Q 53: Poster: Quantum Optics and Photonics III

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

Q 53.1 Thu 17:00 P OGs

Topological phases and dynamics of topological excitations in the one-dimensional super-lattice Bose Hubbard model with non-local interactions — •Rui Li, Dominik Linzner, and Michael Fleischhauer — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

We investigate Mott insulating phases of the one-dimensional super-lattice Bose-Hubbard model (SL-BHM) with local and next-nearest-neighbor interactions at fractional fillings. In an infinite system the ground state of this model is degenerate and the different ground states can be distinguished by a topological quantum number. In a finite system with periodic boundary conditions, incommensurate with the filling of the bulk ground state, domain walls appear, which are topological excitations. We calculate the phase diagram of the extended SL-BHM and analyze the dynamics of such topological excitations using time-evolving block decimation (TEBD) simulations. We discuss potential applications of the topological excitations for robust information transport.

Q 53.2 Thu 17:00 P OGs

Absence of topological order in open non-interacting bosonic systems — •Christopher Mink, Lukas Wawer, Dominik Linzner, and Michael Fleischhauer — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

In recent years, systems with topological order have attracted interest, as they have been associated with exotic, strongly correlated quantum states and can possess protected edge states. However, these fascinating features are not robust against dissipation. In previous investigations [1], we found that the winding of the many-body polarization remains a viable topological invariant for open quantum systems. Waveguide technology can be used to realize non-interacting bosonic systems with topological band structure [2,3]. Thus it is instructive to study the topology of these systems in particular. By characterizing steady states using correlations, we can express the polarization for non-interacting, i.e. Gaussian fermionic and bosonic systems in terms of the one-body correlation matrix. We show that non-interacting fermionic systems can in general exhibit a non-trivial winding of polarization, while the same does not hold true for bosonic systems.

[1] D. Linzner et. al., Phys. Rev. B 94, 201105(R) (2016).
[2] M. Hafezi et. al., Nat. Photonics 7, 1001 (2013).
[3] M. C. Rechtsman et. al., Nature (London) 496, 196 (2013).

Q 53.3 Thu 17:00 P OGs

Towards a hybrid quantum system: ultrafast ionization of a Bose-Einstein condensate — Tobias Kroker[2,3], •Steffen Pehmöller[2], Bernhard Ruff[2,3], Juliette Simonet[1,3], Philipp Wessels[1,3], Markus Drescher[2,3], and Klaus Sengstock[1,3] — [1]Zentrum für Optische Quantentechnologien, Hamburg, Germany — [2]Institut für Experimentalphysik, Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

The combination of ultracold atomic systems and ultrafast laser pulses promises insight into the coherence properties of macroscopic dissipative quantum systems and enables the preparation of hybrid quantum systems through local ionization of atoms in strong laser fields. Here, we report on our progress in setting up a quantum gas machine where the ultracold gases are optically transported into the focal region of the femtosecond laser beam. Our setup aims for counting ions while detecting the impact pattern of the photoelectrons. Furthermore, we report on quantitative studies of strong-field ionization of a Bose-Einstein condensate via loss measurements and pulsed momentum transfer due to dipole forces.

Q 53.4 Thu 17:00 P OGs

Magnetic field control for new periodic driving schemes in optical lattices — •Tobias Klafka, Alexander Ilin, Julius Seeger, Christoph Ölschläger, Juliette Simonet, and Klaus Sengstock — Institut für Laserphysik, Universität Hamburg

For quantum gas experiments, an improved control over the magnetic field allows implementing new driving schemes for Floquet engineering. In particular, this becomes important when internal atomic states are coherently coupled. In spin-dependent hexagonal lattices, magnetic fields can be used to open the Dirac cones in a controlled manner.

We report on the setup of an active compensation for stray magnetic fields which can be implemented in nearly any quantum gas experiment. DC and AC magnetic fields can be attenuated below 1mG for frequencies up to 1kHz. The magnetic field stability has been characterized using Ramsey spectroscopy of a Bose-Einstein condensate.

Q 53.5 Thu 17:00 P OGs

Observation of parametric resonances in 1D shaken optical lattices — •Jakob Näger[1,2], Karen Wintersperger[1,2], Martin Reitter[1,2], Ulrich Schneider[3], and Immanuel Bloch[1,2] — [1]Ludwig-Maximilians-Universität München, Schellingstr. 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching — [3]University of Cambridge, Cambridge, UK

We study a BEC of 39K with tunable interactions in a shaken 1D optical lattice. Due to the interplay between the external drive and interactions dynamical instabilities arise [1]. The short-time dynamics can be captured by parametric resonances within Bogoliubov theory, which should lead to a fast decay of the BEC. At long times, the behavior will be dominated by collision processes described by a Fermi's Golden rule approach that slow down the decay. Varying the shaking parameters and interactions, we observe the transition between the two heating regimes. Moreover, we can identify the onset of the parametric instabilities at short times by analysing the 2D quasimomentum distribution of the excited atoms.

[1] S. Lellouch et al., arXiv:1610.02972v1 (2016)

Q 53.6 Thu 17:00 P OGs

Cavity-induced supersolidity and its elementary excitations — •Philip Zupancic, Julian Leonard, Andrea Morales, Tilman Esslinger, and Tobias Donner — ETH Zürich, Zürich, Schweiz

We report on the first coupling of a Bose-Einstein condensate to two optical cavities. The combination of self-organisation processes with discrete symmetries in each cavity gives rise to one enhanced, continuous symmetry. When this U(1) symmetry is broken, a supersolid emerges – a state of matter that is both crystalline and superfluid. We provide evidence for both key properties. The light fields leaking from the cavities allow real-time observation of crystal movements. We investigate the mode spectrum of our supersolid phase and present measurements on the mode softening at the phase transition and the paired Nambu-Goldstone/amplitude modes inside the phase.

Q 53.7 Thu 17:00 P OGs

Towards Raman coupling induced 2D spin-orbit coupling for ^{87}Rb — •Sebastian Bode, Felix Kösel, Holger Ahlers, Naceur Gaaloul, and Ernst M. Rasel — IQ Universität Hannover

Presentation of the experimental steps towards synthesizing 2D Spin-orbit-coupling in a spinor Rubidium Bose-Einstein condensate.

