEC and are able to perform Bragg interferometry with high fidelity. Introducing a relaunch mechanism allows us to span a fountain geometry including all required atom-optical operations in a volume of less than a one centimeter cube. This geometry enables the operation of a quantum gravimeter based on a Mach-Zehnder type interferometer sequence with a free-fall time of $T = 25\,\mathrm{ms}$. Additionally techniques like delta-kick collimation, Stern-Gerlach type deflection, higher-order and double Bragg beam splitters are studied in detail. This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) due to an enactment of the German Bundestag under grant numbers DLR 50WM1552-1557 (QUANTUS-IV-Fallturm).

Q 31.33 Tue 17:00 P OGs

Atom-chip based BEC sources for compact and transportable experiments — •H. Heine[1], J. Matthias[1], N. Grove[1], M. Sahelgozin[1], A. Kassner[2], M. Rechel[2], S. Abend[1], S. T. Seidel[1], W. Herr[1], M. C. Wurz[2], J. Müller[3], W. Ertmer[1], and E. M. Rasel[1] — [1]IQ, Leibniz Universität Hannover — [2]IMPT, Leibniz Universität Hannover — [3]IfE, Leibniz Universität Hannover

Cold atom interferometers are starting to be used as inertial sensors in geodetic measurement campaigns competing with state-of-the-art classical sensors but are limited in accuracy by the residual thermal expansion of the atomic ensemble. Meanwhile, atom chips have been used to create Bose-Einstein condensates (BECs) with high repetition rates, providing a source of low expanding atomic ensembles ideal for compact and transportable precision experiments.

On this poster we will contrast our current atom-chip source with the features of the next generation atom chips targeting higher flux, compactification and simplification. The flux can be increased by utilizing non-adhesive conjunction techniques, leading to better vacuum quality and hence lowering background collision losses. With advanced electrical contacting of the chip and simplification in the optical setup, very compact and transportable systems can be realized.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG) in the scope of the SFB 1128 geo-Q and by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) due to an enactment of the German Bundestag under grant number DLR 50WM1650.

Q 31.34 Tue 17:00 P OGs

Precision gravity measurements with Very Long Baseline Atom Inteferometry — •Christian Meiners, Dorothee Tell, Etienne Wodey, Dennis Schlippert, Christian Schubert, Wolfgang Ertmer, and Ernst M. Rasel — Institut für Quantenoptik, Gottfried Wilhelm Leibniz Universität Hannover

Matter-wave interferometers are a novel method for probing inertial forces as rotations and accelerations. By using quantum objects as test masses they can reach extremely high stability and low systematic uncertainty. One direction of development of these sensors is the compactification to make them applicable in field geodesy whereas an other development is to extend the baseline from tens of centimeters to several meters, to increase the sensitivity which scales with the free fall time squared. Our very long baseline atom interferometer (VLBAI) will not only establish a complementary method to state of the art gradiometers and superconducting gravimeters when operated with a single species but also aims at quantum tests of the universality of free fall at levels comparable to the best classical tests and beyond by utilizing two different atomic species.

We present our strategies and recent progress on the construction of a VLBAI facility in Hannover, implementing ultra-cold samples of rubidium and ytterbium atoms, a magnetically shielded interferomtry region, and a state of the art vibration isolation.

The VLBAI facility is a major research equipment funded by the DFG. We also acknowledge support from the CRCs 1128 "geo-Q" and 1227 "DQ-mat" and the RTG 1729.

Q 31.35 Tue 17:00 P OGs

A compact diode laser system for atom interferometry on a sounding rocket — •Vladimir Schkolnik[1,2], Ortwin Hellmig[3], André Wenzlawski[4], Jens Grosse[5], Anja Kohfeldt[2], Klaus Döringshoff[1], Andreas Wicht[2], Patrick Windpassinger[4], Klaus Sengstock[3], Claus Braxmaier[5,6], Markus Krutzik[1], Achim Peters[1,2], and The MAIUS Team[1,2,3,4,5,6,7] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]FBH Berlin — [3]U Hamburg — [4]JGU Mainz — [5]ZARM U Bremen — [6]DLR Bremen — [7]LU Hannover

Laser systems with precise and accurate frequencies are one of the key elements in modern precision experiments based on atom interferometers and atomic clocks. Future space missions including quantum interferometry based gravity mapping, tests of the equivalence principle or the detection of gravitational waves rely on robust and compact lasers with high mechanical and frequency stability.

Here we present a compact diode laser system for atom interferometry with ultra-cold atoms aboard sounding rockets. Our laser system is flight-proven through successful operation in the MAIUS mission. Design, assembly and qualification of the laser system as well as its performance during the flight are discussed.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy under grant numbers DLR 50WM 1237-1240, and 1345.

Q 31.36 Tue 17:00 P OGs

Testing the Universality of Free Fall with cold atoms — •Henning Albers, Dipankar Nath, Logan L. Richardson, Dennis Schlippert, Christian Schubert, Wolfgang Ertmer, and Ernst M. Rasel — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

The development of cold atom sensors has given rise to a unique and broad field of applications. They can be used for inertial sensing and as well as fundamental tests of the laws of physics. By performing a differential measurement of the Earth's local gravitational acceleration, g, of two distinct atomic species, namely ^{39}K and ^{87}Rb, we are able to provide a sensitive test of the Universality of Free Fall (UFF) with atomic test masses [1].

In this work, we show the recent progress towards testing the UFF with an inaccuracy on the level of 10^{-9}. To reach this goal we utilize an optical dipole trap at 1960 nm. In addition, the correction of ground coupled inertial noise, measured by a commercial seismometer, in an atom interferometer is an important aspect, both for the realization of transportable atom gravimeters, as well as the 10 m Very Long Baseline Atom Interferometer (VLBAI) apparatus working with Rb and Yb [2].

[1] D. Schlippert et al., Phys. Rev. Lett. 112, 203002 (2014)
[2] J. Hartwig et al., New J. Phys. 17, 035011 (2015)

Q 31.37 Tue 17:00 P OGs

Pushing quantum sensor technology towards ultra-compact and integrated setups — •Marc Christ[1], Achim Peters[1], Markus Krutzik[1], and The KACTUS Team[1,2,3] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]Ferdinand-Braun-Institut, Berlin — [3]Leibniz Universität Hannover

Reliable long-term operation of integrated quantum sensors in space imposes challenging requirements on the utilized technology and materials. In the last decade, the progress in miniaturization achieved in the context of the QUANTUS and LASUS collaborations greatly benefited from atom chip technology, microintegrated diode laser systems and compact opto-mechanics.

Within the KACTUS project, we explore innovative technologies to realize even more compact and integrated quantum sensor prototypes, for instance by implementing Magneto-optical traps and dipole laser setups on-chip. To achieve long lifetimes of Bose-Einstein condensates generated in these devices, the UHV performance is crucial.

We present the design of a versatile tool allowing mass spectrometry and gas rate measurements at 10^{-11} mbar base pressure. Combined with a sample transfer and conditioning system, UHV qualification of single components to medium sized assemblies is possible. This enables rapid prototyping of innovative, integrated setups and qualification of novel bonding techniques.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy under grant number DLR 50WM1648.

Q 31.38 Tue 17:00 P OGs

A cryogenic ion trap experiment for highly charged ions — •Steven A. King[1], Tobias Leopold[1], Peter Micke[1,2], Lisa Schmöger[1,2], Maria Schwarz[1,2], José R. Crespo López-Urrutia[2], and Piet O. Schmidt[1,3] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Institut für Quantenoptik, Universität Hannover, 30167 Hannover

Highly charged ions (HCI) with narrow optical transitions are promising systems for tests of fundamental physics and improved optical frequency standards. However, to fully make use of these systems the high charge state production needs to be combined with the techniques of single ion trapping at cryogenic temperatures.

We present a cryogenic ion trap setup for highest precision quantum logic spectroscopy of HCI. The HCI are extracted from a room temperature permanent magnetic EBIT and re-trapped in a Paul trap together with Be^{+} ions [1]. These ions provide sympathetic cooling and act as the logic species in the quantum logic scheme. Initial data from our low vibration cryogenic system and Paul trap will be presented.

As the next step we will perform optical spectroscopy on the well investigated fine structure transition of Ar^{13+} and determine the isotope shift between $^{36}Ar^{13+}$ and $^{40}Ar^{13+}$.

[1] Schmöger et al., *Science* 347, 6227 (2015)

Q 31.39 Tue 17:00 P OGs

A fibre link for optical clock comparison between London and Paris — •Jochen Kronjäger[1], Giuseppe Marra[1], Olivier Lopez[2], Nicolas Quintin[2], Anne Amy-Klein[2], Won-Kyu Lee[3,4], Paul-Eric Pottie[3], and Harald Schnatz[5] — [1]NPL, Teddington, UK — [2]LPL, Universite Paris 13, Villetaneuse, France — [3]LNE-SYRTE, Observatoire de Paris, UPMC, Paris, France — [4]KRISS, Daejon 305-340, South Korea — [5]PTB, Braunschweig, Germany

Comparing independently built optical clocks is the main way of benchmarking this rapidly developing technology. Comparisons between different National Metrology Labs have traditionally employed satellite links which, however, lack the stability and accuracy needed for optical clocks. Optical frequency transfer through long-haul fibre links enables comparisons between remotely located optical clocks with a transfer stability and accuracy much better than state-of-the art clocks.

The London-Paris optical frequency fibre link has been established to compare the optical clocks developed at NPL and SYRTE. It utilizes around 800 km of commercial telecommunication fibre with 10 bidirectional optical amplifiers (EDFAs) installed at regular intervals.

Our setup employs a novel hybrid topology which combines conventional active fibre noise compensation and two-way technology. We present details of the link implementation and characteristics, along with results from initial optical clock comparisons campaigns.

Together with the link between France and Germany, the London-Paris link will allow simultaneous comparisons of multiple remote clocks and chronometric levelling between the UK and Europe.

