Q 11: Poster: Quantum Optics and Photonics I

Time: Monday 16:30–19:00 Location: Empore Lichthof

Q 11.1 Mon 16:30 Empore Lichthof

Towards an atomic erbium Bose-Einstein condensate generated in a quasistatic dipole trap — •Daniel Babik, Jens Ulitzsch, Henning Brammer, Roberto Röll, and Martin Weitz — Institut für Angewandte Physik, Wegelerstraße 8, 53115 Bonn

We report on progress in an ongoing experiment directed at the generation of an atomic Bose-Einstein condensate of erbium atoms in a quasistatic optical dipole trap. In alkali atoms with their S-ground state configuration in far detuned laser fields with detuning above the upper state fine structure splitting the trapping potential is determined by the scalar electronic polarizability. In contrast for an erbium atomic quantum gas with its $L > 0$ electronic ground state, the trapping potential for inner-shell transitions also for far detuned dissipation-less trapping laser fields becomes dependent on the internal atomic state (i.e. spin). Therefore it is expected to reach much longer coherence times with atomic erbium in spin-dependent optical lattice experiments and for far detuned Raman manipulation in comparison with alkali atoms.

In our Bonn experiment an erbium atomic beam is decelerated by a Zeeman-slower using radiation tuned to the strong 400.91 nm transition of atomic erbium. Following work by the Innsbruck group, we then trap erbium atoms in a narrow-line magneto-optical trap using the atomic transition at 582.84 nm. In the next experimental step, we plan to load erbium atoms into the quasistatic dipole potential generated by a focused beam near 10.6 μm wavelength and here cool atoms evaporatively to quantum degeneracy.

Q 11.2 Mon 16:30 Empore Lichthof

Implementation of lambda-enhanced gray molasses cooling of 87Rb — •Matthias Tarnowski, Benno Rem, Nick Fläschner, Dominik Vogel, Christof Weitenberg, and Klaus Sengstock — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Efficient laser cooling is an important step in all quantum gas machines. Recently, lambda-enhanced gray molasses cooling on the D1 lines was established for various alkali atoms, leading to substantially lower temperatures compared to the common bright molasses on the D2-line. While gray molasses was first explored with Cs and Rb, the efficiency of lambda-enhancement has so far not been demonstrated for these species. Here, we implement this technique for the first time on the F=2 to F'=2 transition of the 87Rb D2 line and find a pronounced temperature decrease around the two-photon resonance with the repumper, which is produced as a sideband by an EOM. We reach significantly lower temperatures than with the bright molasses. Our results show that the efficiency of laser cooling of rubidium can be substantially increased with little expenses.

Q 11.3 Mon 16:30 Empore Lichthof

Gray-molasses cooling of ^{6}Li towards a double degenerate Bose-Fermi mixture of ^{133}Cs and ^{6}Li atoms — •Manuel Gerken, Stephan Häfner, Juris Ulmanis, Eva D. Kuhnle, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

An ultracold Bose-Fermi mixture of ^{133}Cs and ^{6}Li atoms is an ideal system for the study of the heteronuclear Efimov scenario [1,2] as well as the emergence of polarons due to its large mass imbalance and the tunability of atomic interactions via Feshbach resonances [3]. Here we present our approach to gray-molasses cooling on the D1 line of Li which will be newly implemented in our experiment as a further step after doppler-cooling in the MOT. The process will lead to lower temperatures and higher phase space densities and therefore yield better starting conditions for evaporative cooling of Li. By sympathetically cooling the Cs with Li the generation of a double degenerate Bose-Fermi mixture will be possible.

[1] J. Ulmanis et al., arXiv:1509.05585 (2015)
[2] R. Pires et al., Phys. Rev. Lett. 112, 250404 (2014)
[3] R. Pires et al., Phys. Rev. A 90, 012710 (2014)

Q 11.4 Mon 16:30 Empore Lichthof

Integrated cold atom traps based on additive manufacturing — •William Evans, Reece Saint, Yijia Zhou, Mark Fromhold, Ehab Saleh, Christopher Tuck, Ricky Wildman, Mark Hardy, Ian Maskery, Fedja Orucevic, and Peter Kruger — The University of Nottingham, University Park, Nottingham, NG7 2RD, United Kingdom

Research into atom chip based sensors is focused on producing highly sensitive portable instruments that harness and exploit the properties of ultra-cold atoms. These quantum systems can be employed in high precision accelerometers and gyroscopes or within nanotesla sensitive magnetic devices with micrometer resolution. For use in these systems atom chips often require a current carrying 'under-structure' to produce the magnetic fields necessary to trap atoms.

Current systems typically rely on milled or bent wire structures to complete this task but with recent developments in the application of 3D-printing techniques a wide range of possible designs has opened up. With emphasis on reducing power consumption, optimizing the shape of the magnetic field and reducing size we are developing 3D printed structures utilizing additive manufacturing. For this poster we will present the current advances in our approach and our ambitions for the next generation of structures.

Q 11.5 Mon 16:30 Empore Lichthof

Imaging of Single Atoms in a Two-Dimensional State-Dependent Optical Lattice — •Volker Schilling, Stefan Brakhane, Geol Moon, Carsten Robens, Wolfgang Alt, Andrea Alberti, and Dieter Meschede — Institute of Applied Physics, Bonn, Germany

Detecting photons in a large solid angle is crucial for fast imaging in ultra-cold atom experiments. In the quantum technologies group in Bonn, we are currently building up a new experiment containing our in-house built high numerical aperture (NA = 0.92) in-vacuum objective which enables single site resolution of neutral caesium atoms in a two-dimensional state-dependent optical lattice. We prepare single caesium atoms in the lattice at a working distance of 150μm in front of the high-NA objective inside a dodecagonal ultra-low birefringence vacuum glass cell [1]. The high-NA objective is characterised by analysing the fluorescence signal coming from single caesium atoms. The experimental configuration and the state-dependent transport in two independent dimensions is presented. The high-NA imaging system in combination with the two-dimensional state-dependent optical lattice will provide fast image acquisition after simulation of complex physical phenomena, for instance, artificial magnetic fields by means of discrete-time quantum walks in two dimensions.

[1] Stefan Brakhane et. al., *Ultra-low birefringence dodecagonal vacuum glass cell*, Submitted (2015)

Q 11.6 Mon 16:30 Empore Lichthof

Two-dimensional quantum walks in artificial magnetic fields — •Muhammad Sajid, Stefan Brakhane, Wolfgang Alt, Dieter Meschede, and Andrea Alberti — Institute for Applied Physics, wegelerstr. 8, D-53115, Bonn University

Quantum walks hold the prospect to simulate quantum transport and topological effects in solid-state systems and have been realized in various experiments including ultra-cold 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 one-dimensional spin-dependent optical lattices where acceleration of the lattice corresponds to an electric field acting on charged particles [2].

