Q 30: Poster II

Zeit: Dienstag 16:30–19:00 Raum: VMP 9 Poster

Q 30.1 Di 16:30 VMP 9 Poster

Transport of Bogoliubov excitations in correlated disorder
— Christopher Gaul, Nina Renner, and •Cord Axel Müller — Physikalisches Institut, Universität Bayreuth, Deutschland

We investigate the dynamics of an interacting BEC in presence of an external disorder potential by considering its Bogoliubov excitations. The effective disorder-averaged Bogoliubov dispersion relation is calculated via the self-energy of the impurity-scattering Hamiltonian derived recently in [1]. We find that the excitation life time is determined by elastic scattering events, whereas corrections to the speed of sound are due to virtual excitations by inelastic scattering and pair creation/annihilation processes. We explore a variety of regimes by varying the finite disorder correlation length as compared to the excitation wave-length and condensate healing length and confront our predictions with numerical simulations.

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

Q 30.2 Di 16:30 VMP 9 Poster

Emergence of mesoscopic entanglement for a Bose-Einstein condensate in a double well with time-dependent potential differences
— •Bettina Gertjerenken, Stephan Arlinghaus, Niklas Teichmann, and Christoph Weiss — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany

We explore the relation between mean-field chaos and multi-particle entanglement for a Bose-Einstein condensate in a periodically shaken double well [1]. The entanglement-flag used to identify mesoscopic entenglement is the quantum Fisher information.

[1] Phys. Rev. Lett. 100, 140408 (2008).

Q 30.3 Di 16:30 VMP 9 Poster

Phase fluctuations in one-dimensional quasi-condensates on an atom chip
— •Thomas Betz, Robert Bücker, Christian Koller, Stephanie Manz, Wolfgang Rohringer, Aurélien Perrin, Thorsten Schumm, and Jörg Schmiedmayer — Atominstitut - Technische Universität Wien, Stadionallee 2, A-1020 Vienna, Österreich

The intrinsic elongated geometry of wire traps on an atom chip provides direct access to ultra-cold one-dimensional systems. In contrast to the three-dimensional case, one- dimensional ultra-cold Bose gases do not exhibit long-range order. The respective phase fluctuations are observed in interference experiments with split one-dimensional Bose-Einstein condensates, using radio-frequency induced double well potentials [1,2], or by directly observing density modulations in time-of-flight images [3]. Studying the spectrum of these modulations after a ballistic expansion of the atomic cloud allows to compare our system to the predictions of theory.

[1] T. Schumm et al., Nature Phys. 1, 57 (2005) [2] G.-B. Jo et al., PRL 99, 240406 (2007) [3] D. Hellweg et al., Appl. Phys. B 73 781 (2001)

Q 30.4 Di 16:30 VMP 9 Poster

Time-normally ordered correlation functions in the Wigner representation
— •Bettina Berg[1], Lev I. Plimak[1], Anatoli Polkovnikov[2], Murray K. Olsen[3], Michael Fleischhauer[4], and Wolfgang P. Schleich[1] — [1]Institute of Quantum Physics, Ulm University, Germany — [2]Department of Physics, Boston University, USA — [3]ARC Centre of Excellence for Quantum-Atom Optics, University of Queensland, Australia — [4]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

Applicability of the so-called truncated Wigner approximation ($-W$) [1] is extended to multitime averages of Heisenberg field operators.

We develop a path-integral approach in phase-space based on the symmetric operator ordering. This results in a new class of averages of the Heisenberg operators which we call time-symmetric. The $-W$ emerges as an approximation within this path-integral approach.

Furthermore, we show how the time-symmetric averages calculated by $-W$ can be converted to the time-normal order by relating commutators of Heisenberg operators to response of the system. For two-time commutators, this is nothing but Kubo's renowned formula for the linear response function [2]. The latter can be easily calculated numerically by introducing "quantum jumps" into phase-space trajectories [3].

[1] M. J. Werner, P. D. Drummond, J. Comput. Phys. **132**, 312 (1997). [2] R. Kubo, *Lectures in Theoretical Physics, v. 1* (Wiley, New York, 1959). [3] M.K. Olsen et al., Phys. Rev. **A62**, 023802, (2000); A. Polkovnikov, Phys. Rev. **A68**, 053604 (2003).

Q 30.5 Di 16:30 VMP 9 Poster

Atom-optics and matter wave dynamics in optical dipole potentials
— •Johannes Küber, Thomas Lauber, Oliver Wille, and Gerhard Birkl — Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt

In our experiment we aim to study and exploit the matter wave properties of Bose-Einstein condensates. We generate a BEC of Rb atoms by using a fiber laser at 1070nm to create a crossed dipole potential and cool evaporatively to quantum degeneracy. This approach gives us flexibility and independence of the magnetic properties of our atoms.

In our ongoing experiments, we aim to load ultra-cold atoms and BECs into optical waveguides and trapping potentials. We use miniaturized lens structures including microlens arrays, cylindrical lenses, and ring lenses illuminated by a red detuned laser. After coherent splitting and transport can be achieved it is possible to create integrated atom interferometers.

We also want to investigate the dynamics of wave packets in guiding potentials and superimposed one-dimensional geometries like optical lattices or Fabry-Perot structures. Our setup allows to implement these structures either by using standing waves or micro-lens structures.

Q 30.6 Di 16:30 VMP 9 Poster

Towards the realization of an atomic erbium quantum gas
— •Jörg Drückhammer, Riad Bourouis, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany

The erbium atom in its $^3H_6$ electronic ground state possesses a large orbital angular momentum of $L = 5$. All so far realized quantum gases consist of atoms with an S-ground state configuration, so that in laser fields with detuning above the upper state fine structure splitting the optical dipole trapping potential is determined by the scalar electronic polarizability. In contrast, for an erbium quantum gas (with $L > 0$) the trapping potential also for far detuned dissipation-less trapping laser fields would become dependent on the internal atomic state (spin). Moreover, Raman transitions between different ground state spin projections then become possible with e.g. Nd:YAG laser fields, which can allow for a Fourier-synthesis of in principle arbitrarily shaped lattice potentials using the technique of multiphoton lattices [1]. This has prospects for novel quantum phase transitions in e.g. strongly correlated frustrated lattice configurations.
We present here experimental work aimed at laser cooling [2] and dipole trapping of atomic erbium, which should then allow for evaporative cooling towards quantum degeneracy by all-optical means. The current status of the experimental setup will be summarized.

[1]T. Salger, C. Geckeler, S. Kling und M. Weitz, PRL **99**, 190405(2007)
[2]J. J. McClelland and J.L. Hanssen, PRL **96** , 143005(2006)

Q 30.7 Di 16:30 VMP 9 Poster

Towards the observation of second sound in a strongly interacting Fermi gas
— •Edmundo R. Sánchez Guajardo[1,2], Christoph Kohstall[1,2], Stefan Riedl[1,2], Leonid Sidorenkov[1], Johannes Hecker Denschlag[1], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Österreich

Second sound is predicted to occur when two coexisting hydrodynamic fluids, one of them a superfluid, oscillate out of phase with respect to each other. In a strongly interacting Fermi gas such a system is realized close to a Feshbach resonance, where both the superfluid and the normal states are hydrodynamic. The low-lying collective modes previously studied in this Fermi gas correspond to in-phase oscillations of the two fluids. We discuss possible scenarios to excite and detect out-of-phase oscillations and thus to probe phenomena related to second sound.

Q 30.8 Di 16:30 VMP 9 Poster

Mixtures of ultracold fermionic atoms in low dimensions — •Armin Ridinger, Thomas Salez, Saptarishi Chaudhuri, Ulrich Eismann, David Wilkowski, Frédéric Chevy, and Christophe Salomon — Laboratoire Kastler Brossel, Ecole Normale Supérieure, Université Pierre et Marie-Curie-Paris 6, 24 rue Lhomond, CNRS, F-75231 Paris Cedex 05, France

We present the design of our new apparatus for creating cold mixtures of 40K and 6Li fermions with which we intend to study condensed matter physics phenomena. Our apparatus will allow us to simulate several Hamiltonians describing intereracting many-body fermionic systems in one, two and three dimensions. We report on the initial performances of our subsystems including a 2D MOT source of Potassium atoms, a Zeeman slowed Lithium beam, and a dual species magneto-optical trap. We are now working on the magnetic transport towards the science chamber where we intend to evaporate the mixture to quantum degeneracy in an optically plugged quadrupole trap. In this chamber with large optical access periodic potentials will be realized using optical lattices and a high resolution imaging system will be installed. We further report on the constuction of a solid-state laser source for Lithium in the one Watt power range suitable for laser cooling of Lithium.