Q 31.40 Tue 17:00 P OGs

Evaluation of a sub-hertz cavity for an ^{27}Al$^+$ optical frequency standard — •Lennart Pelzer[1], Stephan Hannig[1], Johannes Kramer[1], Nils Scharnhost[1], Steven King[1], and Piet O. Schmidt[1,2] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [2]Leibniz Universität Hannover, 30167 Hannover

We present a 39.5 cm long ULE cavity for the stabilisation of a 1070 nm laser. After two frequency doubling stages, the light will probe the ^{1}S$_0$ $\leftrightarrow$ ^{3}P$_0$ clock transition of a trapped Al$^+$ ion, which has a natural linewidth of $2\pi\times$ 8 mHz. To achieve the necessary level of stability to resolve such a narrow transition, environmental perturbations to the cavity length have to be minimised. A long ULE spacer together with mirrors having a large radius of curvature suppresses the contribution of Brownian thermal noise, which poses the most fundamental limit to the achievable stability, to an estimated fractional level of 7×10^{-17}. Especially for such a long cavity spacer, vibration-induced deformations have to be cancelled by exploiting symmetries in the spacer. The evaluation of stability-limiting effects shows the progress in suppressing all relevant noise sources below the thermal noise limit.

Q 31.41 Tue 17:00 P OGs

Enhancing the sensitivity of single photon recoils in spectroscopy with non-classical states — •Marius Schulte[1], Niels Lörch[2], Piet. O. Schmidt[3,4], and Klemens Hammerer[1] — [1]Institute for Theoretical Physics and Institute for Gravitational Physics (Albert-Einstein-Institute), Leibniz University Hannover, Callinstrasse 38, 30167 Hannover, Germany — [2]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [3]QUEST Institut, Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [4]Institute for Quantum Optics, Leibniz University Hannover, Welfengarten 1, 30167 Hannover, Germany

The sensitivity in measuring displacements in phase space based on absorbed photons in spectroscopy is discussed. Non-classical squeezed states, cat states and small linear combinations of Fock states are shown to result in an enhancement of sensitivity, compared to the ground state of motion. A theoretical model gives the dynamics of photon recoil spectroscopy in terms of a Fokker-Planck equation thereby including incoherent processes allowing to compare the stability of spectroscopy states with respect to additional diffusion. This also predicts Doppler effects leading to systematic shifts in the observed resonance frequency. Limitations on the sensitivity based on imperfect state preparation and the attainable quantum Fisher information are discussed.

Q 31.42 Tue 17:00 P OGs

Aufbau eines hochstabilen Einzel-Ionen-Mikroskop — •Felix Stopp[1], Georg Jacob[1], Karin Groot-Bering[1], Mark Keil[2], Ron Folman[2] und Ferdinand Schmidt-Kaler[1] — [1]QUANTUM, Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]Atom Chip Group, Dept. of Physics, Ben-Gurion University of the Negev, 84105 Be'er Sheva, Israel

Einzelne lasergekühlte Ionen, die deterministisch aus einer linearen Paulfalle extrahiert werden können, erlauben eine neuartige Methode der Mikroskopie mit einer räumlichen Auflösung von wenigen Nanometer [1]. Die aktuell experimentell erreichte Fokusgröße von 6 nm ist durch mechanische Vibrationen und thermische Drifts im Aufbau begrenzt. Wir diskutieren die Konstruktion eines Aufbaus, in dem ein kompaktes, hochstabiles Fallen- und Ionenlinsendesign zur Anwendung kommen wird. Dazu wird der Teilchenstrahl in kurzen Entfernungen über der zu analysierenden Oberfläche fokussiert und nach der Wechselwirkung in einem Detektor registriert. Weiterhin geplant ist, das Ion nach der Wechselwirkung erneut einzufangen und seinen Quantenzustand zu detektieren. Dies ermöglicht Energieverlustspektroskopie mit Ionen, die nah über zu untersuchende Oberflächen gelenkt werden. Das Ion dient so als Sonde von elektrischen und magnetischen Feldern, bzw. zur Untersuchung von nano- und mikro-strukturierten Proben.

[1] Jacob et al., Phys. Rev. Lett. **117**, 043001 (2016)

Q 31.43 Tue 17:00 P OGs

Superresolving Imaging of arbitrary Arrays of Thermal Light sources in the Visible using Multiphoton Interferences — •Anton Classen[1,2], Felix Waldmann[1], Sebastian Giebel[1], Raimund Schneider[1,2], Daniel Bhatti[1,2], Thomas Mehringer[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

Measuring higher-order photon correlations is an emerging technique in the field of imaging to overcome the classical resolution limit [1-4]. We propose to use higher-order spatial photon cross-correlations measured in the far field of statistically independent thermal light sources (TLS) to reconstruct arbitrary two-dimensional TLS source geometries. The technique generalizes an earlier imaging scheme which resolves one-dimensional source arrangements with sub-Abbe resolution [4]. By choosing specific detector positions the technique allows to sequentially isolate the spatial frequencies of the sample within different correlation orders, enabling us to retrieve the source distribution with increased accuracy. We present experimental data verifying the theoretical predictions and discuss the conditions under which sub-Abbe resolution is achieved. [1] Oppel et al., Phys. Rev. Lett. 109 233603 (2012); [2] T. Dertinger et al., Q. Rev. Biophys. 46, 210 (2013); [3] D. G. Monticone et al., Phys. Rev. Lett. 113, 143602 (2014); [4] A. Classen et al., accepted for publication in Phys. Rev. Lett.

Q 31.44 Tue 17:00 P OGs

Cryogenic ion trap apparatus for quantum information processing with ^{9}Be$^+$ ions — •Fabian Ude[1], Timko Dubielzig[1], Sebastian Grondowski[1], Henning Hahn[2,1], Giorgio Zarantonello[2,1], Martina Wahnschaffe[2,1], Armado Bautista-Salvador[2,1], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-technische-Bundesanstalt Braunschweig

We report on a cryogenic ion trap apparatus for quantum information processing and quantum simulation experiments with ^{9}Be$^+$ ions in surface-electrode ion traps. The ion trap is cooled by a vibration isolated closed cycle cryostat to reduce the detrimental effect of anomalous motional heating. We characterize the vibration isolation using a Michelson interferometer and find residual vibration amplitudes <20 nm 0-pk. We report on the setup of the cryogenic shields and thermal management for bringing in a large number of DC and RF control signals. We present the trap RF drive based on a miniaturized cryogenic helical resonator and discuss its performance.

Q 31.45 Tue 17:00 P OGs

Establishing gate fabrication for advanced multi-layer SiGe Quantumdots — •Philip Schrinner[1,3], Arne Hollmann[1], Tim Leonhardt[1], Stefan Trellenkamp[2], and Lars Schreiber[1] — [1]JARA Institute for Quantum Information, RWTH Aachen University, Germany — [2]Peter Grünberg Institute (PGI-8), FZ Jülich, Germany — [3]Center for Nanotechnology, Westfälische Wilhelms-Universität Münster, Germany

Electron spin qubits in electrostatically defined Si/SiGe quantum dots combine excellent coherence times (T2* = 1 mu s [1]), small feature size and CMOS compatibility and therefore promise to be an excellent candidate for a scalable semiconductor based universal quantum computer. In comparison to previous fabrication layouts an advanced multi-layer gate design has been shown to further decrease the number of gates per qubit, the size of the gate pattern, charge noise and gate cross-coupling [2,3]. My work focuses on the development of such fabrication technology by isolating three expected fabrication challenges and address them with the fabrication of corresponding test structures. I will present methods to fabricate an array of sub 30 nm wide gates with a sub 70 nm pitch, electrically isolated by a few nano-meter thick oxide layer and the alignment precession of gate layers with respect to each other. As a result, I will give all the required ingredients to fabricate multi-layer quantum dot gate patterns for multi-qubit devices. [1] E. Kawakami et al., Nature Nano-tech. 9, 666 (2014). [2] G. Borselli et al., Nanotechnology 26, 375202 (2015). [3] D. M. Zajac et al., Appl. Phys. Lett. 106, 223507 (2015).

Q 31.46 Tue 17:00 P OGs

Cooling and Reset of a Superconducting Qubit using Quantum Optimal Control — •Daniel Basilewitsch[1], Rebecca Schmidt[2], Sabrina Maniscalco[2], Dominique Sugny[3,4], and Christiane Koch[1] — [1]Theoretical Physics, University of Kassel,

Kassel, Germany — [2]Turku Center for Quantum Physics, University of Turku, Turku, Finland — [3]Laboratoire Interdisciplinaire Carnot de Bourgogne, CNRS-Université de Bourgogne, Dijon, France — [4]Institute for Advanced Study, Technical University of Munich, Garching, Germany

The requirement of fast and accurate initialization of qubits into known initial states is one important key for the realization of quantum information processing tasks. Our approach is to achieve cooling of a superconducting qubit by means of controlled coupling to an auxiliary qubit, in order to use the auxiliary qubit as entropy sink. Using optimal control theory (OCT), we show that the maximal fidelity and minimal time for realizing this fidelity depend on the initial state of the bipartite system consisting of primary and auxiliary qubit. When starting from a factorized state, the maximal fidelity is determined by the initial purity of the auxiliary qubit, while the minimal time is limited my the coupling strength. In case of correlated initial states this limit can be exceeded when allowing for time-dependent controls on the primary qubit. This shows that correlations can be exploited for resetting the qubit.

Q 31.47 Tue 17:00 P OGs

Experimental analysis of decoherence mechanisms in a single-atom memory for photonic qubits — •Stefan Langenfeld, Matthias Körber, Olivier Morin, Andreas Neuzner, Stephan Ritter, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany

Quantum memories can preserve qubits for an extended duration. In combination with the capability to map photonic qubits into and out of the memory, this has important applications in quantum computation and communication. To improve on achievable coherence times, a thorough understanding of the relevant decoherence mechanisms is indispensable. Our system consists of a single atom trapped in a two-dimensional optical lattice in a high-finesse cavity [1]. The qubit is initially stored in a superposition of Zeeman states, making magnetic field fluctuations the dominant decoherence mechanism. We reduce the magnetic field induced decoherence by transferring the qubit into a decoherence-free subspace. Here, the coherence time is no longer limited by magnetic field noise, but by differential light shifts of the new qubit states. We will discuss how this new limitation can be overcome and which future steps can be taken to further increase the coherence time.