Here we report on a theoretical study of discrete-time quantum walks subject to a magnetic field on a square lattice, which simulates the dynamics of a two-dimensional electronic system in a magnetic field [3]. In particular, I discuss the topological properties of magnetic quantum walks by identifying Chern topological invariants and by demonstrating the existence of topologically protected edge states carrying quantized current at spatial boundaries [4]. In addition, I present an experimental proposal how to realize artificial magnetic fields using neutral atoms in a two-dimensional spin-dependent optical lattice.

[1] M. Karski et al. Science 325, 174 (2009).
[2] M. Genske et al. PRL 110, 190601 (2013).
[3] Pablo Arnault and Fabrice Debbasch, arXiv:1508.00038v3
[4] J. K. Asboth and J. M. Edge, PRA 91, p. 022324 (2015)

Q 11.7 Mon 16:30 Empore Lichthof

Diffusion of Single Atoms in a Bath — •Daniel Adam[1], Farina Kindermann[1], Andreas Dechant[2], Michael Hohmann[1], Tobias Lausch[1], Daniel Mayer[1], Felix Schmidt[1], Eric Lutz[2], and Artur Widera[1] — [1]TU Kaiserslautern, Department of Physics, Kaiserslautern, Germany — [2]Friedrich-Alexander-Universität, Department of Theoretical Physics, Erlangen, Germany

Diffusion processes are a central phenomenon in almost all natural sciences ranging from cell transport in biology over traffic modelling to financial market theory. The typical measured quantity to evaluate the random walk process is the mean squared displacement (MSD). If the MSD increases linearly with the evolution time of the system one assumes normal diffusion and hence implies three well known properties: First the underlying single step distribution is Gaussian, second the system is ergodic, and third the auto correlation function is stationary. Here we engineer a system of a single atom in a periodic potential, which is coupled to a photon bath. The MSD shows normal diffusion for almost all times, but a closer look at the microscopic properties reveals an exponential single step distribution and ergodicity is not reached within timescales large compared to the characteristic timescale of the system. In addition the autocorrelation function shows ageing typically known from glassy materials. A continuous time random walk (CTRW) model with exponential step distribution perfectly fits to our data. Our results may shed light on the microscopic behavior of related biological systems.

Q 11.8 Mon 16:30 Empore Lichthof

Influence of particle distinguishability on coherence phenomena in optical lattices — •Tobias Brünner, Alberto Rodriguez, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Strasse 3, D-79104 Freiburg, Deutschland

Cold, interacting atoms in tilted optical lattices exhibit coherent dynamics, for instance Bloch oscillations in position and momentum space. The influence of interactions between the particles was studied and can generally be associated with a suppression of the coherence phenomena. However, the role of the particle-indistinguishability on this dynamics has not been investigated systematically yet. From many-photon interference experiments we know that the degree of distinguishability has a non-trivial influence on the evolution of the underlying many-particle state, and manifests itself in the outcomes of coincidence measurements. In a similar fashion, we want to identify how and where the indistinguishability can be observed in the dynamics of cold, interacting atoms in tilted optical lattices. As our first step, we compare the spectrum of a Bose-Hubbard Hamiltonian for identical atoms with that of a Hamiltonian describing two distinguishable species. Tuning the degree of distinguishability between the two species allows for an assessment of the 'quantum-to-classical' transition, i.e. the transition from identical bosons to distinguishable particles.

Q 11.9 Mon 16:30 Empore Lichthof

Simulation of magnetic chip traps — •Johannes Battenberg and Reinhold Walser — TU Darmstadt, Deutschland

Trapping magnetizable atoms with magnetic traps is the basic tool to experiments with ultracold atomic gases [1, 2, 3]. In the QUANTUS experiment, which is performed in the drop tower in Bremen (ZARM), the required magnetic field is created by a multi-layer microchip. These multiple current conducting layers provide a multitude of current combinations and offer a variety of different magnetic traps of different shapes, minimum locations and spatial alignments. From the experimental point of view, it is desirable to choose the general trap parameters and look up the required current. Therefore, one needs a simulation to provide this reverse map.

A modular framework was developed in Python to calculate the static magnetic field of the chip. We employ a finite element method using the Biot-Savart-Law. With this tool we can characterize the trap potential and identify key properties like trap frequencies and anharmonicities.

[1] W. Hänsel *et al.*, Bose-einstein condensation on a microelectronic chip, *Nature* **413**, 498–501 (2001)
[2] J. Fortágh and C. Zimmermann, Magnetic microtraps for ultracold atoms, *Rev. Mod. Phys.* **79**, 235–289 (2007)
[3] R. Folman *et al.*, Microscopic atom optics: From wires to an atom chip, *Adv. At. Mol. Opt. Phys.* **48**, 263–356 (2002)

Q 11.10 Mon 16:30 Empore Lichthof

Creation of a superposition of opposite circular states in Rydberg atoms using optimal control theory and quantum Zeno dynamics — •Sabrina Patsch[1], Daniel M. Reich[2], Jean-Michel Raimond[3], and Christiane P. Koch[1] — [1]Universität Kassel — [2]Aarhus University — [3]Collège de France

An alkali Rydberg atom in a circular state has a single valence electron excited to the maximum value of the magnetic quantum number m. Its electronic orbital which is very sensitive to magnetic fields forms a torus similar to the orbit in the classical Bohr model. We attempt to create a superposition of two circular Rydberg states with opposite values of m, a so-called cat state. The creation of such a superposition opens the possibility to build highly precise sensors for measuring magnetic fields.

The central issue is to prevent decoherence during the preparation of the superposition state, given experimental limitations such as those in the setup for quantum Zeno dynamics at the Collège de France [1]. We employ optimal control theory [2] for resonant driving using rf fields combined with microwave fields inducing Zeno dynamics to minimize the time needed to circularise an atom without significant loss of efficiency.

[1] Signoles, A. et al. Confined quantum Zeno dynamics of a watched atomic arrow. *Nature Phys.* 10, 715 (2014).
[2] Reich, D.M. et al. Monotonically convergent optimization in quantum control using Krotov's method. *J. Chem. Phys.* 136, 104103 (2012).