Cyclically coupling the hyperfine Zeeman states via Raman transitions, will create an effective gauge field [1], resembling the ones in spintronic systems [2]. Such artificial interactions offer rich ground state dynamics and allow the realization of advanced solid state simulators with non-Abelian character in a versatile cold-atom system.

[1] L. Huang et al., Nature Physics 12, 540-544 (2016).
[2] H. C. Koo et al., Science 325, 1515 (2009).

Q 53.8 Thu 17:00 P OGs

Deterministic Loading of Arbitrary Potentials — •Romain Müller, Robert Heck, Otto Eliasson, Jens Laustsen, Aske Thorsen, Jan Arlt, and Jacob Sherson — Aarhus Universitet, Denmark

The ability to detect and manipulate single atoms in optical lattices [1,2,3] and the deterministic loading of atoms into tweezers [4,5,6] has opened the doors for novel types of experiments.

In this poster we present our route to combine single atom control in optical lattices and deterministic loading into smooth or periodic arbitrary potentials using multiple digital micromirror devices (DMD) in combination with a quantum gas microscope. This should allow to simulate various quantum phenomena and to study the dynamics in different systems, like in ring lattices. Due to the high speed of the

DMDs (10kHz frame rate), they will also allow incorporating the players' results of our game 'Quantum moves' to test the quantum speed limit [7].

[1] W. Bakr et al., Nature 462, 74-77
[2] J. Sherson et al., Nature 467, 68-72
[3] C. Weitenberg et al., Nature 471, 319-324
[4] A. Kaufman et al., Nature 527, 208-211
[5] D. Barredo et al., Science Vol. 354, Issue 6315, pp. 1021-1023
[6] M. Endres et al, Science Vol. 354, Issue 6315, pp. 1024-1027
[7] J. Sørensen et al, Nature 532, 210-213

Q 53.9 Thu 17:00 P OGs

Non-equilibium BCS state in a Fermi gas — •Alexandra Behrle, Timothy Harrison, Martin Link, Andreas Kell, Kuiyi Gao, and Michael Köhl — Physikalisches Institut, University of Bonn, 53115 Bonn, Germany

Ultracold Fermi gases with tunable interactions have been widely used to investigate the BEC-BCS crossover in the last decade and superfluidity of Fermi gases with different interactions have shown a variety of rich physics. So far, the focus of research has mainly been on the equilibrium state of an attractive gas of cooper pairs. Non-equilibrium coherent dynamics of the BCS state was proposed for studying collective modes, pair formation and excitations in superconductivity, however, experimental realization has been hindered by the difficulty of performing fast enough changes in to the system. In this talk, we will show our efforts in preparing and detecting a non-equilibrium BCS-superfluid of fermionic 6Li atoms. We focus on the coherent dynamics with fast modulation and quenched interactions using fast ramps across the Feshbach resonance.

Q 53.10 Thu 17:00 P OGs

Spin and Charge Correlation Measurements in the 2D Hubbard Model — Jan Drewes[1], Luke Miller[1,2], Eugenio Cocchi[1,2], Chun Fai Chan[1], Nicola Wurz[1], •Marcell Gall[1], Daniel Pertot[1], Ferdinand Brennecke[1], and Michael Köhl[1] — [1]Physikalisches Institut, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany — [2]Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, United Kingdom

We experimentally study the emergence of correlations in an ultracold, fermionic 2D lattice system, representing a realisation of the Hubbard model. Our ability to precisely tune the system parameters over a large range and the possibility to simultaneously detect the density distribution of both spin components in-situ enables us to examine the emergence of density and spin correlations as a function of doping interaction strength and temperature. In addition we gain from the measurement of the equation of state insight into the full thermodynamics of the 2D Hubbard model. To improve our preparation and detection capabilities, we use a spin spiral technique which allows us to detect the spin structure factor at arbitrary wave vectors. Further we employ a spatial light modulator to reshape the underlying trapping potential of the optical lattice to realize the homogeneous Hubbard model and reach lower temperatures by redistributing entropy between different spatial regions.

Q 53.11 Thu 17:00 P OGs

BEC of ^{41}K in a Fermi Sea of ^{6}Li — Rianne S. Lous[1,2], Isabella Fritsche[1,2], •Fabian Lehmann[1,2], Michael Jag[1,2], Emil Kirilov[1,2], Bo Huang[1], and Rudolf Grimm[1,2] — [1]IQOQI, Austrian Academy of Science, Innsbruck, Austria — [2]Inst. for Experimental Physics, University of Innsbruck, Innsbruck, Austria

We report on the production of a double-degenerate Fermi-Bose mixture of ^{6}Li and ^{41}K. In our experimental sequence the potassium atoms are sympathetically cooled by the lithium atoms, which are evaporatively cooled in an optical dipole trap. We obtain 10^4 ^{41}K atoms with a BEC fraction close to 1 and a $T/T_F \approx 0.05$ with 10^5 ^{6}Li atoms in each spin state. To measure the temperature of our fermionic sample we use the ^{41}K BEC as a tool for thermometry. As the system is in thermal equilibrium we evaluate the condensed fraction of our ^{41}K atoms and extract the temperature of the atoms. To investigate the properties of the ^{6}Li-^{41}K mixture near the inter-species Feshbach resonance at 335.8 G we use another scheme of evaporation around 300 G which enables us to achieve similar temperatures. We explore both the repulsive side and attractive side of the Feshbach resonance and observe phase separation for strong repulsive interactions and collapse for attractive interactions. This work is supported by the Austrian Science Fund FWF within the SFB FoQuS.

Q 53.12 Thu 17:00 P OGs

Probing Many-body physics with an ultra-narrow clock transition in an Ytterbium quantum gas — •Bodhaditya Santra[1], Benjamin Abeln[1], Bastian Hundt[1], André Kochanke[1], Thomas Ponath[1], Anna Skottke[1], Klaus Sengstock[1,2], and Christoph Becker[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

During the last decade ultracold fermionic alkaline earth quantum gas attracted a lot of attention due to their unique properties such as long-lived meta-stable state, an ultra-narrow optical clock transition, SU(N) symmetric interactions as well as the existence of an interorbital Feshbach resonance. In particular fermionic Yb quantum gas allow for quantum simulation of lattice systems with orbital degrees of freedom, like the Kugel-Khomskii model or the Kondo lattice model (KLM).