Q 30.9 Di 16:30 VMP 9 Poster

Quantum Dynamics of Spin 1 Bosons in SMA — •Jannes Heinze[1], Frank Deuretzbacher[1,2], and Daniela Pfannkuche[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Germany — [2]Mathematical Physics, Lund Institute of Technology, Sweden

We investigate the dynamics of $f = 1$ spinor condensates using the fully quantum mechanical single-mode-approximation (SMA) model by Law et al. [PRL **81**, 5257], including the quadratic Zeeman effect. This model was used by Widera et al. [PRL **96**, 190405] to describe their measurements for two atoms. In this contribution, we present exact analytical results and numerical calculations for larger particle numbers N and thereby identify effects due to many-particle correlations. We discuss the behavior for different initial states and magnetic fields. For the fully stretched state where all atoms are aligned in the x-direction, we find a novel beat note phenomenon at large magnetic fields, which should be observable in experiments for small particle numbers larger than two. This beat note is a clear sign of genuine many-particle correlations. Starting from exact analytical results as well as numerical simulations of the quantum dynamics for large particle numbers, we discuss the mean field limit. The quantum dynamics are shown to converge toward the SMA mean field solution in the thermodynamic limit. That is, the many-particle correlations disappear for $N \to \infty$ and N/V constant, where V is the volume of the system. Therefore we are able to make predictions about corrections to the mean field solutions due to finite particle numbers.

Q 30.10 Di 16:30 VMP 9 Poster

Spectroscopy of BECs in Triangular Lattices — •Julian Struck, Parvis Soltan-Panahi, Georg Meineke, Christoph Becker, and Klaus Sengstock — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Ultracold atoms in optical lattices provide unique access to controllable many-body-systems, reaching from the weakly-interacting to the strongly-correlated regime. We have realized an experimental setup for the generation of a two-dimensional lattice with a non-square symmetry through the use of a three beam lattice. By changing the polarization of the lattice beams two different lattice types can be realized: a spin-independent triangular lattice and an spin dependent hexagonal lattice.

A one dimensional standing-wave lattice perpendicular to the two-dimensional lattice can be used to realize a three-dimensional periodic confinement.

Furthermore, our experimental setup allows control over the internal degrees of freedom in the hyperfine ground manifold of ^{87}Rb. Thus we are able to study the dynamics of spinor condensates in the lattice.

Here we present the latest ideas and measurements at our experiment with special emphasize on spectroscopy methods for the detection and identification of e.g. ground state phases or number occupation on lattice sites, as well as spin dynamics on optical lattices.

Q 30.11 Di 16:30 VMP 9 Poster

Non-Abelian gauge field induced phase fluctuations in low-dimensional quantum gases — •Frank Zimmer[1], Andreas Jacob[2], Michael Merkl[1], Luis Santos[2], and Patrik Öhberg[1] — [1]SUPA, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, United Kingdom — [2]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, D-30167, Hannover, Germany

Phase fluctuations of ultra-cold quantum gases have been intensively investigated in recent years mainly because of their implications on applications such as matter wave interferometers, chip-based wave guides or atom laser beams. In addition their occurrence can also be used for more fundamental applications such a thermometry.

In this work we study a spinor gas subject to an optically induced non-Abelian gauge potential, and its influence on the low-energy elementary excitations. Based on this we discuss for different spatial dimensions their impact on the observable phase fluctuations.

Q 30.12 Di 16:30 VMP 9 Poster

Towards single site addressability in optical lattices — •Manuel Endres, Christof Weitenberg, Jacob Sherson, Jan Petersen, Immanuel Bloch, and Stefan Kuhr — Institut für Physik, Universität Mainz

The investigation of ultracold quantum gases in optical lattices is usually limited to global properties of the system. By contrast we are developing experimental techniques revealing the local distribution of the trapped gas. The main part of the experiment is an optical imaging system with a spatial resolution smaller than the lattice spacing of a near infrared optical lattice.

The preparation of the quantum gas begins with a 2D$^+$-MOT as a source of cold atoms. After precooling the atoms in a 3D-MOT, they are transferred to a magnetic quadrupole trap and further cooled with rf-evaporation. Making use of an optical tweezer, the cold atom cloud is transported and loaded into a 3D optical lattice in front of the ultra-high resolution imaging system.

Collecting the fluorescence light of the trapped atoms will enable us to observe the local dynamics of the many-body system. With an additional strongly focused laser beam, single sites of the optical lattice can be addressed. Possible applications of single site addressability are e.g. single qubit rotations or perturbations of the many-body system on a local scale. In general the experimental setup will open new possibilities for the investigation and manipulation of strongly correlated atomic systems for quantum simulation and quantum information processing.

Q 30.13 Di 16:30 VMP 9 Poster

Fermionic Atoms in Optical Lattices — •Victor Bezerra[1], Flavio S. Nogueira[1], and Axel Pelster[1,2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

We investigate an interacting two-component Fermi gas in an optical lattice. To this end we analyze the underlying Hubbard Hamiltonian with an additional term which breaks explicitly the U(1) symmetry. Within a strong-coupling expansion, where the hopping energy is considered to be smaller than the interaction energy, we determine the phase diagram both at zero and at finite temperature. It turns out that our theory interpolates between the Mott insulating state with an unbroken and a BCS-like state with a broken U(1) symmetry. We point out applications for future experiments and the relevance of our results for the BEC-BCS crossover in optical lattices.

Q 30.14 Di 16:30 VMP 9 Poster

Fermionic quantum gases with tunable interactions in optical lattices — •Ulrich Schneider, Lucia Hackermüller, Thorsten Best, Sebastian Will, Simon Braun, and Immanuel Bloch — Johannes Gutenberg-Universität Mainz

Mixtures of ultracold fermionic atoms in optical lattices can serve as a tool to test theoretical models of condensed matter physics, a prominent example being the Fermi-Hubbard-Hamiltonian. A Feshbach resonance can be used to control the interaction between the atoms and allows us to explore both the repulsive and the attractive side of the Hubbard model.

In the experiment we sympathetically cool ^{87}Rb and ^{40}K in an optically plugged quadrupole trap followed by an optical dipole trap and reach temperatures of 0.15 T/T_F for a ^{40}K spin mixture in F=9/2: m_F=-9/2 and m_F=-7/2. The combination of a blue-detuned optical lattice with a red-detuned dipole trap enables us to vary the trapping potential and the lattice depth independently, thereby giving us direct control over the central filling factor.

For repulsive interactions we show how the system evolves from compressible, metallic states to Mott-insulating and finally band-insulating states for increasing harmonic confinements. In the case of attractive interactions we observe a counter-intuitive increase in cloud size for strong interactions, which can be explained by a strong decrease of the entropy capacity. In addition, we present new measurements of the formation dynamics and mobility of doublons in the optical lattice.

Q 30.15 Di 16:30 VMP 9 Poster

Quantum Transport of Atoms in Fourier-Synthesized Optical Lattices — •Sebastian Kling[1], Tobias Salger[1], Luis Morales-Molina[2], Carsten Geckeler[1], Tim Hecking[1], and Martin Weitz[1] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Department of Physics, National University of Singapore, 2 Science Drive 3, Singapore 117542

We report on experimental results on quantum transport of Bose-Einstein condensates in periodic optical potentials of variable spatial symmetry. We have studied the band structure of the Fourier-Synthesized lattices by means of Landau-Zener transitions and Bloch oscillations. More recently, we have investigated quantum transport in driven optical potentials to yield a Hamiltonian (i.e. within the interaction time dissipation-free) quantum ratchet.
To realize such lattice potentials of variable spatial symmetry, we superimpose a conventional standing wave of $\lambda/2$ spatial periodicity with a fourth-order optical potential of $\lambda/4$ spatial periodicity. The latter is generated using the dispersive properties of multiphoton Raman transitions.

Q 30.16 Di 16:30 VMP 9 Poster

Combining a magnetic Feshbach resonance with an optical bound-to-bound transition — •Christoph Vo, Dominik Bauer, Matthias Lettner, Gerhard Rempe, and Stephan Dürr — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

We use optical coupling between bound molecular states to control the properties of a magnetic Feshbach resonance in ^{87}Rb. For far detuned light the coupling causes an ac-Stark shift of the molecular states. This shifts the position of the magnetic Feshbach resonance which couples an incoming atomic state to the ground state of the optical transition. In this way we can shift the resonance away from 1007.4 G by $\sim$0.5 G, which is more than the width of the resonance. Application of the light can change the scattering length by an amount comparable to the background value. The light induces two-body loss with a rate coefficient of $\sim 10^{-12}$cm^3/s, which is much less than for an optical Feshbach resonance.

With the light close to resonance we observe an Autler-Townes doublet which is probed by the magnetic Feshbach resonance. We measure the two-body loss coefficient as a function of magnetic field for different optical detunings to obtain the transition frequency, the transition dipole matrix element, the excited state's magnetic moment and its lifetime.

Q 30.17 Di 16:30 VMP 9 Poster

Microwave near-field potentials for the generation of many-particle entanglement in a Bose gas — •Max Fabian Riedel, Pascal Böhi, Theodor Wolfgang Hänsch, and Philipp Treutlein — Max-Planck-Institut für Quantenoptik und LMU München

We report an experiment on the coherent manipulation of small Bose-Einstein condensates with state-selective potentials generated by on-chip microwave near-fields. We characterize the microwave near-field distribution on the μm scale and show how we use the potentials to entangle atomic spin and motional state of a BEC in a controlled and reversible way. This is the key ingredient for a quantum phase gate previously proposed in [1].