[1] H. Specht et al., Nature 473, 190 (2011).

Q 31.48 Tue 17:00 P OGs

Carving of atomic Bell states with a cavity — •Bastian Hacker, Stephan Welte, Severin Daiss, Stephan Ritter, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Entangled pairs of atoms are ideal for the study of fundamental quantum correlations and as a resource for many tasks in quantum information processing. At the node of an optical quantum network they can be applied for local information processing tasks, and, when strongly coupled to flying qubits, as a resource for more complex network operations. Our experiment applies the technique of quantum state carving to create entangled states of two rubidium atoms trapped in one optical cavity. The cavity strongly couples both atoms to the field of a reflected light pulse and thereby allows us to perform projective measurements on the combined two-atom state that can lead to maximally entangled states in a heralded fashion. Using coherent qubit control and several protocols we demonstrate the creation of all four Bell states. Dependence on experimental parameters will be discussed. Our entangled atoms in a cavity are an ideal starting point for applications like entanglement distribution, distributed quantum computing or a quantum repeater.

Q 31.49 Tue 17:00 P OGs

Entangled Photon Pair source — •Oleg Nikiforov and Thomas Walther — AG Laser und Quantenoptik, Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt, Germany

Quantum Key Amplification (QKA) offers information-theoretical security for communication superior to the majority of contemporary classical key distribution and amplification schemes. An entangled photon pair source is being set up for the QKA experiment “Quantum Key Hub“ within the Collaborative Research Center CROSSING at TU Darmstadt.

The energy-time entangled photons at telecommunication wavelengths will be used for entanglement-based QKA protocols and should obtain high coherence length. Therefore transform limited pulses are created at the 1550 nm wavelength using an fiber amplifier [1]. Then, after second harmonic generation in an PPLN crystal, the converted light pulses lead to creation of entangled photon pairs via spontaneous parametric down conversion of type II in a PPKTP crystal [2]. The current experimental status is discussed.

[1] K. Schorstein and T. Walther. “A high spectral brightness Fourier-transform limited nanosecond Yb-doped fiber amplifier”. Applied Physics B 97 (2009), pp. 591-597.

[2] E. Keller, and M. H. Rubin. ”Theory of two-photon entanglement for spontaneous parametric down-conversion driven by a narrow pump pulse“. Physical review. A 56.2 (1997): 1534-1541.

Q 31.50 Tue 17:00 P OGs

An FPGA based detection system for QKA — •Stefan Schürl, Kai Roth, Oleg Nikiforov, and Thomas Walther — AG Laser und Quantenoptik, Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt, Germany

Quantum Key Amplification (QKA) offers information-theoretical security for communication superior to the majority of contemporary classical key distribution and amplification schemes. Alice and Bob modules are being designed for the QKA experiment “Quantum Key Hub“ within the Collaborative Research Center CROSSING at TU Darmstadt.

In order to evaluate timing statistics of photon pair incidents, we present a modified version of the board designed by J.K.Peters [1]: an inexpensive FPGA-based 4 channel system for timing aquisition of TTL signals with an enhanced timing resolution of under 500 ps. This resolution is achieved by creating additional clocks using built in phase-lock loops. The current experimental status is discussed.

[1] J. K. Peters, S. V. Polyakov, A. L. Migdall, and S. W. Nam, “Simple and inexpensive FPGA-based fast multichannel acquisition board”; https://www.nist.gov/services-resources/software/simple-and-inexpensive-fpga-based-fast-multichannel-acquisition-board (2015).

Q 31.51 Tue 17:00 P OGs

Towards single neutral atoms in crossed fiber cavities — •Dominik Niemietz, Manuel Brekenfeld, Joseph Dale Christesen, Stephan Ritter, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Cavity quantum electrodynamics provides a rich toolbox for the investigation of fundamental phenomena in quantum physics with intriguing applications in quantum information processing. The coupling rate between the cavity light mode and a single emitter, e.g., a neutral atom trapped in the cavity, is inversely proportional to the square root of the mode volume. Limits imposed by traditional manufacturing processes of the cavity mirrors were overcome with the introduction of fiber cavities [1], where fiber end facets are machined by means of CO_2 laser ablation. Besides small mode volumes and therefore larger coupling rates, fiber cavities also allow for new cavity geometries due to their smaller dimensions. We are currently setting up a new apparatus consisting of two crossed fiber cavities, coupling independently two light modes to one single atom. This constitutes an important step towards the realization of a spatially and functionally integrated quantum repeater [2]. We will present the current status and future plans for our apparatus including fabrication results of elliptical and spherical fiber mirrors.

[1] D. Hunger *et al.*, New J. Phys. **12**, 065038 (2010)
[2] M. Uphoff *et al.*, Appl. Phys. B **122**, 46 (2016)

Q 31.52 Tue 17:00 P OGs

Towards cavity-enhanced spectroscopy of single ions in a crystal — •Natalie Wilson, Benjamin Merkel, and Andreas Reiserer — Max Planck Institute of Quantum Optics, Garching, Germany

A future quantum network will consist of quantum nodes that are connected by optical photons, allowing users to perform tasks and interact in ways that are not possible with current technology. In this context, rare-earth-ion doped crystals have recently emerged as a promising platform. In contrast to other impurities, these ions can exhibit telecommunication-wavelength transitions between inner shells which are well-decoupled from the crystal and therefore protected from decoherence. However, because of the narrow linewidth of these transitions, spectrally resolving individual ions is challenging.

In this work, we propose a method to overcome this challenge by embedding rare-earth-ion doped crystals into optical resonators. Because of the Purcell effect, the narrow linewidths will be broadened, and photon emission will efficiently be channelled into the resonator output mode, leading to a dramatically enhanced fluorescence signal. This might enable studies of the crystalline environment of individual ions with the goal to harness them for the implementation of quantum networks and repeaters.

Q 31.53 Tue 17:00 P OGs

Towards quantum optical experiments with silicon vacancy color centers in diamond at millikelvin temperatures — •David Gross, Jonas Nils Becker, Carsten Arend, Pavel Bushev, and Christoph Becher — Fakultät NT (FR Physik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany

The search for a solid state spin-photon-interface for quantum communication applications allowing for efficient entanglement generation as well as long distance communication is a challenging task. Showing very narrow-band emission and all-optical coherent control, the silicon vacancy center (SiV) in diamond is a promising candidate for such an interface. However, the ground state coherence time of the SiV is limited to 35-45 ns by phonon-mediated processes, whereas pure spin-relaxation times in the millisecond regime have been reported. Therefore, by supressing phonon-induced decoherence, large spin coherence times can potentially be reached, rendering the SiV an ideal system for efficient long-distance quantum communication. We here present design and first experiments with a confocal microscope setup placed in a dilution refrigerator allowing full optical access at temperatures in the mK range. This enables the measurement of the SiV's coherence properties beyond the phonon limited regime and potentially paves the way for future quantum information processing experiments using SiV centers requiring long coherence time scales.

Q 31.54 Tue 17:00 P OGs

RF-Spektroskopie von $^{40}Ca^{+}$-Kristallen — •Jens Welzel, Felix Stopp und Ferdinand Schmidt-Kaler — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz

Der Zeemangrundzustand $S_{1/2}$ in einfach geladenem Kalzium spaltet in einem homogenen Magnetfeld in die Zustände $m = +\frac{1}{2}$ und $-\frac{1}{2}$ auf. Wir verwenden eine planare Ionenfalle für einzelne gespeicherte Ionen oder Ionenkristalle und arbeiten bei einer Energieaufspaltung der Zeemanzustände von 9,3 MHz. Zunächst wird der Zustand der Ionen durch optisches Pumpen in $m = -\frac{1}{2}$ initalisiert. Radiofrequenz wird nahe der Resonanz eingestrahlt und anschließend der Zustand der Ionen nach einem Transfer von $m = -\frac{1}{2}$ in den metastabilen $D_{5/2}$ Zustand, gefolgt von laserinduzierter Fluoreszenz, nachgewiesen. Wir berichten von Kohärenzmessungen und der Verbesserung der Spinkohärenz durch Echosequenzen. Stromdurchflossene Leiter, integriert in der Ionenfalle, erlauben einen magnetischen Gradienten von $(16,7 \pm 0,8)\ \frac{\mathrm{T}}{\mathrm{m}}$ in radialer Richtung [1]. Wir beobachten Seitenbandanregungen für einzelne Ionen mit $\eta = (1,2 \pm 0,4) \cdot 10^{-3}$, ebenso wie Seitenbandspektren für lineare Kristalle nahe der Zickzackinstabilität [2].

[1] Welzel, J. et al. Eur. Phys. J. D **65**, 285–297 (2011).
[2] Kaufmann, H. et al. PRL **109**, 263003 (2012).

Q 31.55 Tue 17:00 P OGs

Single trapped ions for Rydberg quantum logic — Patrick Bachor[1,2], •Justas Andrijauskas[1,2], Jochen Walz[1,2] und Ferdinand Schmidt-Kaler[1] — [1]Institut für Physik, Universität Mainz, Staudinger Weg 7, D-55128 Mainz — [2]Helmholtz-Institut Mainz, D-55099 Mainz

The excitation of cold trapped single ions into Rydberg states enables new possibilities in quantum information and non-equilibrium physics. The interplay between Coulomb and Rydberg interactions motivates several proposals for fast multi-qubit gate operations, novel many-body phenomena such as hexagonal plaquette spin-spin interactions, and the driving of fast structural phase transitions in ion crystals.

In our experiment linear crystals made up from $^{40}Ca^{+}$ ions in a linear segmented Paul trap are used. We excited the $52F$, $53F$ [1] and the $22F$ [2] Rydberg states using a single photon vacuum-ultraviolet excitation near 122.042 nm, 122.032 nm and 123.256 nm wavelengths, respectively. To move towards quantum logic, we recently implemented coherent initialization into different $3D_{5/2}$ Zeeman states, sideband ground state cooling and local addressing of single ions for the excitation into the Rydberg state.