Q 11.11 Mon 16:30 Empore Lichthof

Rydberg quantum optics in ultracold gases — Hannes Gorniaczyk, Christoph Tresp, Ivan Mirgorodskiy, Christian Zimmer, •Asaf Paris-Mandoki, and Sebastian Hofferberth — 5. Physikalisches Institut, Universität Stuttgart, Germany

Mapping the strong interaction between Rydberg excitations in ultracold atomic ensembles onto single photons via electromagnetically induced transparency enables the realization of optical nonlinearities which can modify light on the level of individual photons.

Following previous work [1] in which a single-photon transistor was realized, we investigate the use of an electrically tuned Förster-resonance to improve the transistor performance. The strong amplification of this transistor allows performing fine-structure-resolving spectroscopy of the Förster resonance.

We also present our investigation of anisotropic interaction between individual polaritons coupled to Rydberg D-states. The anisotropy breaks the one-dimensionality of the system even when the propagating light is focussed more tightly than the Rydberg blockade volume. This effect provides an additional tool for engineering photon-photon interaction in a Rydberg system [2].

[1] H. Gorniaczyk, C. Tresp, J. Schmidt, H. Fedder, and S. Hofferberth, "Single Photon Transistor Mediated by Inter-State Rydberg Interaction", Phys. Rev. Lett. 113, 053601 (2014).
[2] C. Tresp, P. Bienias, S. Weber, H. Gorniaczyk, I. Mirgorodskyi, H. P. Büchler, S. Hofferberth, "Dipolar Dephasing of Rydberg D-state polaritons", Phys. Rev. Lett 115, 083602 (2015).

Q 11.12 Mon 16:30 Empore Lichthof

Large bandwith excitation of rydberg atoms in thermal vapor cells — •andy rico, alban urvoy, robert löw, harald kübler, and tilman pfau — 5. Physikalisches Institut, University of Stuttgart, Germany

Over the past years, significant experimental effort has been made towards studying Rydberg atoms in vapor cells. It has given new insight into the fundamental physics of ensemble of Rydberg atoms, as well as opened the door for technical applications, such as MW electric field sensing among others. In most previous studies of Rydberg atoms in vapor cells, attaining a high enough excitation bandwidth was critical to obtain both fast enough excitation dynamics and high Rydberg population. Here we first present new results on the observation of electric field modulation up to several GHz in a cesium vapor cell through Rydberg excitation. The large excitation bandwidth allows here the system to follow the fast modulation. We also discuss the potential and limitations of this scheme as a light modulator. Second, we examine the recently observed optical bistability in a vapor cell [1], which is obtained for high Rydberg population,for different orbital angular momentum states. We investigate this effect in our system and discuss the possible nature of the underlying mechanism.

[1] C. Carr et al., PRL 111, 113901 (2013)

Q 11.13 Mon 16:30 Empore Lichthof

Dynamics of ultracold Rydberg macrodimers — Heiner Saßmannshausen, Frédéric Merkt, and •Johannes Deiglmayr — ETH Zurich, Laboratory of Physical Chemistry, Switzerland

We report on a study of pairwise interactions between Cs atoms excited to $n\text{p}_{3/2}$ Rydberg states of principal quantum numbers in the range $n = 22-36$ [1]. Molecular resonances arising from dipole-dipole and higher long-range-interaction terms between the Rydberg atoms are identified on the basis of their spectral positions, their response to static and pulsed electric fields, and millimeter-wave spectra between pair states. The Rydberg-atom–pair states are found to spontaneously decay by Penning ionization and the dynamics of the ionization process are investigated. To interpret the experimental observations, a potential model was derived that is based on the numerical determination of the eigenvalues and eigenfunctions of the long-range interaction Hamiltonian. With this potential model, which does not include adjustable parameters, all experimental observations could be accounted for, and the results demonstrate that long-range-interaction models provide a global and accurate description of interactions in ultracold Rydberg gases which accounts for phenomena as diverse as the formation of Rydberg macrodimers, Penning ionization in dense Rydberg gases, and Rydberg-excitation blockade effects.

[1] H. Saßmannshausen, F. Merkt, and J. Deiglmayr, Phys. Rev. A 92, 032505 (2015)

Q 11.14 Mon 16:30 Empore Lichthof

Rydberg-dressed interactions in trap loss spectroscopy of ultracold potassium — •Stephan Helmrich, Alda Arias, Nils Pehoviak, Emil Pavlov, Tobias Wintermantel, and Shannon M Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

The introduction of long-range interactions between particles in ultracold atomic gases can give rise to new and exotic phases of matter. Weakly admixing a Rydberg state to ground state atoms (Rydberg dressing) presents one avenue towards realising such interactions. We aim to perform Rydberg dressing of ultracold potassium atoms, utilising a two-photon ladder-transition close to two-photon resonance. A strong cooperative enhancement in interaction strength due to multiphoton and multiatom excitations is theoretically predicted. It allows to externally control both interaction strength and dressed-state lifetime by the Rabi frequencies and the detunings of both laser fields. Furthermore, we will present spectroscopy measurements of trap loss due to interaction effects, which allow us to directly compare theoretical predictions with experimental observations. We will show first signatures of interactions induced through Rydberg dressing, which are the first step towards simulating quantum systems with strong and long-range correlations. This would enable the study of novel pairing mechanisms, supersolidity or new types of superfluidity.

Q 11.15 Mon 16:30 Empore Lichthof

Longitudinally homogeneous medium of tunable length for Rydberg EIT — •Steffen Schmidt, Daniel Tiarks, Giovanni Girelli, Stephan Dürr, and Gerhard Rempe — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

In electromagnetically induced transparency (EIT), an initially opaque medium is made transparent for probe light by applying a strong control beam. As this is a quantum interference effect, it relies on the coherence of the system. In Rydberg EIT, the energy of a Rydberg state depends on the density of the surrounding ground state atoms. If the density of ground state atoms is position dependent, then the density dependent resonance shift causes dephasing which deteriorates the performance of EIT [1]. The transverse inhomogeneity can be made irrelevant by tightly focusing the light. To avoid problems from a longitudinal inhomogeneity, we prepare a longitudinally homogeneous medium by an appropriate design of an optical dipole trap. The trap has the additional feature that the length of the medium is tunable between 20 and 300 μm. A long medium makes it possible to remain at low atomic density, so that the dephasing rate is low, and simultaneously to reach high optical depth, so that the effects of Rydberg blockade can be large.

[1] S. Baur et al. Phys. Rev. Lett. 112, 073901 (2014).