Beyond quantum information processing, our system is ideally suited to tune inter-species vs. intra-species interactions in a two-component Bose gas by controlling wave function overlap. This can be utilized to generate squeezing and many-particle entanglement in BECs [2]. We report on the progress of experiments investigating this possibility further.

[1] P. Treutlein, T. W. Hänsch, J. Reichel, A. Negretti, M. A. Cirone, and T. Calarco, Phys. Rev. A **74**, 022312 (2006)
[2] Y. Li, P. Treutlein, J. Reichel, A. Sinatra, arXiv:0807.1580 (2008)

Q 30.18 Di 16:30 VMP 9 Poster

Towards Continuous Loading of an Optical Dipole Trap with Magnetically Guided Ultra Cold Atoms — •Anoush Aghajani-Talesh, Markus Falkenau, Peter Christian, Axel Griesmaier, and Tilman Pfau — Universität Stuttgart, 5. Physikalisches Institut

Using a Cr BEC the first dipolar quantum gas was investigated recently [1]. So far, however, chromium experiments suffer from low atom numbers below 10^5 in a single BEC. To substantially improve this number, we develop a novel loading scheme for an optical dipole trap (ODT) using a magnetic guide as source of cold atoms. In this poster we present the status of our experiment: our system is capable of producing a flux of $6.3 \cdot 10^9$ guided atoms/s. To load the ODT, which is formed by a 300 W fiber laser, from this flux, a dissipative process in the ODT region is required. This can be implemented by combining a magnetic field barrier with optical pumping in the trap region. This continuous loading process was studied numerically. Our calculations show, that further reducing the transverse temperature of the guided atoms from currently 1.5 mK can appreciably enhance the ODT loading efficiency. Currently, the feasibility of transverse Doppler cooling in a compressed region in the guide is investigated experimentally.

[1] Lahaye et al., Nature **448** , 672 (2007)

Q 30.19 Di 16:30 VMP 9 Poster

Miniaturized Microwave Paul Trap for Electron Guiding — •Johannes Hoffrogge, Markus Schenk, Michael Krüger, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Garching bei München, Germany

We present numerical modelling results on an experiment aiming at guiding electrons in an AC quadrupole guide. In order to stably and tightly confine electrons in the transverse direction the guide has to be miniaturized and operated at microwave frequencies. Therefore, we plan to combine a microfabricated microwave guiding structure with the electrode layout of a planar two-dimensional Paul-trap on a chip substrate. With electrons emerging from a high brightness single atom tip direct injection into the transverse ground state of the guide should be feasible. This would lead to a well-defined motional quantum system with potential applications in interferometry and quantum information processing. Numerical simulations on the electrode design as well as first microwave tests of prototype structures will be presented.
We also discuss first steps towards the realization of a novel scheme to accelerate electrons with a laser field in a transparent grating structure.

Q 30.20 Di 16:30 VMP 9 Poster

A planar segmented Ion Trap with a Y-Junction — •A. Bautista-Salvador, M. Hettrich, S. A. Schulz, U. Poschinger, F. Ziesel, M. Deiss, G. Huber, R. Reichle, and F. Schmidt-Kaler — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein Allee 11, D-89077 Ulm

We present a novel planar segmented trapping structure for single or few ions for applications in Quantum Information. The key feature of this trap is a loading zone, which is connected to a Y - junction. Thus, the ion may be shuttled in a controlled way either to the right or to the left arm by using the 58 individually addressable dc-electrodes, which was not possible with planar trapping devices so far [1,2]. We expect complex interaction sequences e.g. the interchange of two ions to be possible in our device. We discuss the geometry and fabrication of the trap electrode structure, where our method allows the inter-electrode gaps are as small as 1.2 to 4.0 μm. We report the electrical tests of the device and its operation with a single ion.

[1] S. Seidelin et. al., Phys. Rev. Lett. **96**, 253003 (2006)
[2] J. Labaziewicz et.al., Phys. Rev. Lett. **100**, 013001 (2008)

Q 30.21 Di 16:30 VMP 9 Poster

A two-colour dipole trap for neutral Caesium atoms based on ultra-thin optical fibres — •Daniel Reitz, Eugen Vetsch, Guillem Sagué, Regine Schmidt, and Arno Rauschenbeutel — Abteilung QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We present our experimental setup which allows us to trap more than 10^3 cold neutral Caesium atoms close to the surface of an ultra-thin optical fibre for about 50 ms. The atoms are first captured by a standard three dimensional magneto-optical-trap and then directly loaded into our two-colour dipole trap, which is created by the evanescent fields of two laser beams co-propagating through the fibre. The trap lasers at 1064 nm and 780 nm are far detuned and have a total power of about 40 mW, resulting in trapping potential of a few hundred μK. In order to detect the atoms in the trap, we measure the transmission of a weak resonant probe beam of 1 pW launched through the fibre. Each atom absorbs a few percent of this probe beam via evanescent field coupling so that the overall ensemble of atoms is optically dense for the probe. This paves the way towards the realisation of fibre-coupled atom-light-interfaces for quantum communication applications.

Financial support of the Volkswagen Foundation and the ESF is gratefully acknowledged.

Q 30.22 Di 16:30 VMP 9 Poster

High resolution imaging of an ultracold quantum gas — •Tatjana Gericke, Peter Würtz, Andreas Koglbauer, and Herwig Ott — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz

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

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

Q 30.23 Di 16:30 VMP 9 Poster

Coherent motional control and interferometry of single atoms in state selective potentials — •Tan Wang, Wolfgang Alt, Jai-Min Choi, Leonid Förster, Michał Karski, Andreas Steffen, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik, Uni Bonn

In our experiment we have achieved full quantum control over single Caesium atoms trapped in a 1D optical lattice, including the position along the lattice axis and the electronic and vibronic states.

We present our implementation for resolved sideband cooling relying on microwave radiation and state selective potentials. Displacing the trapping potentials for two spin states allows to effectively control the Lamb-Dicke parameter in the system and axial cooling to the vibrational ground state. Starting from the ground state, we drive coherent transitions to various vibrational states, where the Rabi-frequency depends on the displacement of the trap potentials. Further, we coherently split the wave function of single trapped atoms and delocalise it over several lattice sites using the spin dependent transport. Recombining the wave functions, we have realised a single trapped atom interferometer.

Our results point to controlled interactions of two neutral Caesium atoms.

Q 30.24 Di 16:30 VMP 9 Poster

Focusing down the beam of a deterministic single ion source to nm resolution — •Robert Fickler, W. Schnitzler, N. M. Linke, F. Schmidt-Kaler, and K. Singer — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm

We have realized a universal deterministic ultracold ion source on the basis of a segmented linear ion trap [1,2]. For single ion extraction we measured a mean velocity of 19.47km/s with a 1σ-spread of only 6.3m/s and a beam divergence of 600μrad. Due to the small chromatic and spherical aberration it should be possible to focus down this beam to a few nm with a simple einzel-lens [3]. In order to optimize the shape and dimension of the lens we calculated different versions with a custom-made numerical ion-ray-tracing simulation. The realized lens consists of three asymmetric layers, has an aperture of 1mm, a focal length of 10mm and is operated in the accelerating mode. Simulations for a beam with the attributes of the measured data predict a focal spot size in the nm regime and show that it is possible to achieve a spot radius of 1nm with ions cooled to the motional ground state. With our setup targeting the Heisenberg limit we have realized the perfect point source for implanting ions on demand with nm resolution, which e.g. is essential for realizing a scalable quantum computer [4].

[1] J. Meijer et al., Appl. Phys. A**83**, 321 (2006)
[2] J. Meijer et al., Appl. Phys. A**91**, 567 (2008)
[3] K. Shimizu, Jpn. J. Appl. Phys. **22**, 1623 (1983)
[4] F. Jelezko et al., Phys. Rev. Lett. **93**, 130501 (2004)

Q 30.25 Di 16:30 VMP 9 Poster

Quantum Jumps and Continuous Spin Measurement in a Strongly Coupled Atom-Cavity System — Wolfgang Alt, Tobias Kampschulte, Mkrtych Khudaverdyan, Sebastian Reick, •Alexander Thobe, Artur Widera, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany

In our experiment, we study the coherent interaction between a predetermined, small number of atoms and the light field inside a high-finesse optical resonator in the strong coupling regime. To this end, we trap caesium atoms in a high-gradient magneto-optical trap and transport them into the center of the resonator mode, using an optical dipole trap [1].

By monitoring the transmission of a probe laser resonant with the cavity, we are able to measure the spin state of a single atom in 2ms without changing it. Continuous observation reveals quantum jumps between the two hyperfine states of caesium. Utilizing this non-destructive detection method, we record the interaction induced normal mode splitting of the atom-cavity system by probing the atomic state. We further demonstrate conditional dynamics of the internal states of multiple atoms, simultaneously coupled to the resonator field. Our non-destructive state detection is the first step towards a quantum non-demolition measurement of the atomic spin as is required for probabilistic atom-atom entanglement schemes.

[1] M. Khudaverdyan et al., New J. Phys. **10**, 073023 (2008).