[1] T. Feldker et al., Phys. Rev. Lett. 115 (2015) 173001
[2] P. Bachor et al., J. Phys. B. 49 (2016) 154004

Q 31.56 Tue 17:00 P OGs

Analytical tools for investigating strong-field QED processes in tightly focused laser fields — Antonino Di Piazza and •Alessandro Angioi — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

The computation of QED rates in intense laser fields is typically performed within the plane-wave approximation [1], although the high intensities considered in most calculations are only reachable in planned facilities by tightly focusing the laser energy not only in time but also in space. A novel approach [2], based on the assumption that the energy of the involved charged particles is the largest dynamical energy scale in the problem, allows to relax this hypothesis and paves the way for the calculation of QED processes in fields with generic spatiotemporal structure. Here we will show the practical feasibility of this method for two elementary QED processes, namely nonlinear Breit-Wheeler pair production [3] and nonlinear Compton scattering. The rates for these processes show significant quantitative deviations with respect to the analogous results in a plane wave, and the corresponding results could be important for the design of experiments aiming at measuring these processes.

[1] A. Di Piazza et al., *Rev. Mod. Phys.* **84**, 1177 (2012).
[2] A. Di Piazza, *Phys. Rev. Lett.* **113**, 040402 (2014).
[3] A. Di Piazza, *Phys. Rev. Lett.* **117**, 213201 (2016).

Q 31.57 Tue 17:00 P OGs

Casimir Force and Heat Transfer between Topological Insulators — •Sebastian Fuchs[1], Frieder Lindel[1], Mauro Antezza[2], and Stefan Buhmann[1] — [1]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [2]Université de Montpellier, Montpellier, France

Due to broken time-reversal symmetry, topological insulators may show very interesting optical properties [1]. This leads to the possibility of switching between an attractive and a repulsive Casimir-Polder potential between a topological insulator and an atom [2]. Motivated by these findings, we investigate theoretically the Casimir pressure between two infinitely extended topological insulators. Moreover, it stands to reason to study the heat transfer for such a setup in case of two different temperatures. Thus we want to establish a connection with a recent study of persistent heat currents between three topological insulators at the same temperature [3].

[1] J. A. Crosse, Sebastian Fuchs, and Stefan Yoshi Buhmann, Phys. Rev. A 92, 063831 (2015)
[2] Sebastian Fuchs, J. A. Crosse, Stefan Yoshi Buhmann, arxiv: 1605.06056
[3] Linxiao Zhu, Shanhui Fan, Phys. Rev. Lett. 117, 134303 (2016)

Q 31.58 Tue 17:00 P OGs

Quantum Friction with Hyperbolic Structures — •Marty Oelschläger[1,2], Francesco Intravaia[1], and Kurt Busch[1,2] — [1]Max-Born-Institut, 12489 Berlin, Germany — [2]Institut für Physik, Humboldt Universität zu Berlin, 12489 Berlin, Germany

One crucial difference between classical and quantum physics is the concept of vacuum, which in the quantum description is not empty but pervaded by roiling fluctuations. These give rise to a plethora of phenomena of which the best known are van der Waals/Casimir-Polder forces. Recently, there has been a resurgent and growing interest in non-equilibrium fluctuation-induced phenomena and in particular in quantum-friction. Unlike the classical case quantum friction does not involve any contact between the objects and the force is mediated by the interaction with the vacuum fluctuations of the quantum electromagnetic field. Importantly, vacuum is not immutable and its structure can be modified with solids and nano-structures. In this work we consider quantum friction between an atom moving at constant velocity parallel to the surface of a hyperbolic material made of alternating metallic and insulating layers. We investigate the behaviour of the frictional force as function of the atomic velocity and of the distance from the surface and compare them with the expressions for the non-structured system. Special attention is paid to the role of widely used treatments based on the Markov, the local thermal equilibrium and/or the effective medium approximation.

Q 31.59 Tue 17:00 P OGs

Atom Position Control — •Karl Nicolas Tolazzi, Christoph Hamsen, Tatjana Wilk, and Gerhard Rempe — Max Planck Institute of Quantum Optics, Hans-Kopfermann-Straße 1, 85748 Garching

A strongly coupled single-atom-cavity system is well suited to implement quantum nonlinear optics at the single-photon level. In order to achieve strong coupling with a constant and reproducible coupling strength, the single atom must be well positioned within the cavity mode. In our experiment the atom is held inside the cavity in a three dimensional optical lattice that is formed by a blue-detuned intracavity standing wave together with a blue and a red transverse standing wave. Fluorescence light that is emitted during cooling of the atom is collected by a high numerical-aperture objective and detected on a camera. With a single 2 dimensional (2D) image, the 3D position of the atom can be determined using the out-of-focus blur to assess the out-of-plane direction. This allows for measuring the position and extent of the vacuum cavity mode in three dimensions by probing the atom-cavity coupling via normal-mode spectroscopy and post-selecting on specific atom positions. As the standing waves of the transverse traps are movable due to piezo elements on the retroreflecting mirrors, we are able to control the atom position via feedback. The knowledge of the atom position with respect to the cavity mode and the ability to shift and stabilize its position grant a high and constant coupling strength between them over many experimental cycles and is here shown by reaching an average coupling strength close to the theoretical value.

Q 31.60 Tue 17:00 P OGs

Fiber Fabry-Perot cavities fabrication for cavity quantum electrodynamics experiments — •Michael Kubista, Seyed Alavi, Wolfgang Alt, Jose Gallego, Tobias Macha, Miguel Martinez-Dorantes, Deepak Pandey, Lothar Ratschbacher, Eduardo Urunuela, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn

Fiber Fabry-Perot cavities (FFPC), formed by micro-machined mirrors on the end-facets of optical fibers [1], are used in an increasing number of technical and scientific applications. Here, we present the fabrication process of the micro mirrors and two different approaches to construct FFPC: a piezo-mechanically actuated cavity with feedback based on the Pound-Drever-Hall locking technique and a novel rigid cavity design that makes use of the high passive stability of a monolithic cavity spacer and employs thermal self-locking and external temperature tuning [2]. Furthermore, we discuss effects specific to FFPC such as Raman scattering and asymmetric line shapes. Finally, we present our latest results regarding imaging and strong coupling of small ensembles of 87Rb neutral atoms to one of our fiber cavities.

[1] D. Hunger, et al N. J. Phys. 12, 065038 (2010). [2] Gallego, J. et al. Appl. Phys. B (2016)

Q 31.61 Tue 17:00 P OGs

Excitons in WS2 coupled to a Microcavity — •Christian Gebhardt[1], Michael Förg[1], Hanno Kaup[1,2], Thomas Hümmer[1,2], Hisato Yamaguchi[3], Theodor Wolfgang Hänsch[1,2], Alexander Högele[1], and David Hunger[1,2] — [1]Ludwig-Maximilians Universität München Faculty of Physics, Schellingstr. 4/III, D-80799 München, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [3]Center for Integrated Nanotechnologies, Materials Physics and Applications Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA

Two-dimensional atomic crystals of transition metals dichalcogenides have come to be a recent field of interest due to their attractive optoelectronic properties. In the scope of this work we investigate the excitons in monolayer tungsten disulphide (WS2) coupled to a microcavity. Due to high exciton binding energies and a strong oscillator strength it is possible to observe collective strong coupling of excitons and photons at room temperature. In our experiment we use a tunable open-access cavity with one curved mirror and one planar mirror on top of which WS2 is placed. This type of setup allows to control the spatial separation of both cavity mirrors and thus to vary the exciton-photon coupling in situ. Furthermore, the mirrors define a stable, micron-scale cavity mode, which can form a potential for the exciton polaritons and thus lead to interaction effects. We observe polaritons in our setup which show spatial variation of the Rabi splitting energy on the monolayer sheets. We report on the current state of the experiment.

Q 31.62 Tue 17:00 P OGs

Superradiance of Classical Fields via Projective Measurements — •Daniel Bhatti[1,2], Steffen Oppel[1], 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, 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, USA

We study the state evolution of the fields produced by classical sources, when recording intensity correlations of higher order in a generalized Hanbury Brown and Twiss setup [1]. Apart from an offset, we find that the angular distribution of the last detected photon is identical to the superradiant emission pattern generated by an ensemble of two-level atoms in entangled symmetric Dicke states. As a consequence, we demonstrate that the Hanbury Brown and Twiss effect, originally established in astronomy to determine the dimensions or distances of stars, and Dicke superradiance, commonly observed with atoms in symmetric Dicke states, are two sides of the same coin. We show that the phenomenon derives from projective measurements induced by the measurement of photons in the far field of the sources and the permutative superposition of quantum paths identical to those leading to superradiance in the case of single photon emitters [2].

[1] D. Bhatti, et al., Phys. Rev. A 94, 013810 (2016).
[2] R. Wiegner, et al., Phys. Rev. A 92, 033832 (2015).

Q 31.63 Tue 17:00 P OGs

Backwards Master Equation — •Jonas Lammers[1,2] and Klemens Hammerer[1,2] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Leibniz Universität Hannover

The evolution of a quantum system undergoing continuous measurements is governed by the so-called conditional stochastic master equation. Using the past measurement record, it predicts the state of the system at a given time. We develop a method which allows to verify that state by *retrodiction*, using the future measurement record to compute the backwards evolution of the system.

We derive the stochastic backwards evolution equation of a quantum optical system using only basic quantum mechanics. The conditions on the system are very general so as to make the formalism applicable to a wide range of different setups. As an application, we examine how a Gaussian state evolves in a linear system, and compute the backwards equations of motion of its first and second moments. More concretely, we consider a one-dimensional harmonic oscillator under continuous position measurements coupled to a thermal bath. The proposed procedure allows to affirm the presence of desired properties such as entanglement or other non-classical features in a past quantum state, or even its whole density matrix.