Q 11.16 Mon 16:30 Empore Lichthof

Simulating many-body spin-dynamics with Rydberg atoms — •Renato Ferracini Alves, Miguel Ferreira-Cao, Vladislav Gavryusev, Adrien Signoles, Gerhard Zuern, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Simulating many-body spin-dynamics is of great interest both for its connection to practical systems, such as quantum magnetism, spintronics, and polar molecules [1], as well as for getting a deeper insight in systems driven by a many-body Hamiltonian. In our experiment we realize a Heisenberg XX-model by mapping two dipolar-interacting Rydberg states to two spins states ($|nS\rangle \to |\downarrow\rangle$ and $|nP\rangle \to |\uparrow\rangle$). This scheme allows us to explore the dynamics of spin systems with long range interactions [2].

We will present preliminary results of the measurement of microwave-driven Rabi oscillations between the spin-states, in which interactions lead to damping of the contrast for high Rydberg densities [3]. Also, we describe advanced techniques, such as Ramsey spectroscopy, that will be implemented to investigate further the spin-dynamics.

[1] B. Yan et al., Nature 501, 521-525 (2013)
[2] D. Barredo et al., Phys. Rev. Lett. 114. 113002 (2015)
[3] D. Maxwell et al., Phys. Rev. Lett. 110, 103001 (2013)

Q 11.17 Mon 16:30 Empore Lichthof

Precision two-color spectroscopy of long-range ground-state vibrational levels in ultracold ^{40}Ca — Veit P. Dahlke[1], •Evgenij Pachomow[1], Eberhard Tiemann[2], Fritz Riehle[1], and Uwe Sterr[1] — [1]Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig — [2]Institut für Quantenoptik, Leibniz-Universität Hannover, Welfengarten 1, 30167 Hannover

We have measured the three most weakly bound ground state vibrational levels in the $X^1\Sigma_g^+$ potential of $^{40}Ca_2$, using two-colour photoassociation with different intermediate levels in the $a^3\Sigma_u^+$, $c^3\Pi_g$ exited state potential. We have interrogated cold ensembles of about 10^5 calcium atoms trapped in a crossed dipole trap at temperatures of approximately 1 μK. The unperturbed binding energies have been measured with kHz accuracy benefiting from few Hertz linewidth offset-locked tunable lasers and detailed lineshape analysis.

The interaction potential at typical internuclear separations for these weakly bound levels is dominated by the long range coefficients C_6, C_8 which have been derived using a full quantum computation including information of the inner potential range. Our data also give a precise value for the s-wave scattering length $a = 308(10)a_0$ and is an important step in the implementation of low loss optical Feshbach resonances for alkaline earth metals.

Q 11.18 Mon 16:30 Empore Lichthof

Molecular Beam Setup for Quantum Logic Spectroscopy of single Molecular Ions — •Jan Christoph Heip[1], Fabian Wolf[1], Chunyan Shi[1], and Piet O. Schmidt[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Germany

Molecular ions have a rich level structure and therefore are useful for applications ranging from precision measurements to quantum information processing. Besides the motional degrees of freedom, they exhibit also vibrational and rotational degrees of freedom, rendering direct laser cooling a challenge. We have demonstrated non-destructive rotational state detection and quantum logic spectroscopy in MgH^+ using a co-trapped Mg^+ logic ion [1]. Furthermore, we will present the design of an improved experimental setup including a molecular beam and an RF-Paul-trap with segemented blades. The molecular beam will enable the investigation of a large variety of molecular ions and significantly shorten the time required for preparing a single cold molecular ion.

[1] F. Wolf et al., *Non-destructive state detection for quantum logic spectroscopy of molecular ions*, arXiv:1507.07511 (2015).

Q 11.19 Mon 16:30 Empore Lichthof

Towards ultracold LiK ground-state molecules — •Markus Debatin[1,2], Sambit Pal[2], Mark Lam[2], and Kai Dieckmann[2] — [1]Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Center for Quantum Technologies (CQT), National University of Singapore, Block S15, 3 Science Drive 2,Singapore 117543

Ultracold heteronuclear molecules have seen increasing interest in the scientific community over the last few years [1]. Due to their large electric dipole moment of 3.6 Debye LiK ground-state molecules are particularly suited to investigate the physics of strongly-interacting dipolar quantum gases.

In our experiment [2] we perform spectroscopy on ultracold ^{6}Li^{40}K Feshbach molecules with the aim to create ground-state molecules. Starting with samples of about $3 \cdot 10^4$ ultracold Feshbach molecules we currently investigate transitions mainly to levels close to the asymptote of the $B^1\Pi$ electronic potential. For these levels a good coupling efficiency to the ground state of the $X^1\Sigma^+$ potential is predicted. This will be investigated in the next steps in order to develope a scheme to transfer the Feshbach molecules to the absolute ground state via a simulated Raman adiabatic passage (STIRAP). Our spectroscopy results as well as an update on the current experimental status will be presented.

[1] M. A. Baranov et al. Chem. Rev. 112, 5012-5061, 2012 [2] A.-C. Voigt et al. Phys. Rev. Lett. 102, 020405, 2009

Q 11.20 Mon 16:30 Empore Lichthof

High resolution imaging system for experiments on degenerate NaK — •Roman Bause[1,2], Frauke Seesselberg[1], Nikolaus Buchheim[1], Zhenkai Lu[1], Immanuel Bloch[1,2], and Christoph Gohle[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany — [2]Ludwig-Maximilians-Universität, Schellingstraße 4, 80799 München, Germany

Ultracold mixtures of two species of atoms could be used to study a wide range of open problems. To investigate such systems, we have constructed an apparatus that can produce a degenerate Bose-Fermi mixture of ^{23}Na and ^{40}K atoms. Among other things, we are planning to investigate quantum gases with a tunable dipole-dipole interaction, which could be done by producing NaK molecules in their absolute ground state.

A crucial ingredient for such experiments is an imaging system that allows observation of both atomic species with sub-micrometer resolution. We achieve this with a custom objective (NA=0.6), which offers diffraction-limited imaging at wavelengths of 589 and 767nm. It simultaneously supports a near-infrared optical lattice for 2D confinement of the atomic or molecular sample in the object plane of the system. We will present the experiences we have made during the construction and testing of this setup.

Q 11.21 Mon 16:30 Empore Lichthof

News from the Garching NaK mixture — •Nikolaus Buchheim, Frauke Seesselberg, Zhenkai Lu, Roman Bause, Tobias Schneider, Immanuel Bloch, and Christoph Gohle — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching

Ultracold quantum gases with long-range dipolar interactions promise exciting new possibilities for quantum simulation of strongly interacting many-body systems like fractional MOT insulators and supersolid phases. Our experimental apparatus is capable of creating ultracold sodium and potassium mixtures with high phase space density, weakly bound feshbach molecules and aims towards generating ultracold polar ^{23}Na^{40}K molecules in their vibrational, rotational and hyperfine ground state.