We will present recent progress of the Hamburg Yb experiment towards realizing the KLM and correlated KLM, including measurements on spin polarized as well as on interacting Fermi gases with an improved clock laser setup.

This work is supported by the DFG within the SFB 925 and the Marie Curie Initial Training Network QTea.

Q 53.13 Thu 17:00 P OGs

Local control of transport in an atomic quantum wire: from one scanning gate to a finite size lattice — •Samuel Häusler[1], Martin Lebrat[1], Dominik Husmann[1], Laura Corman[1], Sebastian Krinner[1], Shuta Nakajima[2], Jean-Philippe Brantut[1], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zürich, 8093 Zürich, Switzerland — [2]Department of Physics, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan

Building on the holographic shaping of optical potentials and a high-resolution microscope, we demonstrate the local control of fermionic lithium atoms flowing through a one-dimensional structure. We first image the transport through a quantum wire, in a way similar to the scanning gate technique applied to solid state devices. By scanning the position of a sharp, repulsive optical gate over the wire and measuring the subsequent variations of conductance, we spatially map the transport at a resolution close to the transverse wavefunction inside the wire. The control of the gate at the scale of the Fermi wavelength makes it sensitive to quantum tunnelling. Furthermore, our knowledge of the optical potential allows a direct comparison of the experimental maps with a numerical and an analytical model for non-interacting particles.

The flexibility offered by our setup makes it relatively simple to imprint more complex structures. By projecting several consecutive scatterers, a lattice of variable length can be built inside the quantum wire. This opens the path to study metal-insulator physics with strong attractive interactions.

Q 53.14 Thu 17:00 P OGs

Interacting Anyons in a One-Dimensional Optical Lattice — •Martin Bonkhoff, Kevin Jägering, Sebastian Eggert, and Axel Pelster — State Research Center OPTIMAS and Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We analyze in detail the properties of the one-dimensional Anyon-Hubbard model, which can be mapped to a corresponding Bose-Hubbard model with a density-dependent Peierls phase via a generalized Jordan-Wigner transformation [1]. At first we extend the modified version of the classical Gutzwiller-mean-field ansatz of Ref. [2] in order to obtain the pair-correlation function for both the bosonic and the anyonic system. A comparison of the resulting quasi-momentum distributions with high-precision DMRG calculations reveals in general a parity breaking, which is due to anyonic statistics. Afterwards, we determine how the boundary of the superfluid-Mott quantum phase transition changes with the statistical parameter. We find in accordance with Ref. [1] that the statistical interaction has the tendency to destroy superfluid coherence.

[1] T. Keilmann, S. Lanzmich, L. McCulloch, and M. Roncaglia, Nat. Commun. **2**, 361 (2011)
[2] G. Tang, S. Eggert, and A. Pelster, New J. Phys. **17**, 123016 (2015)

Q 53.15 Thu 17:00 P OGs

Creating topological interfaces and detecting chiral edge modes in a two-dimensional optical lattice — •Frederik

Görg[1], Nathan Goldman[2], Gregor Jotzu[1], Michael Messer[1], Kilian Sandholzer[1], Rémi Desbuquois[1], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zurich, Zurich, Switzerland — [2]CENOLI, Université Libre de Bruxelles, Brussels, Belgium

The appearance of topological properties in lattice systems caused by a non-trivial topological band structure in the bulk is closely related to the existence of chiral edge modes via the bulk-edge correspondence. These edge states appear at the interface of two spatial regions with a distinct topology, which for example naturally arise at the boundaries of a sample surrounded by vacuum. In cold atom systems, these edge modes are difficult to detect, since the underlying harmonic trapping potential does not feature sharp boundaries. Therefore, we propose a different method to design topological interfaces within the bulk of the system. We illustrate this scheme by an optical lattice realization of the Haldane model, where a spatially varying lattice beam leads to the appearance of distinct topological phases in separated regions of space. The versatility of the method allows to tune the position, the localization length and the chirality of the edge modes. We numerically study the propagation of wave packets in such a system and demonstrate the feasibility to experimentally detect chiral edge states. Finally, we show that the edge modes, unlike the bulk states, are topologically protected against the effects of disorder, which makes a random potential a powerful tool to detect edge states in cold atom setups.

Q 53.16 Thu 17:00 P OGs

Transport dynamics in optical lattices with flux — •Ana Hudomal[1], Ivana Vasić[1], Walter Hofstetter[2], and Antun Balaž[1] — [1]Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany

Recent cold atom experiments have realized artificial gauge fields in periodically modulated optical lattices [1,2]. We study the dynamics of atomic clouds in these systems by performing numerical simulations using the full time-dependent Hamiltonian and comparing these results to the semiclassical approximation. Under constant external force, atoms in optical lattices with flux exhibit an anomalous velocity in the transverse direction. We investigate in detail how this transverse drift is related to the Berry curvature and Chern number, taking into account realistic experimental conditions.

[1] G. Jotzu et al., Nature **515**, 237 (2014).
[2] M. Aidelsburger et al., Nature Phys. **11**, 162 (2015).

Q 53.17 Thu 17:00 P OGs

Towards the investigation of collective scattering in nanofiber-trapped atomic ensembles — •Adarsh S. Prasad, Jakob Hinney, Samuel Rind, Philipp Schneeweiss, Jürgen Volz, Christoph Clausen, and Arno Rauschenbeutel — TU Wien - Atominstitut, Stadionallee 2, 1020 Wien, Austria

We realize an efficient optical interface between guided light and laser-cooled atoms which are arranged in two linear arrays in a two-color evanescent-field dipole trap created around an optical nanofiber [1]. In this configuration, the probability of a nanofiber-guided photon being absorbed and then re-emitted into free space by a trapped atom is as high as 10%. For a periodic array of atoms, interference of the fields scattered by different atoms result in a collective emission into a cone with a well-defined angle with respect to the fiber axis. We plan to study this collective emission and its dependence on various experimental parameters. The next step will be to adjust the periodicity of the atomic array to fulfill the Bragg condition such that fiber-guided light is strongly back-reflected [2]. Here, the interaction between the atomic array and the fiber-guided light depends strongly on the polarization of the light field. In particular, light that is polarized in (orthogonal to) the plane of atoms will be weakly (strongly) reflected. We want to implement such highly reflecting atomic arrays, which could then be used to implement cavity quantum electrodynamics experiments in which the resonator itself is made of quantum emitters.