Q 31.64 Tue 17:00 P OGs

Wavefront propagation study concerning the influence of non-ideal mirror surfaces inside a split-and-delay unit on the focusability of XFEL-pulses — •Victor Kärcher[1], Sebastian Roling[1], Liubov Samoylova[2], Karen Appel[2], Harald Sinn[2], Frank Siewert[3], Ulf Zastrau[2], and Helmut Zacharias[1] — [1]Westfälische-Wilhelms-Universität Münster, Wilhelm-Klemm Str. 10, 48149 Münster — [2]European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld — [3]Helmholtz-Zentrum für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin

For the High Energy Density (HED) instrument at the SASE2 - Undulator at European XFEL an x-ray split-and-delay unit (SDU) is built covering photon energies from $h\nu = 5\,\mathrm{keV}$ up to $h\nu = 24\,\mathrm{keV}$. 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. In order to reach intensities on the order of $10^{15}\,\mathrm{W/cm^2}$ the XFEL pulses will be focused by means of compound refractive lenses (CRL) to a diameter of $\mathrm{D} = 24\,\mu\mathrm{m}$. The influence of wavefront disturbances caused by height- and slope-errors of the mirrors inside the SDU on the quality of the two focused partial beams is studied by wavefront propagation simulations using the WPG-framework.

Q 31.65 Tue 17:00 P OGs

An XUV and soft X-ray split-and-delay unit for FLASH II — •Dennis Eckermann[1], Sebastian Roling[1], Matthias Rollnik[1], Marion Kuhlmann[2], Elke Plönjes[2], Frank Wahlert[1], and Helmut Zacharias[1] — [1]Physikalisches Institut, WWU Münster, Wilhelm-Klemm Straße 10, 48149 Münster — [2]Deutsches Elektronen Synchrotron, Notkestraße 85, 22607 Hamburg

An XUV and soft X-ray split-and-delay unit is built that enables time-resolved experiments covering the whole spectral range of FLASH II from $h\nu = 30$ eV up to 2500 eV. With wave front beam splitting and grazing incidence angles a maximum delay of - 6 ps < Δt < +18 ps will be possible with a sub-fs resolution. Two different coatings are required to cover the complete spectral range. Therefore, a design that is based on the three dimensional beam path of the SDU at BL2 at FLASH has been developed which allows choosing the propagation via two sets of mirrors with these coatings. A Ni-coating will allow a total transmission on the order of T = 55 % for photon energies between 30 eV and 600 eV at a grazing angle $\theta = 1.8°$ in the variable delay line. In the fixed delay line the grazing angle is set so $\theta = 1.3°$. With a Pt-coating a transmission of T > 13 % will be possible for photon energies up to 1500 eV. For a future upgrade of FLASH II the grazing angle can be changed to $\theta = 1.3°$ in order to cover a range up to $h\nu = 2500$ eV.

Q 31.66 Tue 17:00 P OGs

A split-and-delay unit for the European XFEL: Enabling hard x-ray pump/probe experiments at the HED instrument — •Marco Butz[1], Sebastian Roling[1], Karen Appel[2], Stefan Braun[3], Peter Gawlitza[3], Harald Sinn[2], Frank Wahlert[1], Ulf Zastrau[2], and Helmut Zacharias[1] — [1]Physikalisches Institut, WWU Münster, Wilhelm-Klemm Straße 10, 48149 Münster, Germany — [2]2European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld, Germany — [3]3Fraunhofer Institut IWS, Winterbergstraße 28, 01277 Dresden, Germany

For the High Energy Density (HED) instrument at the SASE2 - Undulator at the European XFEL an x-ray split-and-delay unit (SDU) is built covering photon energies from hν = 5 keV up to hν = 24 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 x-ray FEL pulses are split by a sharp edge of a silicon mirror (BS) coated with Mo/B_4C and W/B_4C multilayers. Both partial beams then pass variable delay lines. For different wavelengths the angle of incidence onto the multilayer mirrors will be adjusted in order to match the Bragg condition. Because of the different incidence angles, the path lengths of the beams will differ as a function of wavelength. Hence, maximum delays between ±1.0 ps at hν = 24 keV and up to ±23 ps at hν = 5 keV are possible.

Q 31.67 Tue 17:00 P OGs

A cavity-enhanced single photon source using the silicon vacancy center in diamond — •Julia Benedikter[1,2], Hanno Kaupp[1,2], Christoph Becher[3], Theodor W. Hänsch[1,2], and David Hunger[1,2,4] — [1]Ludwig-Maximilians-Universität München, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Universität des Saarlandes, Saarbrücken, Gemany — [4]Karlsruher Institut für Technologie, Karlsruhe, Germany

Single photon sources are an integral part of various quantum information applications, and quantum emitters in the solid state at room temperature appear as a particularly promising implementation. We couple the fluorescence of individual silicon vacancy centers in nanodiamonds to a tunable optical microcavity to demonstrate a single photon source with increased efficiency, higher brightness, and improved spectral purity compared to the intrinsic emitter properties. We use a fiber-based microcavity with a mode volume as small as $3.4\lambda^3$ and a quality factor of 1.9×10^4 and observe an effective Purcell factor up to 9, and lifetime changes by up to 31%, limited by the finite quantum efficiency of the particular emitters studied here. With the availability of improved materials, our achieved parameters predict up to 1GHz single photon rates, and device efficiencies above 90%.

Q 31.68 Tue 17:00 P OGs

Towards single NV centers in nanostructures as probes for optical near fields — •Alexander Meyer, Richard Nelz, Michel Challier, Selda Sonusen, Ettore Bernardi, and Elke Neu — Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken

Single nitrogen vacancy (NV) color centers in nanostructured diamond are photostable dipoles, forming single photon sources. Since the excited state lifetime depends on the environment of the NV, it is possible to detect environmental changes via lifetime imaging. The hereby gathered information reveals the quantum efficiency of NV centers in these nanostructures [1]; a parameter highly crucial for the usability of NV centers as probes for optical near fields. As a way to change the environment and simultaneously measure the excited state lifetime, we use a home-built combination of an atomic-force and a confocal microscope. We here present preliminary results of proof-of-principle experiments to analyze the quantum efficiency of shallow NV centers in single-crystal nanostructures.

[1] Mohtashami and Koenderink, New J. Phys. **15** 043017 (2013)

Q 31.69 Tue 17:00 P OGs

Optical Antennas for Color Centers in Diamond — •Philipp Fuchs[1], Thomas Jung[1], Hossam Galal[2], Mario Agio[2], Xiao-Liu Chu[3], Stephan Götzinger[3], and Christoph Becher[1] — [1]Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken — [2]Universität Siegen, Laboratorium für Nano-Optik, Walter-Flex-Str. 3, 57072 Siegen — [3]Friedrich-Alexander-Universität Erlangen-Nürnberg, Department Physik, 91058 Erlangen

Color centers in diamond, especially the nitrogen and the silicon vacancy center, have become very promising candidates for the implementation of stationary qubits and bright single photon sources. One of the most challenging problems when working with these defects is the low collection efficiency of the photoluminescence photons out of unstructured diamond films. Because of total internal reflection at the diamond-air-interface, this problem cannot be solved simply by using high NA objectives and the collection efficiency is usually limited to a few percent. Here, we show two new approaches to increase this efficiency by precisely controlling the color centers' dielectric environment. The considered structures are based on thin diamond membranes fabricated via reactive ion etching. Combining the thin membrane with a planar antenna structure allows for creation of tailored radiation patterns, leading to a high directivity and thereby high collection efficiency for all emitters in the membrane at the same time. A radiating dipole in such structures can be calculated analytically, which allows for computer-aided optimization of the structure.

Q 31.70 Tue 17:00 P OGs

Nanofabrication of Optimized Diamond Scanning Probe — •Michel Challier[1], Richard Nelz[1], Philipp Fuchs[1], Julia Purtov[2,3], Ettore Bernardi[1], Selda Sonusen[1], René Hensel[3], and Elke Neu[1] — [1]Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken — [2]Universität des Saarlandes, Fakultät NT - Fachrichtung Materialwissenschaft und Werkstofftechnik, Campus E1.3, 66123 Saarbrücken — [3]INM - Insititut für neue Materialien GmbH, Campus D2.2, 66123 Saarbrücken

Nitrogen vacancy (NV) color centers in diamond represent highly-coherent, atomic-sized spin systems with optical spin read-out and photostable fluorescence. To harness their full potential as magnetic and near field sensors, single NVs have to be incorporated into nanophotonic structures. We focus on fabricating scanable single crystalline diamond nanowires on thin ($< 1\,\mu m$) platforms generating probes with high spatial resolution and NV fluorescence. Using numerical methods, we optimized the pillar shapes. Thin membranes, platforms and pillars are created using inductively coupled plasma reactive ion etching, direct laser writing lithography and electron beam lithography. We optimize all process steps in comparison to previous work [1].

[1] Patrick Appel, Elke Neu, Marc Ganzhorn, Arne Barfuss, Marietta Batzer, Micha Gratz, Andreas Tschöpe and Patrick Maletinsky, Rev. Sci. Instrum. 87, 063703 (2016)

Q 31.71 Tue 17:00 P OGs

Robust Silicon-Vacancy Single Photon Sources — •Assegid Mengistu Flatae[1,2], Francesco Tantussi[2], Stefano Lagomarsino[1], Gabriele Messina[2], Hossam Galal[1], Ahmad Mohammadi[3], Francesco De Angelis[2], and Mario Agio[1] — [1]Laboratory of Nano-Optics, University of Siegen, 57072 Siegen, Germany — [2]Italian Institute of Technology, 16163 Genova, Italy — [3]Department of Physics, Persian Gulf University, 75196 Bushehr, Iran

In quantum information science and in fundamental quantum optics a robust narrow-band solid-state single-photon source is desirable. We currently develop techniques for the fabrication and optical characterization of single photon-sources based on the silicon vacancy (SiV) in diamond. SiV color centers are promising candidates as most of the fluorescence signal is concentrated in a narrow zero-phonon line at 738 nm, with a room temperature line-width down to about - 1 nm. In addition, the center exhibits a short excited-state life-time (~ 1 ns) and a very small inhomogeneous broadening. The photonic environment around the single SiV color center can be exploited to control the radiative rate, the quantum efficiency, the angular distribution and the polarization of the emitted photons. Plasmonic gold nano-antennas are particularly interesting for these purposes, as they can achieve a much smaller mode volume in the confined near field (~ 7 orders of magnitude tighter than solid-state micro-cavities) and can easily match the emission wavelength of the emitter due to their broad Plasmon resonances. We design, fabricate and characterize gold nano-antennas for enhancing the emission properties of Siv color centers.