Q 30.26 Di 16:30 VMP 9 Poster

Adaptive estimation of qudits and entanglement — •Christof Happ and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069, Germany

We discuss adaptive methods for estimating an unknown pure d-level-state (qu*d*it), of which only a limited amount of copies is available. Using information from previous measurements, the adpation steps construct measurement bases for further measurements, which improve the estimation quality more than further measurements in fixed or random directions. We present Monte-Carlo simulation results for complete reconstruction of the state (for various d) and for the entanglement (measured by concurrence) of two qubits ($d = 4$).

Q 30.27 Di 16:30 VMP 9 Poster

Quantisation of the electromagnetic field based on the Wheeler wave functional — •Daniela Denot, Lev Plimak, and Wolfgang P. Schleich — Institute of Quantum Physics, Ulm University, Ulm, Germany

We develop an approach to the quantisation of the electromagnetic field based on the concept of Wheeler's wave functional [1].

Wheeler himself introduced a wave functional for the vacuum state. A single-photon state was considered by Bialynicki-Birula [2].

Building on the work by Bialynicki-Birula we construct a full-fledged quantisation approach based on the concept of wave functionals, by introducing the coherent-state wave functionals and phase-space shift. We also consider quantum dynamics in the Wheeler representation.

[1] C. W. Misner, K. S. Thorne, and J. A. Wheeler, Gravitation, W. H. Freeman and Company, New York (1973).
[2] I. Bialynicki-Birula, Optics Communications, **179**, 5 (2000).

Q 30.28 Di 16:30 VMP 9 Poster

Nonlocal realistic theories and continuous quantum systems — •Anna Hauber und Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

Recently [1], a certain class of non-local, realistic theories (NLRT) has been formulated for two-particle systems with dichotomic observables and has been shown to be incompatible with quantum mechanics and with experimental data [2,3]. The proof uses inequalities for correlation functions, as in the original Bell case. We study how to expand the formulation to systems with continuous variables and demonstrate how such systems can violate the predictions of the NLRT. Moreover, we analyze how violations of the NLRT-inequalities are related to violations of Bell-type inequalities.

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[2] S. Gröblacher et al., Nature **446** (2007), 871
[3] C. Branciard et al., Phys. Rev. Lett. **99** (2007), 210407

Q 30.29 Di 16:30 VMP 9 Poster

True Quantum Dephasing — •Julius Helm and Walter T. Strunz — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

Doubly Stochastic channels (channels that are trace preserving and unital – i.e., mapping the identity onto itself) can be distinct into two different classes. On the one hand there are the random unitary processes, which may always be written as a convex sum of unitary transformations, also known as random external fields [1]. On the other hand, and in contrast to the classical analogue, there exist doubly stochastic channels that do not allow for this representation [2]. In the context of quantum error correction this distinction obtains some practical significance, for it was shown that errors can be fully corrected if and only if they belong to the class of random unitary channels [3].

A simple yet crucial example of doubly stochastic channels are dephasing channels, characterized by their diagonal Kraus representation (according to a fixed basis). We study the notion of random unitarity in this context. Here we are able to give physical examples of "true quantum" dephasing channels, that is, channels that do not belong to the class of random unitary channels.

[1] R. Alicki and K. Lendi, "Quantum Dynamical Semigroups and Applications", Springer (1987)
[2] L. Landau and R.F. Streater, Lin. Alg. Appl. 193, 107 (1993)
[3] M. Gregoratti and R.F. Werner, J. Mod. Opt. 50, 915 (2002)

Q 30.30 Di 16:30 VMP 9 Poster

Experimental realization of basic quantum algorithms using a 3-qubit register in diamond — •Matthias Steiner[1], Philipp Neumann[1], Johannes Beck[1], Norikazu Mizuochi[2], Florian Rempp[1], Vincent Jacques[1], Fedor Jelezko[1], and Jörg Wrachtrup[1] — [1]3.Physikalisches Institut, Universität Stuttgart, D-70550 Stuttgart, Germany — [2]Graduate School of Library, Information and Media Studies, University of Tsukuba, 1-2 Kasuga, Tsukuba-City, Ibaraki 305-8550, Japan

One of the major candidates for a potential room temperature quantum processor is the NV center in diamond. Due to the possibility to control and read out single electron and nuclear spins individually spectacular experiments like the creation of multipartite entanglement [1] have been demonstrated recently. Because of the extremely long coherence times the entanglement can be used to perform simple quantum algorithms. Using the nulcear spins of single ^{13}C atoms and the electron spin of the NV-center itself as qubits we show first steps to perform algorithms similar to superdense coding and Deutsch-algorithm under ambient conditions.

[1] P. Neumann et al., *Multipartite Entanglement Among Single Spins in Diamond*, Science, **320,** 1326 (2008)

Q 30.31 Di 16:30 VMP 9 Poster

Towards a two-dimensional lattice of spins — •Christian Schneider[1], Martin Enderlein[1], Thomas Huber[1], Hector Schmitz[1,2], Axel Friedenauer[1], and Tobias Schaetz[1] — [1]Max-Planck-Institut für Quantenoptik — [2]LMU München

One of the state-of-the-art tools to investigate quantum algorithms/simulations is based on ions confined in a linear Paul trap. Recent experiments show that the bulky three-dimensional geometry of standard linear Paul traps can be translated into two-dimensional electrode setups on surfaces (but still being linear Paul traps) [1, 2]. Cryogenic conditions are shown to provide reduced heating rates allowing to further approach the surfaces [3]. A regular two-dimensional array of ions—small enough for sufficient interactions between the ions—could open a great new field of interesting experiments, e. g., the simulation of Quantum Spin Hamiltonians [4, 5], like the Bose-Hubbard model [6], or spin frustrations. Based on the above developments we aim for realizing a surface trap allowing for the confinement of a two-dimensional ion crystal (being equivalent to a lattice of spins). Our first milestone is a proof-of-concept experiment with a 2×2 array of ions at mutual distances of 20μm.

[1] J. Chiaverini et al., Quant. Inf. Comp. **5**, 419, 2005
[2] S. Seidelin et al., Phys. Rev. Lett. **96**, 253003, 2006
[3] J. Labaziewicz et al., Phys. Rev. Lett. **100**, 013001, 2008
[4] D. Porras and J.I. Cirac, Phys. Rev. Lett. **92**, 207901, 2004
[5] A. Friedenauer, H. Schmitz et al., Nat. Phys. **4**, 757, 2008
[6] D. Porras and J.I. Cirac, Phys. Rev. Lett. **93**, 263602, 2004

Q 30.32 Di 16:30 VMP 9 Poster

Security evaluation of a commercial Quantum Key Distribution System — •Carlos H. Wiechers M., Christoffer Wittmann, Dominique Elser, and Gerd Leuchs — Max-Planck-Institut für die Physik des Lichts, Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1, Bau 24, 91058 Erlangen, Deutschland

Quantum Key Distribution (QKD) systems theoretically guarantee secure communication based on fundamental physical laws. First commercial products have become available during the last years. Practical implementations often deviate from their theoretical models which potentially opens security loopholes. We experimentally tested security aspects of a commercial QKD system. Here we present measurements of the mean photon number and parasitic modulations. Within the measurement error we find no discrepancy from the theoretically expected values.

Q 30.33 Di 16:30 VMP 9 Poster

Quantum Key Distribution with passive selection of decoy states — •Felix Just, Malte Avenhaus, Katiuscia Cassemiro, and Christine Silberhorn — Max-Planck-Research Group Günther-Scharowsky-Straße 1 / Bau 24 D-91058 Erlangen

Quantum Decoy protocols promise an alternative way for secure quantum key distribution (QKD) without the necessity of true single photon sources. In order to implement a decoy QKD scheme we investigate the use of a photon source based on parametric down conversion in a periodically poled KTP waveguide. Our goal is the implementation of a highly non-degenerated downconversion process. For decoy cryptography schemes it is crucial to have detailed information about the photon pair statistics of the source. For this purpose the signal photon should be in a wavelength regime where the detection efficiency is optimal. Hence, Si-APDs are used in a time multiplexing detection setup for efficient estimation of photon number statistics. Since the idler photon is intended for the key distribution via a telecommunication fiber network, the respective wavelength constitutes an obvious choice to minimize transmission losses. This in turn requires detection by an InGaAs-APD. Different grating periods on our waveguide chip provide the opportunity of tuning signal and idler wavelength for optimal detection and transmission.

Q 30.34 Di 16:30 VMP 9 Poster

Quantum Information as Complementary Classical Information — •Joseph M. Renes[1] and Jean-Christian Boileau[2] — [1]TU Darmstadt, Germany — [2]University of Toronto, Canada

Since the breakthrough by Calderbank, Shor, and Steane on the existence of quantum error-correcting codes, an oft-used notion in quantum information theory is that we can treat quantum information essentially as a strange combination of two types of classical information, pertaining to two complementary observables "amplitude" and "phase". Correcting errors afflicting either of these observables is sufficient to restore the quantum information to its original state. However, the central results of quantum information theory established recently, such as the achievable rate of quantum communication over a noisy channel, follow a different approach termed decoupling which has a natural origin in the study of quantum cryptography. We show that the decoupling-based results can be concretely established in the complementary classical information picture. By adopting an information-theoretic approach to complementarity, we are able to construct entanglement distillation protocols which straightforwardly seek to distill amplitude and phase correlations without venturing into decoupling. This gives new and intuitive proofs of both the noisy channel coding theorem and the asymptotic rates of both secret-key distillation and state merging.