[1] E. Vetsch et al., Phys. Rev. Lett. 104, 203603 (2010).
[2] Fam Le Kien et. al., Phys. Rev. A 90, 063816 (2014).

Q 53.18 Thu 17:00 P OGs

Setup of a new micro-structured linear Paul trap with integrated solenoids and reduced axial micromotion — •H. Siebeneich, D. Kaufmann, T. Gloger, P. Kaufmann, M. Johanning, and ch. Wunderlich — Department Physik, Universität Siegen, 57068 Siegen, Germany

We present the status of a new 3d segmented ion trap setup with integrated solenoids, in which an improved design allows for a substantial reduction of axial micromotion and for an increased magnetic gradients. Our trap consists of three layers of gold plated alumina, where the segmented outer layers provide the trapping potentials [1], and the middle layer contains solenoids that are used to create a magnetic field gradient [2]. The gradient gives rise to coupling between the ions' internal and motional states. The trap is mounted on a ceramic chip carrier that, at the same time, acts as an ultra-high vacuum interface, featuring about 100 thick-film printed current and voltage feedthroughs. The thick film interface has been improved by replacing previously used Ag-Pd layers by Au layers which reduced their resistivity by a factor of eight. The previously high resistivity used to be a a bottleneck for achieving high solenoid currents and thus a magnetic gradient. The shape of the solenoids was redesigned, leading to an expected reduction of axial micromotion by four orders of magnitudes.
[1] S.A. Schulz et al.: Sideband cooling and coherent dynamics in a microchip multi-segmented ion trap, New Journal of Physics, Volume 10, April 2008 [2] D. Kaufmann et al.: Thick-film technology for ultra high vacuum interfaces of micro-structured traps, Appl Phys B (2012) 107:935-943

Q 53.19 Thu 17:00 P OGs

Design and construction of a Perpetual Atom Laser Machine — •Chun-Chia Chen, Shayne Bennetts, Benjamin Pasquiou, and Florian Schreck — Institute of Physics, University of Amsterdam, Amsterdam, The Netherlands

We have developed a machine aimed at producing a perpetual atom laser, a long standing goal within atomic physics. Continuous production of Bose-Einstein condensate (BEC) or an atom laser requires two incompatible cooling processes, laser cooling a gas sample, then cooling evaporatively until degeneracy is reached. In order to produce a perpetual output these stages take place simultaneously in different parts of our machine. To protect the condensate from scattered photon heating we use a combination of physical separation, baffles and a "transparency" beam. Our machine has now demonstrated a perpetual MOT of 2×10^9 ^{88}Sr atoms with temperatures as low as 20μK on a 7.4-kHz wide laser cooling transition with a continuous loading rate of 7×10^8 atoms/s. Using a different set of parameters and location we have also demonstrated a perpetual MOT of 2×10^8 ^{88}Sr at 2μK with a loading rate of 9×10^7 atoms/s which we have successfully loaded into a dipole trap. By switching to the 0.5% abundance ^{84}Sr isotope we are able to evaporate to BECs of 3×10^5 ^{84}Sr atoms. Critically, for the second location we have validated the effectiveness of our architecture in protecting a BEC from scattered broad-linewidth laser cooling light, which is used in the first cooling stages. We will describe our design and the performance demonstrated so far.

Q 53.20 Thu 17:00 P OGs

Optical 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 an optical lattice clock employing the $^1S_0$ - $^3P_0$ transition. Another interesting venue is the formation of ultra cold Hg-dimers employing photo-association and achieving vibrational cooling by employing a special scheme.

The laser system is based on an interference-filter stabilized external cavity diode laser with excellent spectral properties combined with a home built non-cryogenic fiber amplifier for the 1015nm fundamental wavelength with a slope-efficiency of more than 35 % delivering up to 4W of pump limited output power. The fundamental wavelength is frequency doubled twice to reach the cooling transition at 253.7 nm. The challenging requirements meeting the natural linewidth of 1.27 MHz are mastered by use of a ULE reference resonator.

After integrating a 2D-MOT as an atom source to the vacuum system the first measurements of ultra-cold atoms with the new laser system will be reported.

Q 53.21 Thu 17:00 P OGs

Diffusion of Single Atoms in Bath — •Daniel Adam, Farina Kindermann, Tobias Lausch, Daniel Mayer, Felix Schmidt, Steve Haupt, Michael Hohmann, Nicolas Spethmann, and Artur Widera — TU Kaiserslautern, Department of Physics, Kaiserslautern, Germany

Diffusion is an essential phenomenon occurring in various systems such as biological cells, traffic models or stock markets. While most systems are well described by standard Brownian motion, anomalous diffusion can lead to markedly different dynamical properties.

Experimentally, we study the diffusion of individual atoms illuminated by near-resonant light and trapped in a periodic potential. All relevant parameters such as damping coefficient and potential hight can be controlled in order to realize different diffusive regimes.

We explore the amount of information contained in the Kramers rate, i. e. the rate at which a diffusing atom can escape from a potential well. Furthermore we exploit the excellent control over the optical trapping potential and study the diffusion of the atom in a time-varying periodic trap, complemented by numerical simulations of the dynamics.

Q 53.22 Thu 17:00 P OGs

Kinetic Monte Carlo simulation of percolation in driven-dissipative Rydberg gases — •Stephan Helmrich, Philipp Fabritius, Graham Lochead, and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Directed percolation is perhaps the most prominent example of a unique class of phenomena which exhibit genuine non-equilibrium phase transitions and non-trivial critical behaviour. We explore whether highly tunable gases of ultracold atoms excited to long-range interacting Rydberg states can serve as a clean experimental realisation of percolation phenomena in two and three dimensions. The mechanism investigated is the cooperative excitation of Rydberg atoms triggered when the excitation laser is resonant for atoms within a characteristic distance of another Rydberg atom (facilitated excitation). To simulate the dynamics of this system we use a kinetic Monte Carlo algorithm which is able to reproduce many of the experimental features of laser excited Rydberg gases. We investigate the scaling behavior for the fraction of Rydberg excitations (active sites) and their spatial correlations, both at steady-state and following a sudden quench from the inactive to the active phase. Based on these observations we can address whether percolation can realistically be studied in driven-dissipative systems of ultracold Rydberg atoms.