Q 31.72 Tue 17:00 P OGs

Optical investigation of color centers in nanodiamonds — •Andrea Kurz[1], Olaf Zimmermann[1], Valery Davydov[2], Viatchselav Agafonov[3], Lachlan Rogers[1], Fedor Jelezko[1], and Alexander Kubanek[1] — [1]Institute for Quantum Optics, Ulm University, D-89081 Ulm, Germany — [2]Institute for High Pressure Physics, Russian Academy of Science, Moscow, Russia — [3]Greman, Université F. Rabelais, Tours, France

Over the last decade color centers in diamond have proven to be promising candidates for quantum optics applications [1]. For applications like sensing or cQED it is advantageous to use color centers in nanodiamonds (NDs). However these color centers often exhibit inferior optical qualities compared to bulk diamonds. Although for example spectral properties for silicon vacancies centers have recently been improved dramatically [2], issues like blinking and spectral defusion remain.

Therefore investigating the optical properties for color centers in NDs is an important goal. We are testing methods to increase their optical and coherence properties. The analysis is done with confocal spectroscopy at room and cryogenic temperatures. In the future we aim to incorporate these color center in NDs into cQED experiments.

[1] F. Jelezko, J. Wrachtrup, Phys. Stat. Sol. 203, Issue 13, 2006

[2] U. Jantzen et. al., NJP, Vol. 18, 2016

Q 31.73 Tue 17:00 P OGs

Double-resonant Cavity-enhanced Raman Spectroscopy of Carbon Nanotubes — •Thomas Hümmer[1,2], Theodor W. Hänsch[1,2], and David Hunger[3,1,2] — [1]Ludwig-Maximilians-Universität München, Deutschland — [2]Max-Planck Institut für Quantenoptik, Garching, Deutschland — [3]Karlsruher Institut für Technologie, Karlsruhe, Deutschland

We use a tunable high-finesse optical microcavity[1] to demonstrate Purcell enhancement of Raman scattering in combination with high-resolution scanning-cavity imaging[2]. We detect cavity-enhanced Raman spectra[3] of individual single-walled carbon nanotubes and co-localize measurements with cavity-enhanced absorption microscopy. By using a double resonance of the cavity, where both the excitation light and the Raman-scattered light is simultaneously resonant with a high finesse cavity mode, we expect signal enhancements by four orders of magnitude. We report on the current status of the experiment and explain it with the help of free candy.

[1] Hunger et al., NJP 12, 065038 (2010) [2] Mader et al., Nat Commun 6, 7249 (2015) [3] Hümmer et al Nat Commun 7, 12155 (2016)

Q 31.74 Tue 17:00 P OGs

A supercontinuum source in the extreme ultraviolet using HHG with an OPA system — •Julius Reinhard[1], Martin Wünsche[1,2], Silvio Fuchs[1,2], Jan Nathanael[1,2], Jakob Abel[1], Christian Rödel[1,3], and Gerhard Paulus[1,2] — [1]Institute of Optics and Quantum Electronics, Friedrich-Schiller-University Jena, Germany — [2]Helmholtz Institute Jena, Germany — [3]SLAC, USA

We present a supercontinuum source in the extreme ultraviolet (XUV) using high harmonic generation (HHG) driven by a table-top femtosecond laser and a tunable optical parametric amplifier. The near-infrared (NIR) pulses from the OPA generate the harmonic radiation. Usually the spectrum of the HHG is a comb with maxima at the odd multiples of the fundamental frequency. By averaging over different harmonic comb spectra with slightly different fundamental frequencies a continuous XUV spectrum in the range of 30 to 200 eV is realized [1]. For this, the driving laser wavelength from the OPA is swept automatically during the recording of the XUV spectrum and the supercontinuum is generated within a few seconds. The supercontinuum XUV source with a photon flux up to 3×10^8 photons per eV's is well suited for applications like near-edge absorption fine structure spectroscopy (NEXAFS) [2] or XUV coherence tomography (XCT) [3] and marks an important step for realizing such applications in small-scaled laboratories.

[1] M. Wünsche et al., Optics Express, submitted (2016)

[2] J. Stöhr, NEXAFS spectroscopy, Springer Series in Surface Science, Vol. 25 (2013)

[3] S. Fuchs et al., Scientific Reports 6, 20658 (2016)

Q 31.75 Tue 17:00 P OGs

Picosecond Fiber Amplifiers in a MOPA System for Laser Cooling of Relativistic Ion Beams — •Daniel Kiefer, Christian Kühnel, and Thomas Walther — TU-Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schlossgartenstr. 7, 64289, Darmstadt

Laser cooling of relativistic ion beams has been demonstrated and shown to be a sophisticated technology with achievable low relative momentum spreads [1]. White-light-cooling was proposed as a method to help minimize particle loss due to intra beam scattering (IBS) processes [2] and has been demonstrated for fast stored ion beams [3]. To obtain the required spectral width for laser cooling of relativistic ion beams at GSI (ESR) and FAIR (SIS100, HESR), we plan to use pulsed laser light. A cw MOPA system in combination with acousto-optical and electro-optical modulation provides laser pulses of 50 ns or 70 to 740 ps with a center wavelength of 1030 nm [4]. An efficient fourth harmonic generation process to 257.5 nm demands high peak intensities. Two cascaded fiber amplifiers are used to enhance the energy of the pulses. The setup is chosen so that the amplifier stages work properly for the different pulse lengths covering three orders of magnitude. We show the performance of the amplifiers with regard to power and spectrum. Furthermore, the current status of the experiment will be presented. [1] U. Schramm et al, Proceedings of (2005) Particle Accelerator Conference [2] R. Calabrese, Hyperfine Interactions 99, 259-265, (1996) [3] S. N. Atutov et al, Phys. Rev. Lett. 80, 2129, (1998) [4] D. Kiefer et al, GSI Scientific Report 2015, DOI:10.15120/GR-2016-1

Q 31.76 Tue 17:00 P OGs

SHG in Periodically Poled Lithiumniobate for a CW Laser System used for Cooling of Relativistic Ion Beams — •Sebastian Klammes, Daniel Kiefer, and Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser- und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Laser cooling has become an additional method for increasing the phase space density of ion beams in storage rings [1]. In order to reduce the emittance of the circulating ion beam, suitable conditions must be fulfilled, e.g. radiation of a specific wavelength and an appropriate power must be provided. To this end a fast tunable cw laser system with two SHG enhancement cavities has been developed in the past to achieve the correct wavelength for ion beam cooling [2]. In 2012, the cw laser system was successfully used for cooling C^{3+}-ions [3]. Further developments of the cw laser system led to the replacement of the first enhancement cavity with a magnesium oxide doped periodically poled $LiNbO_3$ (MgO:PPLN) crystal. Observations and experiences with the MgO:PPLN crystal will be presented. Additionally, the latest results and the current status will be featured. [1] U. Schramm and D. Habs. Crystalline ion beams. Progress in Particle and Nuclear Physics 53 (2004), 583-677. [2] T. Beck, B. Rein, F. Sörensen and T. Walther. Solid-state-based laser system as a replacement for Ar^+ lasers. Opt. Lett. 41, 4186-4189 (2016) [3] T. Beck. Lasersystem zur Kühlung relativistischer C^{3+}-Ionenstrahlen in Speicherringen. Dissertation. TU Darmstadt (2015).

Q 31.77 Tue 17:00 P OGs

Spektroskopie von Nd^{3+}-, Ho^{3+}- und Tm^{3+}-dotierten Sesquioxiden im mittleren infraroten Spektralbereich — •Patrick von Brunn[1,2], Alexander M. Heuer[1,2] und Christian Kränkel[1,2] — [1]Institut für Laser-Physik, Universität Hamburg — [2]The Hamburg Centre for Ultrafast Imaging

Laser im mittleren infraroten Spektralbereich sind aufgrund ihrer starken Absorption in Wasser hervorragend geeignet für medizinische Anwendungen, die eine hohe Präzision erfordern. Seltenerd-dotierte Sesquioxide eignen sich besonders als aktive Materialien für derartige Laser. Ihre geringe Phononenenergie führt zu niedrigen nichtstrahlenden Zerfallsraten und ihre hohe Wärmeleitfähigkeit ermöglicht Laserbetrieb bei hohen Ausgangsleistungen. Hier berichten wir über die spektroskopische Analyse verschiedener Seltenerd-dotierter Sesquioxide bis in den mittleren infraroten Spektralbereich. Für Nd^{3+}-, Ho^{3+}- bzw. Tm^{3+}-dotiertes Lu_2O_3 wurden die Absorptionswirkungsquerschnitte und Fluoreszenzspektren sowie die Lebensdauern der beteiligten angeregten Niveaus bestimmt. Die Absorptionswirkungsquerschnitte wurden für Ho^{3+}- und Tm^{3+}-dotiertes Lu_2O_3 im zum optischen Pumpen geeigneten Wellenlängenbereich von 400 nm bis 2200 nm bestimmt. Für die Emissionsmessungen wurde das Messintervall auf den Wellenlängenbereich bis 4,4 μm ausgeweitet. Die Resultate weisen auf potentielle Laserübergänge im Bereich von 4,1 μm und 2,9 μm für Ho^{3+}:Lu_2O_3 sowie 2,6 μm für Tm^{3+}:Lu_2O_3 hin; entsprechende Laserexperimente sind in Planung.