Q 30.35 Di 16:30 VMP 9 Poster

Aufbau einer Heralded- Potonenquelle zur Quantum Key Distribution — •Sabine Euler, Mathias Sinther und Thomas Walther — TU Darmstadt, Institut für angewandte Physik, Schlossgartenstraße 7, 64289 Darmstadt

Die Quantenkryptographie bietet im Gegensatz zu herkömmlichen Verschlüsselungsverfahren eine abhörsichere Variante des Schlüsselaustauschs zwischen Sender (Alice) und Empfänger (Bob) einer Nachricht. Wir entwickeln eine Heralded-Photonenquelle als Alice-Modul. Ein periodisch gepolter KTP-Kristall wird bei 405nm gepumpt, durch einen Typ II Parametric Down Conversion Prozess entstehen zueinander senkrecht polarisierte Photonenpaare mit einer Wellenlänge von 810nm. Eines dieser Photonen wird nachgewiesen und dient als Vorbote, das andere wird von Alice entsprechend bekannter Quantenkryptographie-Protokolle präpariert und an Bob geschickt. Der aktuelle Stand des Projekts wird präsentiert.

Q 30.36 Di 16:30 VMP 9 Poster

Quantum Random Number Generator Using Homodyne De-

tection — •Christian Gabriel[1], Ruifang Dong[1], Christoffer Wittmann[1], Christoph Marquardt[1], Ulrik L. Andersen[1,2], and Gerd Leuchs[1] — [1]MPI für die Physik des Lichts, Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Günther-Scharowsky-Strasse 1, 91058 Erlangen, Germany — [2]Department of Physics, Technical University of Denmark, Building 309, 2800 Lyngby, Denmark

True random number generators are essential for quantum key distribution systems. We investigate a quantum random number generator using homodyne detection. For this we compare measured data of anti-squeezed, squeezed and coherent beams, and analyze the randomness of the signals with various standardized test suits. In addition, we exploit the continuous variable nature of the states to extract more bits per measurement value than in usually used single photon counting methods.

Q 30.37 Di 16:30 VMP 9 Poster

Quantum Information Processing with Atoms in Arrays of Dipole Potentials — Jens Kruse, Malte Schlosser, Christian Gierl, Christoph Ewen, •Peter Schauss, and Gerhard Birkl — Institut für Angewandte Physik, Technische Universität Darmstadt, Schloßgartenstr. 7, 64289 Darmstadt

The coherent control of the internal and external quantum states of ultra-cold neutral atoms represents an important experimental approach towards quantum information processing. In our experiment, we use two-dimensional arrays of optical micro-potentials created by micro-fabricated lens arrays as the architecture for a scalable quantum processor. For the qubit manipulation, we apply coherent Raman coupling to the hyperfine ground states of the trapped ^{85}Rb atoms.
Due to the large lateral separation of neighbouring potential wells our high resolution detection system allows for the determination of atom numbers of separated trap sites.
We demonstrate the versatile site-selective addressability by implementing a liquid crystal display as a spatial light modulator (SLM) in front of a microlens array. By this we control the depth of each potential well separately and produce arbitrary atom distributions. Furthermore we use the SLM to pattern the intensity distribution of our laser field for qubit manipulation and demonstrate the flexible site-specific initialization and coherent manipulation of separated qubits in two-dimensional trap arrays.

Q 30.38 Di 16:30 VMP 9 Poster

Fabrication and characterization of rubidium micro cells — •Thomas Baluktsian[1], Christian Urban[1], Thomas Bublat[2], Harald Kübler[1], Jim Shaffer[3], Robert Löw[1], Harald Giessen[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart Germany — [2]4. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart Germany — [3]The Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, Norman, OK, 73019

Small glass cells filled with rubidium vapor are promising candidates for QIP based on a blockade mechanism between Rydberg atoms. In order to realize e.g. single photon sources based on vapor cells, cell dimensions in the order of the length scale of the Rydberg-Rydberg interaction ($\approx 5\ \mu m$) are required.
We present a method how to fabricate spectroscopy micro cells filled with rubidium vapor. In these cells the rubidium vapor is either confined to a 2D (quantum well) or a 1D (quantum wire) geometry. We performed measurements with a confocal microscope on structures ranging from 10 to 100 μm. Two photon excitation (5S $\rightarrow$ 6D) provides a fluorescence signal that was spectrally analyzed. Wall induced spin changing processes could be identified.

Q 30.39 Di 16:30 VMP 9 Poster

Entanglement distribution between a trapped atom and two photons — •Stephan Ritter, Bernhard Weber, Holger P. Specht, Tobias Müller, Jörg Bochmann, Martin Mücke, David L. Moehring, and Gerhard Rempe — Max-Planck-Institut fü Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

While atoms make an excellent qubit for the storage of quantum states, photons are naturally well suited for the distribution of quantum information. Therefore efficient atom-photon interfaces are an important prerequisite for distributed quantum computing networks.

Here, we report on the implementation of a deterministic entanglement protocol. In a first step, entanglement between a single atom trapped within a high-finesse optical cavity and an emitted photon is created. Subsequently, the atomic quantum state is mapped onto a second photon, allowing for photon-photon entanglement. The entanglement has been verified using both a Bell inequality measurement and full quantum-state tomography [1].

Trapping of the atom within the cavity mode and repeated cooling stages result in an increase in the number of atom-photon entanglement events per atom by a factor of 10^5 compared to previous experiments [2]. In addition, the presence of exactly one atom in the cavity can be detected with greater than 99 % fidelity.

[1] B. Weber *et al.*, arXiv:0811.3612 (2008).
[2] T. Wilk *et al.*, Science **317**, 488 (2007).

Q 30.40 Di 16:30 VMP 9 Poster

Generation of Greenberger-Horne-Zeilinger (GHZ), W, and-cluster states using bimodal cavities — •Denis Gonta[1], Thomas Radtke[2], and Stephan Fritzsche[3] — [1]Max–Planck–Institut für Kernphysik, Postfach103980, D–69029 Heidelberg — [2]Institut für Physik, Universität Kassel,Heinrich-Plett-Str. 40, D-34132 Kassel — [3]Physikalisches Institut der UniversitätHeidelberg, Philosophenweg 12, D-69120 Heidelberg

In the framework of microwave cavity QED, we propose several schemes to engineer the entangled N-partite GHZ and W states [1] as well as the two-dimensional 2×N and 3×N cluster states. These states are produced between a chain of two-level Rydberg atoms in a deterministic way by using the bimodal cavities within the resonant atom-cavity interaction regime. In contrast to standard (single-mode) cavity schemes, such *bimodal* cavities possess two independent modes of the light field. In addition, we suggest some theoretical schemes to reveal the non-classical correlations of the entangled three- and four-partite GHZ and W states in order to ensure that no statistical (i.e. uncorrelated) mixtures of states have been produced. An extension of the scheme to produce two dimensional cluster states of arbitrary size is also possible.

[1] D. Gonta, S. Fritzsche, and T. Radtke, Phys. Rev. A **77**, 062312 (2008).

Q 30.41 Di 16:30 VMP 9 Poster

Kontrollierte Transporte in mikrostrukturierten Ionenfallen — •Frank Ziesel, Ulrich Poschinger, Gerhard Huber, Stephan Schulz, Amado Bautista, Markus Deiss, Kilian Singer und Ferdinand Schmidt-Kaler — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm

Mikrostrukturierte Paulfallen besitzen eine Vielzahl von separat ansteuerbaren Elektroden und erlauben damit einen frei definierbaren axialen Einschluss von einzelnen Ionen oder Ionenkristallen. Durch die zeitliche Änderung der Kontrollspannungen können Ionen transportiert und Ionenkristalle getrennt werden. Wir untersuchen die Eigenschaften von Mikrofallen in dreidimensionaler [1] und planarer Geometrie [2] in numerischen Simulationen, um den Einschluss von Ionen und deren Transport zu optimieren und vergleichen diese Ergebnisse mit Experimenten in einer 3D und einer 2D Mikro-Ionenfalle. Dort konnten wir die Eigenschaften des Fallenpotentials über den gesamten Transportweg spektroskopisch untersuchen. Die numerischen Simulationen stimmen mit den Messungen bis auf weniger als 2% überein. Von besonderem Interesse sind hierbei Kreuzungen in einer Ionenfalle, ebenso wie Übergänge in geometische Strukturen mit Abmessungen von wenigen μm.

[1] S. Schulz et al., New J. Phys. **10**, 045007 (2008)
[2] R. Reichle et al., Fortschr. Phys. **54**, 666 (2006)

Q 30.42 Di 16:30 VMP 9 Poster

Hocheffiziente cw-Biphotonen-Strahlquellen für die Quantenspektroskopie — •Michael Seefeldt, Andreas Jechow, Axel Heuer und Ralf Menzel — Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Straße 24/25, D-14476 Potsdam.