Q 53.23 Thu 17:00 P OGs

Simulation of many-body spin dynamics using Rydberg atoms — •Renato Ferracini Alves, Miguel Ferreira-Cao, Vladislav Gavryusev, Sebastian Geier, Andre Salzinger, Gerhard Zürn, Adrien Signoles, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Due to its long range interactions, ultracold Rydberg gases are a suitable platform for analog quantum simulation of many-body spin dynamics. This allows us to investigate, in a controlled environment, physical phenomena related to practical but less tunable systems, such as quantum magnetism in condensed matter materials. In our experiment we realize these spin models, by mapping two strongly interacting Rydberg states to two spin 1/2 states ($|n, l\rangle \rightarrow |\downarrow\rangle$ and $|n', l'\rangle \rightarrow |\uparrow\rangle$). We will present preliminary results of the characterization of this microwave-driven spin dynamics, through global variables, using a phase-controlled driving field. We measured a density-dependent damping of the magnetization, that we attribute to interactions, and observe that its dynamics cannot be fully explained by mean field approximations. Techniques such as Ramsey interrogation, spin locking and quantum state tomography, enabled by the phase control of the driving field, are used to characterize this magnetization dynamics in more detail.

Q 53.24 Thu 17:00 P OGs

Noise resistant coupling between Rydberg atoms and a superconducting cavity via dipole-dipole interactions — •Daniel Viscor[1], Wildan Abdussalam[1], József Fortágh[2], Antoine Browaeys[3], Thierry Lahaye[3], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany — [2]Physikalisches Institut der Universitat Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [3]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Univ Paris Sud 11, 2 Avenue Augustin Fresnel, F-91127 Palaiseau Cedex, France

We theoretically study the coherent exchange of a single photon between a superconducting microwave cavity and a lattice of strongly interacting Rydberg atoms in the presence of local electric field fluctuations plaguing the cavity surface. We show that despite the increased sensitivity of Rydberg states to electric fields, the Rydberg dipole-dipole interaction can be used to protect the system against the dephasing induced by the spurious fields. Using realistic noise models we show that compared to the case with non-interacting atoms, our system exhibits longer coherence lifetimes and larger retrieval efficiency of the photon after storing into the atoms.

Q 53.25 Thu 17:00 P OGs

Ultra cold dipolar ^{23}Na^{40}K molecules in Garching — Frauke Seesselberg[1], •Xin-Yu Luo[1], Nikolaus W. Buchheim[1], Zhenkai Lu[1], Immanuel Bloch[1,2], and Christoph Gohle[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Ludwig-Maximilians-Universität, Schellingstraße 4, 80799 München, Germany

Ultracold quantum gases with long-range dipolar interactions promise exciting new possibilities for quantum simulation of strongly interacting many-body systems like fractional Mott insulators and supersolid phases. Our experimental apparatus is capable of creating ultracold mixtures of sodium and potassium. Recently we succeeded to produce ultracold ^{23}Na^{40}K molecules in their rotational, vibrational and electronic ground state.

We discuss the experimental apparatus and experimental steps required to achieve this. In particular we investigate the Feshbach molecules creation from the ultracold atomic sample using RF-association near the 89G interspecies Feshbach resonance, efficient ground state transfer to the rovibronic molecular ground state using a stimulated Raman adiabatic passage employing the $\mathrm{d}^3\Pi(v = 5, J = 1, \Omega = 1)$ intermediate state which mixes with the $\mathrm{D}^1\Pi$ electronic state via spin orbit interaction and discuss the properties of the ground state such as it's lifetime and polarizability.

Q 53.26 Thu 17:00 P OGs

Optical transport of ultracold atoms for the production of groundstate RbYb — •Tobias Franzen, Bastian Pollklesener, Fabian Türck, Richarda Niemann, 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 measurements 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.

We employ optical tweezers to transport individually cooled samples of ultracold Rb and Yb from their separate production chambers to a dedicated science chamber. Here we transfer the atoms to a crossed dipole trap, where further evaporative cooling creates a starting point for the exploration of interspecies interactions and pathways towards ground state molecules.

[1] M. Borkowski et al., PRA 88, 052708 (2013)
[2] C. Bruni et al., PRA 94, 022503 (2016)

Q 53.27 Thu 17:00 P OGs

Cavity-controlled chemical reactions of ultracold atoms — Tobias Kampschulte[1], Limei Wang[1], •Guangming Liu[1], Andreas Köhn[2], and Johannes Hecker Denschlag[1] — [1]Inst. f. Quantenmaterie, Universität Ulm — [2]Inst. f. Theoretische Chemie, Universität Stuttgart

Ultracold molecules can be formed from ultracold atoms by photoassociation involving a spontaneous emission process, resulting in a number of final states. Here we want to use strong coupling to an optical cavity to selectively enhance the creation of a certain final state. During this process, a photon will be emitted into the cavity mode which can be detected. A collective enhancement of the effect would enable “superradiant chemistry”. Furthermore, we want to use the cavity for direct optical detection of ultracold molecules.

In the experiment, we are implementing an optical microcavity into an existing Rb BEC apparatus where Rb_2 molecules can be produced by magneto- and photoassociation.

The theoretical challenge lies in the precise calculation of molecular potential surfaces and optical transition moments, in particular for trimers and more complex molecules.

Q 53.28 Thu 17:00 P OGs

Optical formation of weakly-bound, fermionic ^{87}Rb^{87}Sr

molecules — •Alessio Ciamei, Vincent Barbé, Benjamin Pasquiou, and Florian Schreck — Institute of Physics, University of Amsterdam, Amsterdam, The Netherlands

We are pursuing the creation of ultracold RbSr ground-state molecules. In contrast to ultracold ground-state molecules created so far, RbSr molecules do not only have a large electric dipole moment (1.5 Debye), but also an unpaired electron. These properties give us a larger parameter space to tune interactions by applying electromagnetic fields, providing us with a path towards a quantum gas of ground-state molecules and quantum simulation. We present the creation of a ^{84}Sr-^{87}Rb Mott insulator, which is our starting point for molecule association using the Sr $^1S_0 \rightarrow {}^3P_1$ transition. We find that only very weak optical transitions to molecular states exist in this isotopic mixture, hindering us from coherently creating molecules. Using mass-scaling, our spectroscopy data points to a promising molecule association path in the ^{87}Sr-^{87}Rb mixture, which we indeed were recently able to find experimentally. Finally, we present a scheme for the efficient and coherent creation of long-lived, ultracold Sr_2 molecules, which exploits a light-shift compensation method. Together, our spectroscopy data for the ^{87}Sr-^{87}Rb mixture and our light-shift compensation technique, identify a path towards weakly-bound ^{87}Rb^{87}Sr molecules.