Q 31.78 Tue 17:00 P OGs

Two-color spectroscopy for laser stabilization to the ytterbium 1S0-3P1 intercombination line — •Laura Sucke, Christian Halter, Tobias Franzen, Bastian Pollkesenser, Mustafa Jumaah, Cristian Bruni, and Axel Görlitz — Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Deutschland

We present a scheme for frequency stabilization of multiple lasers that are resonant with different transitions and originating from a common ground state. For the detection of weaker transitions we are harnessing the high signal to noise ratio provided by a strong transition. Doppler reduced spectroscopy is performed on an atomic beam by detecting the fluorescence of a strong dipole allowed transition. Individual error signals for this transition as well as additional weaker transitions are recovered from the strong fluorescence signal using lock-in techniques. We demonstrate the application to the strong 1S0-1P1 transition and the 1S0-3P1 intercombination line of ytterbium. We show data on the stability of this locking technique by comparing two identical spectroscopy setups

Q 31.79 Tue 17:00 P OGs

The Gauss-Newton algorithm for light scattering on transparent cylinders — •Gunnar Claussen[1,2], Werner Blohm[1], and Armin Lechleiter[2] — [1]Fachbereich Ingenieurwissenschaften, Jade Hochschule Wilhelmshaven Oldenburg Elsfleth — [2]Zentrum für Technomathematik, Universität Bremen

We aim to determine the diameter of a glass fiber under perpendicular incidence of plane-wave light and treat this question as an inverse scattering problem, which is solvable through an iteratively regularized Gauss-Newton algorithm. Within each step of the algorithm, the expression $||F'[q_n^\delta]h_n + F(q_n^\delta) - u_\infty^\delta||_{L^2}^2 + \alpha_n||h_n + q_n^\delta - q_0||_s^2$ is minimized. This term includes the measured far-field pattern u_∞^δ, the data-to-pattern operator $F(\cdot)$, i.e. the formalism given by the Mie theory for cylinder scattering, and its Fréchet derivate $F'(\cdot)$, the parameter vector q_n^δ and its alteration h_n within the current step of the iteration. The algorithm terminates once the residual $||F(q_n^\delta) - u_\infty^\delta||$ becomes sufficiently small. However, it turns out that for transparent cylinders the residual forms a complex "landscape" in the parameter-space that is characterized by a number of false minima, thereby hindering the correct execution of the algorithm. We introduce a novel variation of the Gauss-Newton algorithm which allows to skip these minima in order to reach the global minimum, allowing us to determine the cylinder diameter with a precision several magnitudes smaller than the incident wavelength λ. We will present the performance of this algorithm in terms of precision, running time, experimental applicability and tolerance towards variations of fixed parameters.

Q 31.80 Tue 17:00 P OGs

Brillouin-LIDAR zur Messung von Temperaturprofilen im Ozean — •David Rupp[1], Sonja Friman[1], Andreas Zipf[1], Charles Trees[2] und Thomas Walther[1] — [1]TU Darmstadt, Institut für Angewandte Physik, 64289 Darmstadt — [2]CMRE, 19126 La Spezia, Italien

Wir entwickeln ein flugtaugliches LIDAR-System zur Messung von Wassertemperaturen im Ozean. Das LIDAR-System soll es ermöglichen, Temperaturprofile bis zu 100 m Tiefe bei einer Ortsauflösung von 1 m in quasi Echtzeit zu ermitteln. Mit Hilfe von mehreren Faserverstärkerstufen erzeugte Laserpulse mit einer Pulsdauer von 10 ns und einer Repetitionsrate von 1 kHz werden frequenzverdoppelt, sodass das ins Wasser eingestrahlte Licht dann eine Wellenlänge von 543 nm hat, abgestimmt auf den Detektor. Die Temperaturinformation wird aus der spektralen Verschiebung des rückwärtig Brillouin-gestreuten Lichts gewonnen. Der Detektor besteht im Wesentlichen aus einem atomaren Absorptionsfilter, der das elastisch gestreute Licht eliminiert und einem atomaren Kantenfilter (ESFADOF), beide auf Rubidium basierend. Der Kantenfilter hat eine von der spektralen Verschiebung abhängige Transmission, welche gemessen und einer Temperatur zugeordnet wird. Im Labor wurde die Funktion des Systems bereits demonstriert und bei einem ersten Feldtest untersucht. Die Funktionsweise des Systems, einige Ergebnisse, bereits durchgeführte und zukünftige Verbesserungen werden vorgestellt.

Q 31.81 Tue 17:00 P OGs

Untersuchung spektraler Eigenschaften von Brillouin-Streuung in Abhängigkeit von Temperatur und Salzgehalt in Wasser — •Andreas Zipf, David Rupp, Julius Wessolek und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, 64289 Darmstadt

Kontaktlose und ressourcenschonende Methoden zur Messung von Temperaturprofilen des Ozeans und dessen Salinität sind mittels LIDAR möglich. Die Anwendung der Systeme vereinfacht die Datenakquise unter Meeresbiologen, Ozeanographen und Meteorologen. In unserer Arbeitsgruppe wird hierfür zur Zeit an einem System gearbeitet, das mit Hilfe von Brillouin-Streuung beide Messparameter in bis zu 100 m Tiefe ortsaufgelöst ermitteln kann. Hierzu wird ausgenutzt, dass sowohl die spektrale Verschiebung, als auch die spektrale Breite der Brillouin-Streuung von Temperatur und Salzgehalt abhängen.

Insbesondere ist dabei die genaue Kenntnis dieser Abhängigkeiten von Bedeutung. In einem selbst angefertigten Test-Aufbau werden Daten der Brillouin-Streuung bei 530 nm an Wasser verschiedener Salzgehalte gewonnen und mit Hilfe eines Fabry-Perot-Interferometers näher untersucht. Ziel ist es, mit Hilfe der gewonnenen Daten die Entwicklung einer zuverlässigen Detektoreinheit für den gepulsten Betrieb bei 543 nm zu erleichtern.

Aufgezeigt werden die aktuellen Erkenntnisse sowie die nächsten Entwicklungsschritte.

Q 31.82 Tue 17:00 P OGs

Generation and characterization of tunable and shapeable few-optical-cycle mid infrared pulses — •Daniel Gerz[1], Nick Paul[1], Cristian Manzoni[2], Giulio Cerullo[2], and Marcus Motzkus[1] — [1]PCI, Ruprecht-Karls-Universität, D-69120 Heidelberg, Germany — [2]Dipartimento di Fisica, Politecnico Milano, I-20133 Milano, Italy

The generation of short (<20fs), broadband, mid infrared (MIR) pulses in a robust manner still remains a significant challenge in various spectroscopic fields. Such pulses can be utilized for a number of different applications, including sub-gap electronic states and coherent control of small molecules. In order to promote major advancements in such fields, development of new, easy to use MIR sources is a must.
In this work, we present a two stage non-collinear parametric amplifier to be used for the generation of few-optical-cycle pulses with center wavelengths ranging from 2.9-3.3 μm and powers in the order of few μW [1].These pulses are then compressed and shaped using a germanium based acousto-optic modulator shaper. The aim is to readily shape such pulses into multipulse sequences which could be applied in multidimensional IR spectroscopy, or as a source of precisely tailored MIR push/dump pulses for 1D 3^{rd} order (or higher) spectroscopies [2]. The pulse characterization is performed with a cross-correlation frequency resolved optical gating (XFROG) setup, which upconverts the MIR into the visible regime for easy and accurate detection.
[1] Brida, D. et al., Opt. Lett. 33, 2901-2903 (2008).
[2] Shim, S.-H. et al., Phys. Chem. Chem. Phys. 11, 748-761 (2008).

Q 31.83 Tue 17:00 P OGs

Selektives Ätzen fs-lasergeschriebener 3D-Mikrostrukturen in kristallinem Y3Al5O12 — •Kore Hasse[1,2], Christian Kränkel[1,2] und Thomas Calmano[1,2] — [1]Institut für Laser-Physik, Universität Hamburg — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg

Mittels fs-Laserstrukturierung ist es möglich 3D-Materialmodifikationen in der Größenordnung von wenigen μm in transparenten dielektrischen Materialien zu erzeugen. Zudem ist die Ätzrate fs-lasermodifizierter kristalliner Materialien wie Y3Al5O12 (YAG) in Phosphorsäure deutlich höher als diejenige des unstrukturierten Materials. Daher können durch fs-Laserstrukturierung und nachfolgendes Ätzen Mikrokanäle in Kristallen wie YAG hergestellt werden, die in mikrofluidischen und optischen Systemen Anwendung finden können. Wir berichten über die Ergebnisse einer systematischen Untersuchung der Ätztiefe in Abhängigkeit von der Ätzdauer in H3PO4 (85%) von fs-lasergeschriebenen Einzelspuren in [111] orientiertem YAG. Dabei wurden sowohl der Einfluss der Strukturierungsparameter, wie auch derjenige der Temperatur der Säure untersucht. Mit durchschnittlichen Ätzraten von bis zu 2,6 μm/h konnten mehr als 4 mm lange Mikrokanäle mit einem Aspektverhältnis (Länge zu Durchmesser) von bis zu 400 geätzt werden.

Q 31.84 Tue 17:00 P OGs

Study of electron photoemission from a tungsten nanotip triggered by ultrashort laser pulses with photon energies from UV to mid-IR — •Ang Li, Martin Kozak, Joshua McNeur, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

Electron photoemission from metallic nanotips is employed in various applications that require high brightness bunched electron beams. Such applications include ultrafast electron microscopy and diffraction [1] as well as the operation of dielectric laser accelerators [2]. The latter is based on micron-scale dielectric nanostructures driven by the high peak field of short laser pulses and has been experimentally demonstrated [3,4]. This acceleration technique requires excellent electron beam quality in order to obtain an efficient acceleration without high losses of electron current. In this contribution we report on a recent experimental study of electron photoemission from tungsten nanotips triggered by the ultrashort laser pulses with photon energies ranging from UV to mid-IR. Further, the observation of transition between single- and multiphoton photoemission is discussed along with the regime of light-induced tunneling process. We focus on the role of Coulomb repulsion in the regime of more than one emitted electron per laser pulse.

[1] A. H. Zewail et al., 4D Electron Microscopy: Imaging in Space and Time (Imperial College Press, London, 2010).
[2] J. England et al., Rev. Mod. Phys. 86, 1337 (2014).
[3] J. Breuer et al, Phys. Rev. Lett. 111, 134803 (2013).
[4] E. A. Peralta et al., Nature 503, 91-94 (2013).