Paare von verschränkten Photonen, sogenannte Biphotonen, zeichnen sich durch nichtklassische Eigenschaften aus. Sie bilden damit die Basis für eine Vielzahl von Experimenten der Quantenoptik. Für die vorgestellten Untersuchungen wurden Biphotonen mit Hilfe der *parametric down-conversion* (PDC) in verschiedenen periodisch gepolten $LiNbO_3$-Kristallen (PPLN) generiert.

Mit der ersten, sehr kompakten Strahlquelle konnten mittels eines frequenzverdoppelten Halbleiterlasers (Anregungswellenlänge 488 nm) in einem PPLN-Wellenleiter Biphotonen in einem räumlichen Mode erzeugt werden. Der maximale Photonenfluss beträgt bei einer Anregungsleistung von 15 mW über 10^{11} Photonenpaare pro Sekunde. Dies entspricht einer Effizienz von $8 \cdot 10^{-6}$. Die Wellenlänge dieser Biphotonenquelle ist in einem Bereich um 976 nm durchstimmbar.

Bei der zweiten Strahlquelle wurde das Anregungslicht eines Ar^+-Lasers (488 nm) in einen Bulk-PPLN eingestrahlt. Es ließen sich $1{,}7{\cdot}10^{11}$ Photonenpaare pro Sekunde mit einer Wellenlänge von 976 nm und einer spektralen Bandbreite von 25 nm nachweisen. Bei einer maximalen Pumpleistung von 100 mW ergibt dies eine Konversions-Effizienz von ca. 10^{-6}.

Es wurden jeweils die spektralen Verläufe, Photonenflüsse sowie Korrelationseigenschaften des erzeugten PDC-Lichts gemessen.

Q 30.43 Di 16:30 VMP 9 Poster

Photon counting with fiber-coupled superconducting single photon detectors — •Gesine Steudle[1], Sander Dorenbos[2], Ingmar Müller[1], Valery Zwiller[2], and Oliver Benson[1] — [1]Humboldt-Universität zu Berlin, AG Nano-Optik, Germany — [2]TU Delft, Kavli Institute of Nanoscience, Netherlands

One of the main challenges of fiber-based single photon devices is the efficient and feasible detection of single photons at telecommunication wavelengths. Especially for quantum communication and quantum cryptography this point is crucial. A promising approach is the use of superconducting single photon detectors. In our case these detectors consist of a small NbN wire which is arranged in a meander. Wires are 5 nm thick and 100 nm wide and the meander area covers $10\mu m \cdot 10\mu m$. To provide optimal coupling to the experimental setup a single mode optical fiber is glued directly on the detector chip. Presently, we archieve system efficiencies of 10% (in the visible). Single photon detection was shown measuring the intensity correlation function of a single photon source. The main advantages of this type of detectors are high count rates of the order of 1 GHz, a time resolution below 100 ps, a low dark cout rate, and reasonable quantum efficiencies in the IR. Furthermore, the fixed fiber coupling provides easy handling of the detector unit.

Q 30.44 Di 16:30 VMP 9 Poster

Phase modulation of single photons — •Eden Figueroa, Jörg Bochmann, David Moehring, Martin Mücke, Christian Nölleke, Stephan Ritter, Holger Specht, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Garching

Recently, photonic sources with the capability to tailor the bandwidth of single photons have been developed. Using either DCLZ schemes in atomic ensembles or atoms trapped in QED cavities the production of long photons (as compared to the detection time) has been achieved. The production of photons with these characteristics enables the high frequency modulation of the photon shape, opening interesting avenues for research [1]. In this work we extend these ideas, by studying the effect of phase modulation in the interference of two photons produced by atoms trapped in a QED cavity. One single photon is sent through a fiber electro-optical modulator, and the result of the applied phase change is studied via its interference with a second un-modulated reference photon. If no modulation is introduced, a Hong-Ou-Mandel behavior is expected. Interestingly, if a phase change is applied within the photon envelope, the coalescence behavior of the interference can be altered. This scheme can be applied in the context of quantum key distribution as proposed by Inoue et al. [2], and might compare favorably to the latter, since intrinsically it does not require phase stability.

[1] P. Kolchin, et al. Phys. Rev. Lett. 101, 103601 (2008)
[2] K. Inoue et al. Phys. Rev. Lett. 89, 037902 (2002)

Q 30.45 Di 16:30 VMP 9 Poster

Generation of Narrow-Band Polarization-Entangled Photon Pairs for Atomic Quantum Memories — •Xiao-Hui Bao[1,2], Yong Qian[1], Jian Yang[1], Han Zhang[1], Zeng-Bing Chen[1], Tao Yang[1,2], and Jian-Wei Pan[1,2] — [1]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China — [2]Physikalisches Institut der Universitaet Heidelberg, Philosophenweg 12, Heidelberg 69120, Germany

We report an experimental realization of a narrow-band polarization-entangled photon source with a linewidth of 9.6 MHz through cavity-enhanced spontaneous parametric down-conversion. This linewidth is comparable to the typical linewidth of atomic ensemble based quantum memories. Single-mode output is realized by setting a reasonable cavity length difference between different polarizations, using of temperature controlled etalons and actively stabilizing the cavity. The entangled property is characterized with quantum state tomography, giving a fidelity of 94% between our state and a maximally entangled state. The coherence length is directly measured to be 32 m through two-photon interference.

Q 30.46 Di 16:30 VMP 9 Poster

Shaped Single Photons from a Coupled Atom-Cavity System — •David Moehring, Jörg Bochmann, Martin Mücke, Bernhard Weber, Holger Specht, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

We report on the fast excitation and subsequent single photon emission of a single atom trapped and coupled to a high-finesse optical cavity [1]. In contrast to the simple exponential decay governing free-space emission, the coupled atom-cavity system evolves with a coherent oscillatory energy exchange between the atom and the cavity. We record the shape of the emitted single photons and investigate the dependence on detuning of the cavity with respect to the atomic resonance. The observed oscillatory behavior is in excellent agreement with theory and illustrates the fundamentals of cavity quantum electrodynamics at the single particle level. Our technique opens up new perspectives for shaping single-photon wave packets as well as new possibilities for quantum networking experiments.

[1] J. Bochmann et al., Phys. Rev. Lett. 101, 223601 (2008).

Q 30.47 Di 16:30 VMP 9 Poster

Towards Nanoemitters Coupled to Surface Plasmons in Metal Nanostructures — •Thomas Aichele[1], Oliver Benson[1], Nils Nüsse[2], and Bernd Löchel[2] — [1]Humboldt-Universität zu Berlin, Inst. Physik, Nanooptik, Berlin, Germany — [2]Helmholtz-Zentrum Berlin f. Materialien und Energie, Anwenderzentrum f. Mikrotechnik, Berlin, Germany

We discuss and present initial experimental results towards the implementation of individual quantum emitters into surface plasmon (SP) waveguide structures. The SP waveguides are made of metal nanostructures on a dielectric surface using electron beam lithography and lift-off. Nanowire quantum dots and diamond nanocrystals are considered as individual quantum emittes. These systems can be translated across the substrate surface using scanning probe microscopy. They are thus precisely positioned on a nanometer scale relative to the metal nanostructures. In this way, a highly compact single-photon device, integrated in on-chip quantum optics experiments can be realized.

Q 30.48 Di 16:30 VMP 9 Poster

Quantum interference and entanglement in flux qubits — •Keyu Xia, Mihai Macovei, Jörg Evers, and Christoph H. Keitel — MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Superconducting qubits, and in particular flux qubits, are promising candidates for a number of applications in quantum information science. In this work, we discuss different aspects of quantum interference and entanglement in flux qubits.

First, we propose a robust coherent control scheme for the creation of Bell states of two coupled flux qubits via a dynamic control of the qubit transition frequency near their optimal point [1]. Using this technique, an arbitrary superposition of different Bell states composed of the collective ground and excited states can be achieved. The preparation is robust against imperfections in the driving fields.

Secondly, we discuss ground state cooling of a nanomechanical resonator. Our approach is to make use of quantum interference via coupling it to a flux qubit. This flux qubit is modeled as a $\Lambda-$type three-level system, enabling the use of electromagnetically induced transparency to implement the ground state cooling. We find ground state occupations of more than 90% in the steady state. Interestingly, compared to sideband cooling of the resonator, a contribution proportional to the initial phonon number of the nanomechanical resonator is suppressed by a factor of the detuning.

[1] K. Xia, M. Macovei, J. Evers, and C. H. Keitel, arXiv:0810.2453

Q 30.49 Di 16:30 VMP 9 Poster

The Riemann ζ-Function in Phase Space — •Cornelia Feiler, Rüdiger Mack, and Wolfgang P. Schleich — Institute for Quantum Physics, Ulm University

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

We propose a new physical approach to the Riemann ζ-function. We consider the states of an harmonic oscillator with a logarithmic cou-

pling to an external field. With an appropriate projection we obtain the values $\zeta(s)$ for $\Re s > 1$. With the help of an entangled system, similar to the Jaynes-Cummings-Model [3], we managed to reach into the critical strip, where the non-trivial zeros of the ζ-function are expected to be.