To this end, a stimulated Raman adiabatic passage (STIRAP) has to be implemented, which is a two photon process capable of transferring weakly bound Feshbach molecules via an intermediate, excited molecular state to the ground state with high efficiency. We employ a spin-orbit coupled intermediate state in the D/d molecular manifold of the NaK system. With our apparatus we are also capable to analyze the properties of a small number of Potassium atoms immersed into a degenerate Bose gas of Sodium atoms. This setting is known as the Bose polaron.

Q 11.22 Mon 16:30 Empore Lichthof

Optical transport of ultracold atoms for the production of groundstate RbYb — •Tobias Franzen, Bastian Pollklesener, Simone Kipp, Kapilan Paramasivam, Christian Halter, and Axel Görlitz — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

Ultracold dipolar molecules constitute a promising system for the investigation of topics like ultracold chemistry, novel interactions in quantum gases, precision measurement and quantum information.

Here we report on a versatile transport apparatus for the production of ultracold RbYb molecules. This setup constitutes an improvement of our old apparatus, where the interactions in RbYb and possible routes to molecule production have already been studied extensively [1,2]. In the new setup a major goal is the efficient production of ground state RbYb molecules.

Separate production chambers allow the parallel production of Yb and Rb samples. Optical tweezers transport both species to a separate science chamber. This chamber provides excellent optical access and room for additional components in- and outside of the vacuum.

[1] F. Münchow et al., PCCP 13(42), 18734 (2011).
[2] M. Borkowski et al., PRA 88, 052708 (2013)

Q 11.23 Mon 16:30 Empore Lichthof

Herstellung angepasster mikro-optischer Strukturen mit einem FIB — •Marcel Salz, Andreas Pfister, Max Hettrich und Ferdinand Schmidt-Kaler — QUANTUM, Institut für Physik, Johannes-Gutenberg-Universität Mainz

Die Verwendung von Focused Ion Beam (FIB) Systemen ist nicht nur fester Bestandteil in der Halbleiterindustrie, sondern hat auch zahlreiche interessante Anwendungen in der Wissenschaft gefunden. Insbesondere lassen sich Glasfasern auf der Nanometerebene kontrolliert bearbeiten, um etwa den Akzeptanzwinkel von Endflächen zu erhöhen [1] oder zur Entwicklung von faserbasierten optischen Pinzetten [2].

Wir berichten über die Herstellung von konkaven Strukturen auf der μm-Skala in den Endflächen von Glasfasern. Um faserbasierte optische Resonatoren zu ermöglichen wurden sphärische konkave Strukturen mit einem Durchmesser von bis zu 100 μm erzeugt, wobei die Abweichungen von der gewünschten Form über den zentralen Bereich von 50 μm kleiner als 20 nm sind. Nach einer dielektrischen Beschichtung bauen wir aus zwei solcher Spiegelendflächen einen optischen Resonator auf, der eine Finesse von 16 500 bei einem vergleichsweise großen Abstand von 250 μm erreicht. Ein solcher Resonator eignet sich für die Integration in mikrostrukturierte Ionenfallen, wo er als Licht-Ionen-Schnittstelle [3] für CQED-Experimente eingesetzt werden kann [4].

[1] V. Callegari et al., J. Micromech. Microeng. 19, 107003 (2009)
[2] C. Liberale et al., Nat. Photon. 1, 723-727 (2007)
[3] B. Brandstätter et al., Rev. Sci. Instrum. 84, 123104 (2013)
[4] A. D. Pfister et al., arXiv:1508.05272 (2015)

Q 11.24 Mon 16:30 Empore Lichthof

Characterisation of efficient single-photon sources based on nitrogen-vacancy centres for radiometric applications — •Beatrice Rodiek[1], Marco López[1], Helmuth Hofer[1], Stefan Kück[1], Xiao-Liu Chu[2], and Stefan Götzinger[2] — [1]Physikalisch Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [2]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany

Single-photon sources (SPS) play today an important role in quantum metrology. The main aim is to realize a SPS with a high photon rate while the background and the multi-photon emission rates are still low. Such a single-photon source would be a candidate for a standard source for radiometry. One way of a SPS realisation is based on colour centres in nanocrystals. At PTB, we are working on SPS based on nitrogen-vacancy- (NV-) centres in nanodiamonds, for their use in the calibration of single photon detectors. To investigate these sources, we use a confocal microscope setup that allows us to excite the colour centres and also to collect the fluorescent emission of the source. The colour centres are characterized in terms of spectrum, count rate, antibunching and stability. A photon rate of approx. 650 kphotons per second at the detector with a high single photon emission purity, indicated by the g2(0)-value as low as 0.05 was obtained. Further results and details of the setup will be presented at the conference.

Q 11.25 Mon 16:30 Empore Lichthof

A silicon vacancy-based quantum memory in diamond — •Johannes Görlitz[1], Jonas Nils Becker[1], Eilon Poem[2], Joshua Nunn[2], Ian Alexander Walmsley[2], and Christoph Becher[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Clarendon Laboratory, University of Oxford, United Kingdom

Due to its favourable spectral properties, the silicon vacancy center (SiV) in diamond is already a promising candidate for the realization of a spin-photon interface for quantum communication applications. Because of its large ground state splitting of about 48 GHz, we propose that the SiV is also a potential candidate for broadband quantum memory applications. We present preliminary work demonstrating the feasibility of such a device based on a Raman-type memory scheme in a dense, homogenous SiV ensemble fabricated by homoepitaxial CVD growth on top of a low strain, high-pressure-high-temperature (HPHT) diamond substrate. The sample is investigated at 4 K in a flow cryostat setup with a transmission geometry specifically build to allow for efficient memory preparation and readout. The ensemble is precharacterized using photoluminescence excitation (PLE) and coherent population trapping (CPT) experiments. The obtained experimental parameters are used in a theoretical model to calculate memory efficiences as well as optimized control pulse parameters that can be used in the near future to build a first experimental realization of the memory.