Q 53.29 Thu 17:00 P OGs

ATLIX - probing the wave nature of antiprotons — •Simon Müller[1], Andrea Demetrio[1], Pierre Lansonneur[2], Patrick Nedelec[2], and Markus K. Oberthaler[1] — [1]Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institut de Physique Nucléaire de Lyon, CNRS/IN2P3, 69622 Villeurbanne, France

The wave behavior of particles is a well accepted and experimentally verified phenomenon. It has been shown for several different species, ranging from electrons to very large organic molecules. Antimatter is expected to show the same behaviour, but experiments on the topic are still in progress. Here we present the current developments in the ATLIX project (Antiproton Talbot-Lau Interferometry eXperiment) where the defined goal is the realization of an antiproton interferometer at the CERN Antiproton Decelerator facility (AD).

The interferometer consists of three material gratings with nanometric periodicity and is planned to be suitable for antiprotons with energy up to 10 keV. A first prototype of the experiment is being carried out in Heidelberg with protons and neutral hydrogen in the 500 eV - 2 keV range. The results of these preliminary experiments will be presented.

Q 53.30 Thu 17:00 P OGs

Realistic simulation of expansion dynamics of an ultracold gas for atom interferometry — •Srihari Srinivasan and Reinhold Walser — Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4a, 64289 Darmstadt

The versatility of Bose-Einstein Condensates (BEC) in experiments has given rise to an entire genre of topics ranging from quantum optics and condensed matter physics to quantum simulators and sensors. The QUANTUS collaboration [1] aims to use atom interferometry with an ultracold ^{87}Rb gas in a compact, rugged module that is either dropped or catapulted inside a vacuum drop tower at ZARM in Bremen [2]. The experiment aims to use atom interferometry in micro-gravity under free fall to test Einstein's Equivalence Principle.

Expansion dynamics of a BEC is well understood analytically [3]. Interferometric fringe contrast of an expanding BEC is strongly influenced by the thermal component of the gas and anharmonicity of the release trap. We aim to realistically simulate the expansion of a BEC from the atom chip trap of QUANTUS-2 [1] by including elementary excitations and also anharmonicities of the release trap. This is done as part of a comprehensive simulation suite for a realistic atom interferometer being developed for comparison with experimental data.

[1] QUANTUS Collaboration:www.iqo.uni-hannover.de/quantus

[2] T. van Zoest et al., Science, **328**, 1540 (2010) and H. Mütinga et al., Phys. Rev. Lett., **110**, 093602 (2013).

[3] Yu Kagan et al., Phys. Rev. A, **54**(3), R1753 (1996) and Y Castin et al., Phys. Rev. Lett., **77**(27), 5315 (1996).

Q 53.31 Thu 17:00 P OGs

Cold quantum gases in adaptive scales — •Jan Teske and Reinhold Walser — Institut für Angwandte Physik, Technische Universität Darmstadt, Hochschulstraße 4A, Darmstadt, D-64289, Germany

The research field of the QUANTUS collaboration are ultracold quantum gases in weightlessness. These experiments are performed at the drop tower in Bremen (ZARM). During the free fall of several seconds the released Bose-Einstein condensate reaches macroscopic system sizes being used for precise measurements of accelerations and rotations [1, 2].

For the analysis of the complex matter wave-optics setup, we have developed a software package, *MatterWaveSim*, including classical ray tracing, beam splitter and magnetic chip trap simulations. In the present contribution we present appropriate numerical methods for Bose-Einstein condensates. We introduce introduce adaptive scales [3] for modelling finite temperature dynamics of an ultracold Bose gas. In particular we study the long time expansion and delta kick cooling with realistic magnetic chip traps.

[1] G. Nandi, R. Walser, E. Kajari, and W. P. Schleich. Dropping cold quantum gases on earth over long times and large distances. *Phys. Rev. A*, **76**, 063617 (2007).

[2] H. Müntinga *et al.* Interferometry with Bose-Einstein Condensates in Microgravity. *Phys. Rev. Lett.* **110**, 093602 (2013).

[3] Y. Castin, R. Dum. Bose-Einstein Condensates in Time Dependent Traps. *Phys. Rev. Lett.* **77** (1996).

Q 53.32 Thu 17:00 P OGs

Superconducting coherent electron beam sources and a compact matter wave interferometer for sensor applications — •Nicole Kerker, Andreas Pooch, Georg Schütz, Michael Seidling, Moritz Layer, Nicolas Seitz, and Alexander Stibor — University of Tübingen, Physical Institute, Quantum Electron - & Ion - Interferometry

In interferometry significant developments of novel techniques where made. They include coherent single atom tip field emitters or delay line detectors with high spatial and temporal resolution which allows correlation analysis. These techniques can be applied in electron interferometry to construct sensors with high sensitivity for rotations or the spectroscopy of vibrational and electromagnetic frequencies. The realization of such a sensor requires a highly coherent and intensive electron field emission source and a compact, robust and portable electron interferometer. Here, we present new developments towards these goals. Increasing electron beam coherence by simultaneously remaining a high intensity can in principle be achieved using niobium tips. Niobium gets superconducting below a temperature of 9.2 K and it has been demonstrated in the literature that the energy spread of the emitted electrons in this regime decreases significantly. We show first results in the preparation of such tips and the characterization of their field emission behavior. We present the design and realization of a compact and robust electron biprism interferometer. The setup can potentially be applied to realize a portable interferometer to test the coherent properties of novel beam emitters and for sensor applications.