Q 31.85 Tue 17:00 P OGs

Controlling metal nanotip shapes for application in laser triggered electron emission via dynamic electrochemical etching — •Philipp Hofmann, Alexander Tafel, Jürgen Ristein, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

Ultra sharp tips are essential for nanometer probe techniques such as scanning tunneling microscopy (STM) and are powerful tools for studying strong field physics due to field enhancement at the tip apex. Simulations [1] have shown that large opening angles of approximately 15° for gold and 40° for tungsten nanotips result in maximum optical field enhancement. Static two electrode etching setups, widely used for their simplicity, lack reproducibility and the tip opening angle cannot be influenced. Additionally, important process parameters such as temperature and etching potential are not accurately controlled. In our new setup, an Arduino Mega 2560 regulates and monitors all relevant etching parameters. The electrochemical potential is measured by a reference electrode and the tip shape can be influenced with a dynamic mechanism. Our setup, tested with tungsten, is designed to be easily adoptable to a wide range of tip materials.

[1] Sebastian Thomas et al., 2015 New J. Phys. 17 063010.

Q 31.86 Tue 17:00 P OGs

Towards a PDC source at NIR wavelengths in a single-mode Rb:PPKTP waveguide — •Christof Eigner, Laura Padberg, Matteo Santandrea, Raimund Ricken, Helge Rütz, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Parametric down conversion (PDC) is a well-established process for the generation of non-classical states and single photons. Especially PDC sources that emit in the visible and near-infrared (NIR) are highly attractive for quantum cryptography due to the possibility of low cost Silicon avalanche detection as well as possible coupling to ion traps. Realizing such a source in periodically poled potassium titanyl phosphate (PPKTP) waveguides permits to deploy high pump intensities because of the high damage resistance of the material and at the time allows to harness the potential of integrated optical circuitry.

Producing the rubidium exchanged PPKTP waveguides ourselves allows us to tailor the waveguide properties and apply specifically designed poling patterns. Here, we discuss our approach to manufacture single-mode waveguides in KTP in the NIR at 800 nm. Moreover, we present the current status of our PDC source for the generation of photon pairs in this wavelength regime.

Q 31.87 Tue 17:00 P OGs

Performance improvement of an SPDC source using time-multiplexing — •Marcello Massaro, Harald Herrmann, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Spontaneous Parametric Down-Conversion (SPDC) sources are widely used in quantum optics to produce single photon states used in various experiments and quantum information protocols. One major limitation of such sources is the noise due to multi-photons contributions when one tries to pump them in order to increase the generation rate. These sources are also limited intrinsically due to the physical process that governs them.

We show here that is possible to improve the performance of such sources by using a time-multiplexing scheme or a feed-forward protocol, in order to push the production rate towards the physical limit or even overcome it completely.

Q 31.88 Tue 17:00 P OGs

Weak meassurement of a rotated mode function — •Sabrina Hartmann, Joachim Fischbach, and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We present a complete quantum optical description of a Mach-Zehnder interferometer, including a Dove prism, which is rotated by a small angle compared to the plane of incidence [1]. The Dove prism changes polarization and rotates the mode function in one arm of the interferometer. We can then postselect photons at the output via polarization and identify a weak value in the correlation function of first order. This allows us to weakly measure the angle, by which the mode function was rotated. Furthermore, we evaluate this interferometric set-up for specific non-classical states.

[1] O.S. Magaña-Loaiza, M. Mirhosseini, B. Rodenburg and R.W. Boyd, *Physical Review Letters*, **112**, 200401 (2014).

Q 31.89 Tue 17:00 P OGs

Towards a feedbacked down-conversion source for large complex quantum states — •Melanie Engelkemeier, Regina Kruse, Linda Sansoni, Sonja Barkhofen, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

In order to realise large photonic quantum states in large networks, we implement a PDC source in a feedback loop to generate time-multiplexed states. By the stimulated generation of photons, the probability to generate photon pairs is increased. We present the source design of a periodically poled KTP crystal [1] and simulations of the setup to outline losses and the stimulation in the system. Furthermore, we will investigate the possibilities to generate complex time-bin correlated states.

[1] Harder, et al., Opt. Exp. 21, 13975-13985 (2013)

Q 31.90 Tue 17:00 P OGs

Quantum signatures in time-domain interferometry — Salvatore Castrignano and •Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The aim of this project is to improve an interferometric scheme proposed in 1997 by A. O. Baron [1]. In this scheme a sample to be studied is placed between two radiation-filtering foils and X-ray radiation, resonant with the Mössbauer nuclei transition, impinges on the whole system. The analysis of sample's internal dynamics is possible through detection of the scattered radiation , in particular the Fourier transform S(q,t) of the dynamical couple-correlation function for the sample G(r,t) can be obtained.

The latter function is a real or complex valued function according to the classical or quantum nature of the measured dynamics [2][3]. Therefore some variations of Baron's scheme are proposed which in principle allow to spot the presence of an imaginary part in the function G(r,t).

Moreover the interferogram in the case of a generic quantum target is derived in a fully quantum frame. In particular the dynamics of a bosonic system subject to a double well potential trap is analysed in order to understand what is the meaning of such Im G(r,t) and what kind of information about the quantum state of the system can be extracted out of it.

[1] Phys. Rev. Lett. 79, 2823
[2] Phys. Rev. 95, 249
[3] Physica 24, 404

Q 31.91 Tue 17:00 P OGs

Velocity Distribution Compression for Electron Beams with

Laser Fields — •Moritz Carmesin[1], Maxim A. Efremov[1], and and Wolfgang P. Schleich[1,2] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQ^{ST}), Universität Ulm, Albert-Einstein-Allee 11, 89081 Ulm, Germany — [2]Texas A & M University Institute for Advanced Study (TIAS), Institute for Quantum Science and Engineering (IQSE), and Department of Physics and Astronomy, Texas A & M University, College Station, Texas 77843-4242, USA

Various applications such as electron microscopy or the free-electron laser require electron beams with a narrow velocity distribution. In order to control its width, we suggest to use the scattering of the electrons off two counter-propagating light waves generating a one-dimensional ponderomotive potential.

Within non-relativistic classical mechanics, we find that it is indeed impossible to decrease the width of a homogeneous distribution of the initial positions. In contrast, it is possible to compress the velocity distribution for an electron beam with a modulated initial distribution.

This work is supported by the German-Israeli Cooperation (DIP). W.P.S. is grateful to Texas A&M University for a Texas APM University Institute for Advanced Study (TIAS) Faculty fellowship.

Q 31.92 Tue 17:00 P OGs

Multi-Photon Information Processing — •Johannes Seiler[1] and Vincenzo Tamma[2] — [1]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany — [2]University of Portsmouth, Portsmouth, PO1 3QL

We propose a new approach towards quantum information processing using multi-photon interferometers with thermal as well as non-classical light sources. The emergence of a second-order interference effect which takes advantage of the correlation between specific interferometer paths with each other is demonstrated in [1]. This effect could be experimentally useful for simulations of small-scale quantum circuits and applications in high-precision metrology and imaging. Furthermore, we present a general formalism to describe the correlation function of an arbitrary multi-photon interferometer. The obtained structure allows an interpretation in terms of bipartite graphs, giving both a great insight into the physics of such setups, as well as enabling reverse engineering of those.

[1] V. Tamma and J. Seiler, *New J. Phys.* 18(3):032002, 2016

Q 31.93 Tue 17:00 P OGs

Integration of photonic structures and thermal atomic vapors — •Robert Löw[1], Ralf Ritter[1], Harald Kübler[1], Nico Gruhler[2], Wolfram Pernice[3], and Tilman Pfau[1] — [1]5. Physikalisches Institut und IQST, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen — [3]Institute of Physics, University of Münster, Heisenbergstr. 11, 48149 Münster

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, frequency references 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. Furthermore, the existing fabrication technology of photonic circuits allows for complex networking and multiplexing designs, potentially even at the single photon level. We report on the status of our work on various photonic structures integrated into a rubidium vapor cell. Specifically, we present our results on combining the atomic medium with Mach Zehnder interferometers [1], ring resonators [2] and slot waveguides. As the atoms are probed in close proximity to the dielectric material, atom-surface interactions and transit time effects play a substantial role.

[1] R. Ritter et al., Appl. Phys. Lett. 107, 041101 (2015).
[2] R. Ritter et al., New J. Phys. 18 103031 (2016).

Q 31.94 Tue 17:00 P OGs

Loading Chromophores into Thin Film Metal Organic Frameworks: Guest-Born Carboxylic Groups Facilitate Dye Incorporation. — •Nicolò Baroni[1], Andrey Turshatov[1], Michael Oldenburg[1], Michael Adams[1], Alexander Welle[2], Engelbert Redel[2], Christof Wöll[2], Bryce S. Richards[1,3], and Ian A. Howard[1] — [1]IMT, KIT, Eggenstein-Leopoldshafen — [2]IFG, KIT, Eggenstein-Leopoldshafen — [3]LTI, KIT, Karlsruhe

Imparting optoelectronic function to surface-anchored metal-organic framework (SURMOF) thin films by loading guest molecules into their porous structures expands the portfolio of applications for which these materials are relevant. In this study, we examine the loading behavior of porphyrin dyes in the SURMOF-2 structures based on Zn metal centers and 1,4-benzenedicarboxylate linkers. Loading is attempted for porphyrin dyes metallated with Pd, Pt, and Zn. For each metalation, the loading behavior of dyes with and without carboxylic pendant groups is compared. The loading procedure is a simple drop-casting, followed by rinse after drying to remove surface-deposited dyes. Using time of flight second ion mass spectroscopy, we demonstrate that the dyes with carboxylic pendant groups penetrate through the whole SURMOF film. We also present a study of the optical properties of the SURMOFs incorporating the guest porphyrin dyes. Examining the steadystate, timeresolved, absorption and emission properties of the system, we find that the guest molecules can interact within the pores leading aggregate behavior to dominate the optical properties. Also,a longlived emission from the unloaded SURMOF itself is observed.