Q 11.26 Mon 16:30 Empore Lichthof

Creating nitrogen-vacancy centers (NVs) in isotopically controlled diamond layers by CVD diamond growth — •Christian Osterkamp, Takashi Yamamoto, Boris Naydenov, and Fedor Jelezko — Universität Ulm, Institut für Quantenoptik

The negatively charged nitrogen-vacancy center (NV) is amongst the leading solid-state quantum bits. The fluorescence of single NVs can be detected and its electron spin can be polarized, read-out and manipulated at ambient conditions. Creation of NVs on demand is an important task for quantum technology applications like quantum computers or magnetic- and electric field sensors [1]. We engineer NVs by delta doping during a plasma enhanced chemical vapor deposition (PECVD) process [2] and we are able to produce isotopically pure diamonds by changing the ratio of 12C/13C atoms in the growth chamber.

[1] C. Müller et al., Nat. Comm., 5 4703 (2014)
[2] C. Osterkamp et al., Appl. Phys. Lett. 106, 113109 (2015)

Q 11.27 Mon 16:30 Empore Lichthof

Closed loop optimal control on NV centers in diamond — •Florian Frank[1], Thomas Unden[1], Jorge Casanova[2], Zhenyu Wang[2], Ressa Said[3], Jonathan Zoller[3], Martin Plenio[2], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, Ulm University, Ulm, Germany — [2]Institute of Theoretical Physics, Ulm University, Ulm, Germany — [3]Institute for Complex Quantum-systems, Ulm University, Ulm, Germany

The objective of optimal control is to control a given system in a way that its output matches a reference. In closed loop optimal control, the controler gets an active feed back of the experiment to tune the control parameters . We use this technique to optmize the fidelity of quantum operations on the nitrogen vacancy center. Therefore we tune the microwave pulses and sequences to maximize the fidelity of this operations.

Q 11.28 Mon 16:30 Empore Lichthof

Towards a quantum simulator based on nuclear spins in diamond — •Timo Weggler[1], Thomas Unden[1], Nikolas Tomek[1], Florian Frank[1], Alexandre Le Boité[2], Janming Cai[5], Paz London[3], Alex Retzker[4], Itho Kohei[6], Martin Plenio[2], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, Ulm University, Germany — [2]Institute for Theoretical Physics, Ulm University, Germany — [3]Department of Physics, Technion, Israel Institute of Technology, Haifa, 32000, Israel — [4]The Racah Institute of Physics, Hebrew University of Jerusalem, 91904 Jerusalem — [5]School of Physics, Huazhong University of Science and Technology, Wuhan 430074, China — [6]Department of Applied Physics and Physico-Informatics, Keio University, Hiyoshi, Yokohama, Japan

Towards a quantum simulator based on nuclear spins in diamond.

Q 11.29 Mon 16:30 Empore Lichthof

Polarization of a C13 nuclear spin bath in diamond in arbitrary aligned fields — •Samuel Müller[1], Jochen Scheuer[1], Ilai Schwarz[2], Qiong Chen[2], Martin B. Plenio[2], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, Ulm University, Albert Einstein Allee 11, 89081 Ulm, Germany — [2]Institute of Theoretical Physics, Ulm University, Albert Einstein Allee 11, 89069 Ulm, Germany

Nuclear magnetic resonance spectroscopy (NMR) and magnetic resonance imaging (MRI) are powerful analysis tools in life science and medicine. The sensitivity of both depends critically on the nuclear spin polarisation. Dynamical nuclear polarization of C13 nuclear spins in diamond via optically pumped Nitrogen-Vacancy centers (NV) allow a high degree of polarization to be reached even at room temperature and low magnetic field.

Here we compare different polarization schemes in terms of their efficiency and robustness against magnetic field misalignment, which is of crucial importance for their application to randomly oriented nanodiamonds. In contrast to ensemble measurements, the single spin approach allows us to investigate the characteristics of a single nuclear spin bath surrounding a NV.

Q 11.30 Mon 16:30 Empore Lichthof

Elementary model of a two–photon double–slit experiment — •Lucas Happ[1], Maxim A Efremov[1,2], and Wolfgang P Schleich[1,3] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQ^{ST}), Universität Ulm, D-89081 Ulm, Germany — [2]A.M. Prokhorov General Physics Institute, Russian Academy of Sciences, 119991 Moscow, Russia — [3]Institute for Quantum Science and Engineering (IQSE), Department of Physics and Astronomy, Texas A&M University, College Station, TX 77843

The principle of complementarity states that in a double–slit experiment the "which–slit" information cannot be measured at the same time as an interference pattern is observed. A recently performed experiment [1] targeted at the verification of this principle. The TEM_{01} mode for the pump light has been applied to create entangled photon pairs via SPDC in a nonlinear crystal. In this way, the entanglement can be used to locate the photons in one of the slits, while at the same time the TEM_{01} mode function, containing two distinct wave vectors, leads to interference in the far field.

We present an elementary model of this experiment by describing the nonlinear crystal by a gas of three–level atoms and the creation of photon pairs by a cascade decay of these atoms. Moreover, to explain the experimental results, we obtain the relevant detection probabilities in terms of the Glauber correlation functions.

[1] Menzel R, Puhlmann D, Heuer A and Schleich W P, Proc. Natl. Acad. Sci. U.S.A. **109**, 9314 (2012)

Q 11.31 Mon 16:30 Empore Lichthof

Superbunching and Nonclassicality as new Hallmarks of Superradiance — •Daniel Bhatti[1,3], Joachim von Zanthier[1,3], and Girish S. Agarwal[2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Department of Physics, Oklahoma State University, Stillwater, OK, USA — [3]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen, Germany

Superradiance, i.e., spontaneous emission of coherent radiation by an ensemble of two-level atoms in collective states introduced by Dicke in 1954 [1], is one of the enigmatic problems of quantum optics. The startling gist is that even though the atoms have no dipole moment they radiate with increased intensity in particular directions [2]. Following the advances in our understanding of superradiant emission by atoms in entangled W-states we examine the quantum statistical properties of superradiance [3]. This requires the investigated system to have at least two excitations. We present results for the spatially resolved photon-photon correlations of systems prepared in doubly excited W-states and give conditions when the atomic system emits nonclassial light. Moreover, we derive conditions for the occurrence of the rare phenomenon of superbunching. Both effects can be witnessed equally in the photon-photon cross correlations of the spontaneously scattered light and highlight the nonclassicalty of such correlations.

[1] R. H. Dicke, Phys. Rev. 93, 99 (1954).
[2] R. Wiegner, et al., Phys. Rev. A 84, 023805 (2011).
[3] D. Bhatti, et al., arXiv:1511.00956 (2015).