Q 53.33 Thu 17:00 P OGs

Second-order correlation analysis for single particle interferometry with applications in sensor technologies — •Robin Röpke[1], Alexander Rembold[1], Georg Schütz[1], Andreas Günther[2], and Alexander Stibor[1] — [1]University of Tübingen, Physical Institute, Quantum Electron - & Ion - Interferometry — [2]University of Tübingen, Physical Institute, Nano Atomoptics

The high phase sensitivity of single particle interferometers makes them susceptible to dephasing perturbations such as mechanical vibrations and electromagnetic oscillations. They can decrease the spatial information and wash-out the interference pattern, leading to a loss of contrast. This is a problem for precision phase measurements especially the perturbing environment can never be perfectly shielded. We demonstrate a method to identify and correct multiple perturbation frequencies with different amplitudes by using spatial and temporal correlations. With a delay line detector we get the spatial and temporal information in a high resolution. This allows a correlation data analysis that significantly reduces the effects of dephasing and allows the reconstruction of the original spatial fringe pattern. We provide a full theoretical description based on second-order correlation theory combined with Fourier analysis. The theory is applied on measurement data from an electron interferometer that has been vibrationally disturbed and electromagnetically dephased by multiple simultaneous oscillations. We demonstrate that our method can extract unknown perturbation frequencies from a washed-out interference pattern which can be applied in sensor technology to analyze external frequencies.

Q 53.34 Thu 17:00 P OGs

Trade-off of atomic sources for extended-time atom interfer-

ometry — •Sina Loriani, Dennis Schlippert, Christian Schubert, Ernst Maria Rasel, and Naceur Gaaloul — Leibniz University of Hanover, Germany

Proposals for atom-interferometry based sensors designed to detect gravitational waves or testing the universality of free fall assume unprecedented sensitivity for long interferometry times [Hogan et al., Phys. Rev. A 94, 033632, (2016)]. These long drift times of several seconds can be achieved by operation in microgravity and by using phase-space-manipulation techniqes like the delta-kick-collimation(DKC), which drastically reduces the expansion rate of atomic samples [Müntinga, et al. Phys. Rev. Lett. **110**, 093602 (2013), T. Kovachy et al., Phys. Rev. Lett. **114**, 143004 (2015)]. We present a set of theoretical models that treat the impact of collisions and mean-field on the performance of the kick and compare the efficiency of the collimation for all possible temperature and density regimes. The theoretical study covers commonly used alkaline and alkaline-earth-like ensembles of atoms (Rb, Sr, Yb, etc.). The figure of merit is the size of the ensemble when being lensed as the atomic lenses are subject to aberrations depending on the spatial extent of the cloud and the potentials being used. The analysis shows a clear advantage when using condensed ensembles.

Q 53.35 Thu 17:00 P OGs

Theoretical study of Bose-Einstein condensates in optical lattices towards large momentum transfer atom interferometers — •Jan-Niclas Siemss[1], Ernst Maria Rasel[2], Klemens Hammerer[1], and Naceur Gaaloul[2] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Germany

Highly sensitive atom interferometers require the two interferometer arms to enclose a large area in spacetime.

In parallel to the implementation of large interrogation times in microgravity [1] and fountains [2], a larger spatial separation with large momentum transfer (LMT) enhances the sensitivity of atomic sensors. A promising method to realize these novel schemes is to combine Bragg pulses and Bloch oscillations in optical lattices to coherently split and recombine the atomic wave packets. However, the finite momentum width of the atomic ensemble or the damping of Bloch oscillations due to tunneling constrain the fidelity of the LMT.

We theoretically analyze the coherent acceleration of BECs in 1D optical lattices to understand and optimize pioneering experiments performed in the QUANTUS collaboration. To this end, a 1D-reduced Gross-Pitaevskii model[3] is adapted to interpret and propose realistic novel LMT schemes.

[1] H. Muentinga et al. Phys. Rev. Lett. 110, 093602 (2013)
[2] S. M. Dickerson et al. Phys. Rev. Lett. 111, 083001 (2013)
[3] L. Salasnich et al. Phys. Rev. A 66, 043613 (2002)

Q 53.36 Thu 17:00 P OGs

Fast BEC transport with atoms chips for inertial sensing — •Robin Corgier[1], Sirine Amri[2], Eric Charron[2], Ernst Maria Rasel[1], and Naceur Gaaloul[1] — [1]Leibniz University of Hanover, Germany — [2]Université Paris-Sud, France

Recent proposals in the field of fundamental tests of foundations of physics assume Bose-Einstein condensates (BEC) as sources of atom interferometry sensors. Atom chip devices have allowed to build transportable BEC machines with high repetition rates as demonstrated in the QUANTUS project. The proximity of the atoms to the chip surface is, however, limiting the optical access and the available interferometry time necessary for precision measurements. In this context, a fast and perturbation-free transport of the atoms is required. Shortcuts to adiabaticity protocols were proposed and allow in principle to implement such sequences with well defined boundary conditions. In this theoretical study, one can engineer suitable protocols to move atomic ensembles trapped at the vicinity of an atom chip by tuning the values of the realistic chip currents and external magnetic fields. Experimentally applicable trajectories of the atomic trap optimizing the transport time and reducing detrimental effects due to the offset of atoms positions from the trap center are found using a reverse engineering method. We generalize the method in order to optimize the size evolution and the center of a BEC wave packet in phase space. This allows an efficient delta-kick collimation to the pK level as observed in the Quantus 2 experiment. With such low expansion rates, atom interferometry experiments with seconds of drift time are possible.

Q 53.37 Thu 17:00 P OGs

Optical systems for BEC-based atom interferometry on the sounding rocket mission MAIUS-I — •André Wenzlawski[1], Kai Lampmann[1], Moritz Mihm[1], Ortwin Hellmig[2], Klaus Sengstock[2], Patrick Windpassinger[1], and the MAIUS team[1,2,3,4,5,6] — [1]Institut für Physik, JGU Mainz — [2]Institut für Laserpyhsik, U Hamburg — [3]Institut für Quantenoptik, LU Hannover — [4]ZARM, Bremen — [5]Institut für Physik, HU Berlin — [6]FBH, Berlin

Atom interferometry in space is gaining ever-increasing interest because of the accessible interrogation times exceeding what is possible on ground by orders of magnitude and thus allowing unprecedented sensitivities. This may enable more precise tests in fundamental physics like a test of the equivalence principle or detection of gravitational waves. As a first step towards realizing atom interferometry based precision measurements in space, the sounding rocket MAIUS-I was launched this winter from northern swedish Esrange demonstrating the technological and scientific feasibility of these kind of experiments.