[1] E. C. Titchmarsh. *The Theory of the Riemann Zeta-Function*. Oxford, Charlendon Press, 1967.
[2] Wolfgang P. Schleich. *Quantum Optics in Phase Space*. Wiley-VCH Verlag, Berlin, 2001.

Q 30.50 Di 16:30 VMP 9 Poster

Raman spectroscopy of a single ion coupled to a high-finesse optical cavity — •Andreas Stute[1,2], Helena G. Barros[1,2], Tracy Northup[1], Carlos Russo[1], Piet O. Schmidt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, A-6020 Innsbruck

We describe an ion-based cavity-QED system consisting of a single trapped $^{40}Ca^{+}$ ion coupled to the mode of a high-finesse optical resonator. Intra-cavity photons are generated in a vacuum-stimulated Raman process between two atomic states driven by a laser and the cavity vacuum field. We observe Raman spectra for different excitation polarizations and find quantitative agreement with theoretical simulations. We can resolve motional sidebands in the Raman spectrum due to the residual motion of the Doppler-cooled ion, which also leads to ion delocalization with respect to the standing wave of the catvity mode. The detection of the photons leaving the cavity through one of the mirrors in a Hanbury Brown and Twiss setup allows the measurement of light intensity and its correlations $g^{(2)}(\tau)$. For a pulsed excitation the $g^{(2)}(\tau)$ reveals the signature of a single photon source, whereas for continuous excitation we can tune the photon statistics from sub-Poissonian to super-Poissonian statistics. This system offers prospects for cavity-assisted resolved-sideband ground-state cooling and coherent manipulation of ions and photons.

Q 30.51 Di 16:30 VMP 9 Poster

Development of a cold atom cavity quantum electrodynamics experiment using tunable bottle microresonators — •Danny O'Shea, Alexander Rettenmaier, and Arno Rauschenbeutel — Abteilung QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We recently developed a novel type of whispering gallery mode resonator that confines light by a mechanism similar to the confinement of electrons or ions in a magnetic bottle. Our "bottle resonators" confine light in mode volumes measuring as small as 1000-1500 μm^3 and can store light for up to ~ 160 ns. This corresponds to a quality factor of 3.6×10^8 at caesium or rubidium wavelengths. Calculations indicate an atom-field coupling rate deep within the so-called strong coupling regime. In contrast to other monolithic structures, such as photonic crystals and microtori, our bottle resonators can be tuned to any desired atomic transition, making them much more amenable to quantum optics experiments. We set up an apparatus to deliver cold rubidium atoms to the location of the bottle resonator using an atomic fountain. The current status of our experiment is presented and we show first results towards the active stabilization of the bottle resonator to an atomic resonance.

Financial support by the DFG, the Volkswagen Foundation, and the ESF is gratefully acknowledged.

Q 30.52 Di 16:30 VMP 9 Poster

Role of entanglement in open system dynamics — •Ansgar Pernice and Walter Strunz — Institut für Theoretische Physik, TU Dresden

When two previously independent quantum systems interact, the total state will almost always become entangled. We expect this to be true also for "open" quantum systems that interact weakly with their "heat baths": system and environment become entangled. Nevertheless, it is interesting to note that the usual description of (Markovian) open quantum system dynamics in quantum optics, solid state or chemical physics rests on an assumption of separability of the total state. Moreover, most instances of decoherence – despite the usual parlance that it results from entanglement – may perfectly be understood without entanglement. In this project we want to investigate in more detail the role of system-environment entanglement in quantum optical and solid state devices, where the heat bath is provided by either light or phonon modes. The influence of temperature and the nature of the presumably oberserved entanglement (bound or free) will be of particular interest.

Q 30.53 Di 16:30 VMP 9 Poster

Collisional-induced emergence of a pointer basis — •Marc Busse and Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwigs-Maximilians-Universität München

The influence of environmental degrees of freedom on a quantum system typically leads to a super-selection of a specific set of robust system states, called pointer states. Most characteristically, any superposition of these states gets rapidly mixed, while the only stable states are the pointer states themselves.

By using a specific unravelling of the master equation of collisional decoherence [1], we study the emergence and dynamics of pointer states in the motion of a quantum test particle in a gas environment. We demonstrate that the complete set of pointer states is obtained by the solitonic solutions of the nonlinear equation corresponding to the deterministic part of the orthogonal unravelling [2]. They move according to the corresponding classical equations of motion. In contrast to linear coupling models, the pointer basis turns out to be non-Gaussian, with a width determined by both the mean free path and the thermal de-Broglie wavelength of the gas environment. By analyzing the jump statistics of the orthogonal unravelling we further derive the statistical weights of the pointer states in the decohered ensemble, which are found to be given by their overlap with the initial state.

[1] K. Hornberger et. al., Phys. Rev. A 70, 053608 (2004).
[2] L. Diosi, Phys. Lett. 114A, 451 (1986).

Q 30.54 Di 16:30 VMP 9 Poster

Experimental demonstration of spin squeezing on the clock transition — •Patrick Windpassinger, Daniel Oblak, Ulrich Hoff, Jürgen Appel, Niels Kjaergaard, and Eugene S. Polzik — QUANTOP, Niels Bohr Institute, Copenhagen, Denmark

The so-called projection noise of an ensemble of uncorrelated atoms is a current limitation to the precision of atomic clocks. In recent experiments on dipole trapped ensembles of Cs atoms in an equal superposition of the clock states we have observed the quantum projection noise by interrogations using off-resonant probe laser light. Since the dispersive light-atom interaction has a quantum nondemolition measurement character we can use the information gained when applying a probe pulse of light to predict the outcome of a subsequent measurement beyond the standard quantum limit. Hence a reduction or "squeezing" of the population difference is encountered. Since a two-level quantum system is equivalent to a spin 1/2 particle this is referred to a pseudo-spin squeezing. The observation of squeezing implies that the particles in the ensemble are non-classically correlated (entangled). When taking into account decoherence resulting from spontaneously scattered probe photons our experiments show about 3 dB of spectroscopically relevant squeezing (noise reduction).

[1] D. Oblak et al., Phys. Rev. A 71, 043807 (2005)
[2] P. Windpassinger et al, Phys. Rev. Lett. 100, 103601 (2008)
[3] J. Appel et al., arXiv:0810.3545 (2008)

Q 30.55 Di 16:30 VMP 9 Poster

Asymptotic dynamics of random unitary channels — •Jaroslav Novotny[1,2], Gernot Alber[2], and Igor Jex[1] — [1]Department of Physics, FJFI CVUT, Prague, Czech Republic — [2]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany

We investigate random unitary channels and their asymptotic dynamics under repeated application. It is demonstrated that, despite the fact that random unitary channels are typically not normal, their asymptotic dynamics are determined completely by their eigenspaces associated with eigenvalues of unit modulus. We also investigate first implications of this general result for the asymptotic dynamics of quantum networks consisting of arbitrary numbers of qubits which are coupled by randomly applied controlled-not operations.

Q 30.56 Di 16:30 VMP 9 Poster

Transmission properties of microresonators coupling to multi-level atoms — •Sandra I. Schmid and Jörg Evers — MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Microresonators offer the possibility to achieve strong coupling between atoms and light fields. For example, in [1,2] strong coupling between a toroidal microresonator and a two-level atom was achieved. The light is fed into the resonator via a tapered glass fiber. Internal reflections form pairs of counterpropagating whispering gallery modes inside the resonator. Atoms can be coupled to these circulating fields via the evanescent field component leaking out of the resonator. Such couplings have an influence on the photon flux that leaves the resonator.

Here, we investigate a system where a three-level atom couples to a microresonator. Each of the atomic transitions couples to one pair of modes within the resonator. In this setup, the position dependence and the polarizations of the light fields have to be considered. We are interested in the impact of the atom on the output photon flux. Our observables are photon intensity and spectrum as well as correlations among different photon modes.

[1] B. Dayan et al., Science 319, 1062 (2008)
[2] T. Aoki et al., Nature 443, 671 (2006)

Q 30.57 Di 16:30 VMP 9 Poster

Towards efficient single photon-atom coupling in free space — •Andrea Golla, Robert Maiwald, Simon Heugel, A. S. Villar, Klaus Mantel, Norbert Lindlein, Markus Sondermann, and Gerd Leuchs — Institut für Optik, Information und Photonik (IOIP), Universität Erlangen-Nürnberg, Staudtstr. 7/B2, 91058 Erlangen

Efficient coupling between light and matter is desirable for quantum information applications as well as for fundamental research. Here we report about the progress of our experiment that aims at efficient excitation of a single ion by a single photon in free space. We discuss several important aspects of the experiment which include: the development and testing of an optically highly accessible ion trap, the choice of the ionic species, the generation of the optimum dipolar radiation pattern by use of a parabolic mirror as well as the correction of the interferometrically measured aberrations of a parabolic mirror.

Q 30.58 Di 16:30 VMP 9 Poster

Spatial high-precision measurements in quantum optical systems — •Qurrat- ul-Ain and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Accurate measurement of the position of a quantum particle or of distances between quantum particles are a subject of long-standing interest in quantum mechanics. A particular class of schemes to measure interparticle distance on a scale short as compared to the involved light wavelengths is based on dipole-dipole interactions between the particles [1,2]. This interaction affects the optical properties and this can be detected in the optical far field.