Q 11.32 Mon 16:30 Empore Lichthof

Detection of quantum correlations of light without quantum discord or entanglement — •Tom Ettrich[1], Semjon Köhnke[1], Melanie Mraz[1], Elizabeth Agudelo Ospina[2], Jan Sperling[2], Werner Vogel[2], and Boris Hage[1] — [1]AG Experimentelle Quantenoptik, Institut für Physik, Universität Rostock, Rostock, Germany — [2]AG Theoretische Quantenoptik, Institut für Physik, Universität Rostock, Rostock, Germany

We give a brief overview of the experimental requirements for the preparation and verification by measurement of Einstein-Podolsky-Rosen (EPR) entanglement based on two squeezed vacuum states generated by optical parametric amplifiers (OPA).

By applying carefully generated phase-randomization with a uniform distribution to the mutual phase of the bipartite state both quantum discord and entanglement vanish for a particular range of parameters. However, the method developed by our theoretical colleagues of the group of W. Vogel provides the means to construct a filtered regularised multimode Glauber-Sudarshan P function from measured homodyne data, which contains negativities and therefore does show quantum correlation.

Q 11.33 Mon 16:30 Empore Lichthof

Correlation measurement via unbalanced homodyning with a weak local oscillator — •Christian Reiher[1], Melanie Mraz[1], Steve Jäger[1], Semjon Köhnke[1], Johannes Kröger[2], Jan

Sperling[3], Heinrich Stolz[2], Werner Vogel[3], and Boris Hage[1] — [1]AG Experimentelle Quantenoptik, Institut für Physik, Universität Rostock, Germany — [2]AG Halbleiteroptik, Institut für Physik, Universität Rostock, Germany — [3]AG Theoretische Quantenoptik, Institut für Physik, Universität Rostock, Germany

We present an experiment to evaluate the photostatistics of squeezed states of light by correlation measurements via unbalanced homodyne detection with a weak local oscillator. As squeezer an optical parametric amplifier with a PPKTP-chrystal is used. The measurements will be carried out with a τ-SPAD (single-photon avalanche diode) click detector. The main task will be to attenuate the light field to a sufficiently low intensity. Hence the cleanness of the used light field is of special interest, i.e. no other light should trigger our detector, like the light of the pump beam, the seed beam or stray light. The pump beam will be blocked by dichroic mirrors and an edge filter. The seed beam will be blocked by two out of phase rotating choppers. The second one opens the path to the detector only while the first one blocks the seed beam, resulting in a disruption of cavity-length-control. First investigations showed, that there is no negative effect on the resonator length by using this method. This way we make sure that no other event will occur during the deadtime of the detector.

Q 11.34 Mon 16:30 Empore Lichthof

Quantum State Tomography of Kerr-squeezed fs-pulses in optical fibres — •Kai Barnscheidt, Oskar Schlettwein, Jakob Studer, and Boris Hage — Arbeitsgruppe Experimentelle Quantenoptik, Institut für Physik, Universität Rostock, D-18059 Rostock, Germany

Balanced homodyne detection is used for optical state tomography accessing the field quadratures of a signal field with a local oscillator. By tuning the phase between signal and a strong local oscillator information about multiple quadratures is gained and can be used for reconstructing the quantum state of the signal. fs-pulses in optical fibres are affected by linear and nonlinear effects due to high intensities and long travelling distances in fibres, influencing the pulse parameter (e.g. pulseshape, wavelength) and further the quantum state of the light. Balanced homodyne detection is based on interference of a strong local oscillator with the signal, hence a constant phase relation and matching pulse parameters are needed during the measurement time. We propose a method able to extract the local oscillator out of the Kerr-squeezed signal itself. An optical cavity is held on resonance to the repetition frequency of the laser using Pound-Drever-Hall lock-in technique. The cavity is transparent for the main part of the pulse, while the information about the quantum state, present in all sidebands, is mostly reflected by the incoupling mirror of the cavity. The reflected beam (signal) and the transient beam (local oscillator) can then be used for balanced homodyne detection to reconstruct the quantum state via tomographic methods.

Q 11.35 Mon 16:30 Empore Lichthof

Simulation of Kerr-Squeezing in Optical Fibers — •Jakob Studer, Oskar Schlettwein, Kai Barnscheidt, and Boris Hage — Arbeitsgruppe Experimentelle Quantenoptik, Institut für Physik, Universität Rostock, D-18059 Rostock, Germany

Squeezed states of light have many promising applications such as gravitational-wave detectors or optical communications. These states can be created by nonlinear processes in crystals or optical fibres.

One possibility is to utilise the optical Kerr effect, which is especially prominent for short pulses in optical fibres. The Kerr nonlinearity creates an arbitrary squeezed state which can be transformed into an amplitude-squeezed state and detected with various experimental methods. We develop a quasiclassical, probabilistic method to simulate such squeezing processes. For this purpose, the propagation of statistically distributed pulses through the fibre is numerically calculated using the Split-Step-Fourier method. Subsequently, the photon-number distribution after the propagation through the simulated setup is ana-lysed to evaluate the resulting amplitude-squeezing.

This method is demonstrated for two specific experimental setups which use optical fibres to create amplitude-squeezed light. Firstly, the squeezing in an asymmetric Sagnac interferometer and secondly the squeezing by spectral filtering of temporal solitons is investigated and compared to experimental results. At the current state, the simulation results show good qualitative and partial quantitative agreement to the experiments.

Q 11.36 Mon 16:30 Empore Lichthof

Towards creating Rydberg polaritons with cold atoms inside a hollow-core fiber — •Maria Langbecker, Mohammad Noaman, 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 where laser cooled Rubidium atoms are transported into a hollow-core fiber. We show the characterization of a Kagomé-type hollow-core fiber whose properties allow for simultaneous atom guiding and two-photon Rydberg EIT excitation and present the first measurements of Rydberg EIT of the optical molasses in front of the fiber. Finally, we discuss our progress towards Rydberg physics in a quasi-one-dimensional geometry.

Q 11.37 Mon 16:30 Empore Lichthof

Tunable polarons of slow-light polaritons in a BEC — •Fabian Grusdt[1,2,3] and Michael Fleischhauer[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Kaiserslautern, Germany — [3]Department of Physics, Harvard University, Cambridge, MA 02138, USA

When a mobile impurity atom interacts with a bath of phonons, for example inside a Bose-Einstein condensate (BEC), it forms a polaron. Here we present a versatile experimental setup that allows to tune both the mass of the impurity and its interactions with the BEC. The impurity is realized as a dark-state polariton, the long-lived quasiparticle of slow light, inside a quasi two-dimensional BEC. We show that its interactions with the Bogoliubov phonons lead to photonic polarons, described by the Bogoliubov-Fröhlich Hamiltonian for sufficiently weak couplings, and make theoretical predictions using an extension of a recently introduced renormalization group approach. Physics beyond the Fröhlich model can also be probed using our scheme. Due to the small impurity mass, the photonic setup is ideally suited to investigate the polaron self-trapping transition in a BEC, which is poorly understood at present.