Here, we present a scheme for the measurement of the distance between two nearby identical atoms via the collective resonance fluorescence. We are in particular interested in a realistic description requiring as little prior knowledge about the system as possible. In contrast to previous work, we consider four-level atoms with complete Zeeman manifolds. Thus, we take into account the usual dipole-dipole couplings that couple the parallel dipole moments as well as the so far mostly neglected couplings between orthogonal dipole moments in the two atoms [3]. A consequence of including these orthogonal dipole-dipole couplings is that those atomic levels may also be populated which are not driven by laser fields.

[1] C. Hettich et al., Nature 298, 385 (2002).
[2] Jun-Tao Chang, Jörg Evers, Marlan O. Scully, and M. S. Zubairy, Phys. Rev. A 73, 031803(R) (2006).
[3] G. S. Agarwal and A. K. Patnaik, Phys. Rev. A 63, 043805 (2001).

Q 30.59 Di 16:30 VMP 9 Poster

Multiphoton absorption in BTO crystals — •Andrew Matusevich and Vladislav Matusevich — Institute of Applied Optics, Friedrich-Schiller-University, Max-Wien-Platz 1, 07743 Jena, Germany

We present experimental and theoretical investigations of the multiphoton absorption in photorefractive BTO crystals. A model for impurity centers characterized by different lifetimes is proposed to explain the dynamics of the photo-induced absorption. Cw-radiation as well as ns- and ps- pulses at 355nm, 532nm are used to investigate non-linear photoinduced absorption processes and show their bistable behaviour. We suppose that the multiphoton absorption in photorefractive crystals can be used for detection of ultra short pulses.

Q 30.60 Di 16:30 VMP 9 Poster

Fabrication and characterization of photonic structures on ultrathin optical fibers — •Christian Wuttke[1], Angelika Sehrbrock[2], Stephan Irsen[2], and Arno Rauschenbeutel[1] — [1]Abteilung QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz — [2]Forschungszentrum caesar, Labor für Elektronenmikroskopie und Analytik, Ludwig-Erhard-Allee 2, 53175 Bonn

We present experimental results on the fabrication and characterization of photonic structures on ultrathin optical fibers. They are realized from standard optical fibers which are flame heated while simultaneously pulling to produce a waist with a diameter of 500 nm. The photonic structure is then carved out of the ultrathin part of the fiber using focused ion beam milling (FIB). The optical properties are spectrally characterized by transmission and reflection measurements. Our current focus lies on the improvement of the periodicity and the reflectivity of the photonic structures and their use for realizing ultra-low mode-volume optical microresonators.

Financial support by the Volkswagen Foundation and the ESF is gratefully acknowledged.

Q 30.61 Di 16:30 VMP 9 Poster

Fabrication and utilization of fiber-based Fabry-Perot resonators in ultra-thin fiber applications — •Andreas Jöckel, Christian Wuttke, and Arno Rauschenbeutel — Abteilung QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We present experimental results on the fabrication and utilization of fiber-based Fabry-Perot resonators. The Fabry-Perot fiber resonators are realized by applying dielectric mirrors in the form of so-called transfer coatings to the end facets of standard optical fibers. With these resonators we observe finesses up to 130 in agreement with the mirror reflectivity of about 98%. An ultra-thin fiber part can be integrated into these resonators by flame heating and elongating the fiber yielding waist diameters down to 500 nm and finesses of 50. These resonators can be used to precisely characterize the loss of the tapered section as well as to enhance the sensitivity of spectroscopic techniques which rely on the ultra-thin fiber's evanescent field. In addition, it is possible to create pure higher order beams by using a multi-mode fiber resonator as a transversal mode filter. These higher order beams are useful in various applications including a new type of atom trap based on ultra-thin fibers [1].

Financial support by the Volkswagen Foundation and the ESF is gratefully acknowledged.

[1] G. Sagué, A. Baade, and A. Rauschenbeutel, New J. Phys. **10**, 113008 (2008).

Q 30.62 Di 16:30 VMP 9 Poster

Optimierung eines nichtlinearen optischen Schleifenspiegels zur Amplitudenregeneration — •Tobias Röthlingshöfer[1], Klaus Sponsel[1], Christian Stephan[1], Georgy Onishchukov[1,3], Bernhard Schmauss[2,3] und Gerd Leuchs[1,3] — [1]Max-Planck-Institut für die Physik des Lichts, Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg — [2]Optische Hochfrequenztechnik und Photonik, Universität Erlangen-Nürnberg — [3]Erlangen Graduate School in Advanced Optical Technologies (SAOT)

Phasenkodierte Modulationsformate werden in der optischen Datenübertragung zunehmend eingesetzt. Durch nichtlineare Effekte in Übertragungsfasern, wie Selbstphasenmodulation, wird jedoch Amplitudenrauschen in nichtlineares Phasenrauschen umgewandelt und beeinträchtigt so besonders phasenkodierte Signale.

Mit Hilfe eines modifizierten Faser-Sagnac Interferometer, z.B. eines dispersionsunbalancierten Schleifenspiegels, ist die Amplituden-Regeneration von phasenkodierten optischen Datenformaten, wie z.B. differentielle Phasenumtastung möglich. Somit wird die Entstehung nichtlinearen Phasenrauschens bei der Signalausbreitung in Übertragungsfasern unterdrückt, ohne dass die Phasenkodierung der Daten zerstört wird. Mittels numerischer Simulationen wurden verschieden modifizierte Sagnac Interferometer hinsichtlich ihrer Regenerationscharakteristik untersucht und miteinander verglichen.

Q 30.63 Di 16:30 VMP 9 Poster

Observation of double-charge vortex solitons in hexagonal photonic lattices — •Dennis Göries[1], Bernd Terhalle[1], Patrick Rose[1], Tobias Richter[2], Tristram J. Alexander[3], Anton S. Desyatnikov[3], Wieslaw Krolikowski[3], Friedemann Kaiser[2], Yuri S. Kivshar[3], and Cornelia Denz[1] — [1]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Germany — [2]Institut für Angewandte Physik, Technische Universität Darmstadt, Germany — [3]Nonlinear Physics Center and Laser Physics Center, Research School of Physical Sciences and Engineering, Australian National University, Canberra, ACT 0200, Australia

Wave propagation in periodic nonlinear structures is associated with many exciting novel opportunities of controlling light for future applications in all-optical information processing. A well known example is the existence of discrete self-localized states, e. g. discrete solitons or more complex discrete vortex solitons carrying phase dislocations and transverse energy flows. In this work, we present the experimental observation of stable double-charge ringshaped vortex solitons generated in optically-induced photorefractive photonic lattices, and corroborate our results by numerical simulations using the full anisotropic photorefractive model. We demonstrate that the stability is determined by intersite power exchange, and show that for a focusing nonlinearity single-charge vortices are unstable whereas double-charge vortices are stable . The results are subsequently extended to the case of a defocusing nonlinearity and reveal that in this case the single charge vortex is stable whereas the double-charge vortex is unstable.

Q 30.64 Di 16:30 VMP 9 Poster

Optimizing the excitation of plasmonic waveguide modes by a nanoantenna — •Jing Wen and Peschel Ulf — MPI für die Physik des Lichts, Erlangen, Germany

Plasmonic waveguides can be regarded as key elements of a future optical integration on a sub-wavelength scale. Hence, their coupling to the macroscopic world namely their excitation remains a challenging task. Here we propose to use nanoantennas to achieve that goal. We performed numerical simulations of the excitation of a plasmonic gap waveguide by a dipole antenna, which is attached to it. The coupling efficiency is strongly influenced by the properties of both the antenna and the plasmonic waveguide. For an optimized configuration the coupling efficiency of the antenna-based excitation can be more than 100 times larger than that without antenna. Surprisingly this optimization can to some extend be performed by using arguments from classical microwave theory as e.g. impedance matching.

Q 30.65 Di 16:30 VMP 9 Poster

Characterisation of single nano-structures with highly focused beams — •Sabine Dobmann, Peter Banzer, Ulf Peschel, and Gerd Leuchs — MPI für die Physik des Lichts, IOIP FAU Erlangen

The optical investigation of sub-wavelength nano-structures becomes more and more important since those will form the building blocks of new optical materials. Those so-called metamaterials gain their rather counter-intuitive properties mainly from the excitation of electric and magnetic resonances in the individual nano-structures which form this 'artifical matter'. For the investigation of these resonances we use highly focused polarisation tailored light which provides a non-homogeneous polarisation distribution at a sub-wavelength scale. Pure longitudinal electric or magnetic field components are formed on-axis, depending on the chosen incoming polarisation structure (radial or azimuthal), while transverse electric and magnetic field components persist off-axis. By placing sub-wavelength nano-structures in the beam different coupling scenarios can be achieved. By choosing beams with the respective polarization pattern structures can be selectively exposed either to pure electric or magnetic fields. To characterize the excited resonances of the nano-structures, we measure the forward- and back-scattered intensities and check for the polarisation distribution of the transmitted or reflected far-fields.