Q 11.38 Mon 16:30 Empore Lichthof

A modified setup for trapping of neutral mercury — •Holger John and Thomas Walther — Technische Universität Darmstadt, Institut für Angewandte Physik, Schlossgartenstraße 7, 64289 Darmstadt

Laser-cooled mercury constitutes an interesting starting point for various experiments, in particular in light of the existence of bosonic and fermionic isotopes. On the one hand the fermionic isotopes could be used to develop a new time standard based on a optical lattice clock. Another interesting venue is the formation of ultra cold Hg-dimers employing photo-association and achieving vibrational cooling by employing a special scheme. The requirements for trapping neutral mercury are given by the cooling transition at 253.7 nm with a linewidth of 1.27 MHz.

We have developed a non-cryogenic Yb-doped fiber amplified ECDL with the fundamental wavelength of 1014.8 nm. It's twice frequency doubled and stabilizied at a build-up reference resonator.

In addition to the laser-system our vacuum-system has been modified with a new compact Hg-source. We will report on the status of the experiments.

Q 11.39 Mon 16:30 Empore Lichthof

Optimizing the homodyne detection efficiency of a femtosecond PDC source — •Thomas Dirmeier[1,2], Imran Khan[1,2], Georg Harder[3], Vahid Ansari[3], Nitin Jain[1,2,4], Birgit Stiller[1,2], Ulrich Vogl[1,2], Gerd Leuchs[1,2,5], Christoph Marquardt[1,2], and Christine Silberhorn[2,3] — [1]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany — [2]Max Planck Institute for the Science of Light, Erlangen, Germany — [3]Applied Physics, Integrated Quantum Optics Group, University of Paderborn, Germany — [4]Center for Photonic Communication and Computing, EECS Department, Northwestern University, Evanston, Illinois, USA — [5]Department of Physics, University of Ottawa, Canada

The realization of quantum networks requires the ability to produce a large number of non-classical states from different sources that are able to easily interfere with each other. Parametric downconversion sources in ppKTP waveguides provide an efficient platform to produce such states in the telecommunication regime with a well-controlled mode structure. At the end of such a network, the receiver efficiency allows for the proper execution of quantum protocols. For a mode-sensitive homodyne detection scheme, this efficiency is mainly governed by the interferometric overlap in space and time between the measured signal and the local oscillator (LO) field. We show the progress on the pulse-to-pulse homodyne detection of different states generated in our engineered ppKTP waveguide source. Specifically, we investigate the influence of different temporal LO pulse shapes.

Q 11.40 Mon 16:30 Empore Lichthof

Towards efficient coupling of light and a single two level atom in free space — •Lucas Alber[1,2], Bharath Srivathsan[1], Martin Fischer[1,2], Markus Weber[1], Markus Sondermann[1,2], and Gerd Leuchs[1,2,3] — [1]Max-Planck-Institute for the Science of Light, Erlangen, Germany — [2]Friedrich-Alexander University Erlangen- Nürnberg (FAU), Department of Physics, Erlangen, Germany — [3]Department of Physics, University of Ottawa, Canada

We report on the efficient free-space interaction between light and a single trapped ion. This is accomplished by transforming a paraxial Gaussian beam into a spherical linear dipole wave using a radial polarization converter and a deep parabolic mirror. We measure the phase shift imprinted on a weak coherent beam by a single $^{174}Yb^{+}$ ion trapped in the focus of the parabolic mirror. Our first result matches the best value reported in any free space experiment so far. The achieved phase shift is mainly limited by aberrations of the parabolic mirror, the twofold degenerady of the ground level, and the spatial spread of the ion's wave function. We will overcome these limitations by using a deformable mirror for aberration correction and by trapping of a $^{174}Yb^{2+}$ ion. The latter species comprises a closed two level transition with a comparably small natural linewidth.

Q 11.41 Mon 16:30 Empore Lichthof

A quantum theory of CCD camera photodetection — •Vanessa Chille[1,2,3], Nicolas Treps[3], Claude Fabre[3], Christoph Marquardt[1,2], Gerd Leuchs[1,2,4], and Andrea Aiello[1] — [1]Max Planck Institute for the Science of Light, G\"unther-Scharowsky-Str. 1/Bldg. 24, D-91058 Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany — [3]Laboratoire Kastler Brossel, Sorbonne Universit\'e - UPMC, ENS, Coll\`ege de France, CNRS; 4 place Jussieu, 75252 Paris, France — [4]Department of Physics, University of Ottawa, 25 Templeton, Ottawa, Ontario, K1N 6N5 Canada

The measurement of a light beam's spatial shape by means of a CCD camera is a standard procedure in optics. Complex spatial modes receive increasing attention, particularly in the context of quantum optics. Thus, the limits of such kind of measurement imposed by quantum physics are of more and more importance.

We present a quantum theory of multi-pixel photodetection, and we use it to determine the quantum noise affecting the measurements of the width and the position of a light beam. An analytic theory is derived and compared to the theory in [1] that investigates the beam width noise independently of the measurement scheme. Numerical simulations are performed. They give realistic and promising predictions for experimental studies. We also study the influence of detector imperfections.

[1] V. Chille et al. arXiv:1506.08588 (2015).

Q 11.42 Mon 16:30 Empore Lichthof

The dynamical Stark effect in the Markovian dynamics of the driven Dicke model — •Daniel Pagel, Andreas Alvermann, and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität, 17487 Greifswald, Germany

The proper description of light-matter interaction in the strong coupling regime is one fundamental topic in quantum optics. Here, we study the Dicke model of driven two-level emitters strongly interacting with a single mode of a cavity beyond the rotating wave approximation. Its dissipative dynamics for weak coupling to an environment can be studied with Markovian master equations. We point out that the usually employed quantum optical master equation is invalid at strong emitter-cavity coupling and describe how exact diagonalization and the Floquet approach can be combined in a solution strategy for the master equation that is applicable also for periodically driven systems. Using this master equation we study the emission of light from the Dicke model and analyze its nonclassical properties. As an indicator of the dynamical Stark effect the peaks in the emission spectra are shifted in dependence on the external driving strength. Depending on the emitter-cavity coupling strength and the bath temperatures we find strong bunching or antibunching and characterize the statistics of the emitted radiation.