Here we will present the optical system for the MAIUS-I experiment, used to cool and manipulate an ensemble of ^{87}Rb atoms as well as the scheme for autonomous frequency stabilization of the lasers with respect to a hyperfine transition of ^{85}Rb.

The MAIUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant numbers 50WM1131-1137.

Q 53.38 Thu 17:00 P OGs

Matterwave Sagnac interferometer using state dependent guiding of atoms in a ring trap. — •Fabio Gentile, Thomas Bishop, Jamie Johnson, Mark Bason, Sindhu Jammy, Tadas Pyragius, Hans Marin Florez, and Thomas Fernholz — The University of Nottingham - NG7 2RD - UK

We present an experimental procedure for the implementation af a matterwave rotation sensor. Recently many progresses have been achieved in atom-based Sagnac interferometry, such as improved sensitivity and elimination of dead times [1]. Differently from other experiments, in our scheme atoms are confined during all the interferometric sequence [2]. Instead of making use of free wave propagation, atomic clouds are steered around a ring trap in a controlled fashion [3,4]. This particular feature opens possibilities for miniaturization of the experimental apparatus towards the realization of compact devices.

[1] PhysRevLett.116.183003(5) (2016) [2] Proc. SPIE 9900, Quantum Optics, 990007 [3] PhysRevLett.115.163001(6) (2015) [4] PhysRevA.75.063406(6) (2007)

Q 53.39 Thu 17:00 P OGs

Atom Interferometry in Space — •Maike D. Lachmann[1], Dennis Becker[1], Stephan T. Seidel[1], Ernst M. Rasel[1], Wolfgang Ertmer[1], and Collaboration QUANTUS[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]LUH, JGU, UHH, FBH, HUB, ZARM, UULM, TUDA, DLR

Atom interferometry with Bose-Einstein condensates (BEC) in space is a promising approach towards a precise test of the equivalence principle. As a first step atom interferometers utilizing sounding rockets are currently being built within the QUANTUS collaboration. With the first rocket mission MAIUS-1 we plan to create BECs and to demonstrate light-pulse atom interferometry in space for the first time.

The presented apparatus uses Rubidium-87 atoms and can create BECs of 10^5 atoms within two seconds. Thanks to this high repetition rate we can perform more than 70 experiments during the six minutes of microgravity. They will adress different aspects of atom interferometry ranging from state preparation, observation of the phase transition to Stern-Gerlach type experiments and analysis of the coherence of a BEC after long free evolution times using magnetic lensing and atom interferometers.

Due to the high constraints of the rocket the payload is optimized in respect to volume, mass and low power consumption. The apparatus was qualified for the flight using vibrational tests and the launch is scheduled for the end of 2016.

On the poster the setup and the results of the MAIUS-1 flight will be presented.

Q 53.40 Thu 17:00 P OGs

Ultra-stable laser for a magnesium lattice clock — •Steffen Sauer, Steffen Rühmann, Dominka Fim, Klaus Zipfel, Nandan Jha, Waldemar Friesen, Pia Koopmann, Wolfgang Ertmer, and Ernst M. Rasel — Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland

One of the key elements for an optical frequency standard are ultra-stable lasers for probing narrow optical transitions. At IQ in Hanover, we are working towards development of an optical lattice clock based on bosonic magnesium [1]. In such clocks the atoms are trapped in optical lattices enabling Doppler- and recoil-free spectroscopy. This sets stringent requirements on the short term stability of the clock lasers performing the spectroscopy.
We report on the progress and performance of our ultra-stable laser system and its distribution to the interrogation chamber. The laser system interrogating the clock transition consists of a diode laser system at 916 nm stabilized to a high finesse cavity isolated from environmental perturbations. The light is transmitted via a 30 m long fiber to a second-harmonic generator (SHG) and frequency doubled to the clock transition wavelength at 458 nm. To suppress the frequency fluctuations induced by this 30 m long fiber, we have implemented an active fiber length stabilization system. Afterwards frequency doubled light is fed via another stabilized fiber to the atoms. Following various improvements we achieve an instability of 4×10^{-16} in 1 s for the laser itself, which is close to the calculated thermal noise floor level.

[1] Kulosa et al., Phys. Rev. Lett. **115**, 240801 (2015)

Q 53.41 Thu 17:00 P OGs

Collective effects in driving the ^{229}Th nuclear transition — •Brenden S. Nickerson and Adriana Pálffy — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The high accuracy of atomic clocks lies behind the success of the Global Positioning System, which requires synchronization of orbiting satellites for triangulation. More precise clocks are desirable for challenging Einstein's theory of general relativity or for Earth-observation satellites tracking the sea level, and would generally allow to push the bounds of observable physics. The unique lowest transition in the ^{229}Th nucleus with frequency in the vacuum ultraviolet (VUV) range and very narrow linewidth promises enhanced precision and amazing stability [1]. This level is a nuclear isomeric state at approx. 7.8 eV that can be reached by VUV lasers. A very exact measurement of the isomeric transition energy has been elusive, with the first confirmation of the level decay coming only recently [2].

Here we investigate the possibility to exploit collective effects in order to design a more sensitive nuclear excitation scheme in the process of scattering of light through a Th-doped crystal. The crystalline environment enforces the Mössbauer regime, allowing for recoil-free emission and absorption and collective behaviour [3]. By taking advantage of such effects we aim to resolve not only the transition energy but provide a clear signature of the excitation.

[1] W. G. Rellergert *et al.*, Phys. Rev. Lett. 104, 200802 (2010).
[2] L. von der Wense *et al.*, Nature 533, 47-51 (2016).
[3] W.-T. Liao *et al.*, Phys. Rev. Lett. 109, 262502 (2012).

Q 53.42 Thu 17:00 P OGs

Realization of magnesium optical lattice clock — •Nandan Jha, Dominika Fim, Klaus Zipfel, Steffen Rühmann, Steffen Sauer, Waldemar Friesen, Wolfgang Ertmer, and Ernst Rasel — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten-1, 30167 Hannover, Germany

Optical lattice clocks have already reached performance levels better than the best Cs fountain clocks. Magnesium with a high-Q $^1S_0 \rightarrow {}^3P_0$ optical transition and a small black body radiation shift is a promising candidate for an optical frequency standard. We present the progress towards the realization of such an optical lattice clock on the dipole forbidden $^1S_0 \rightarrow {}^3P_0$ transition of bosonic ^{24}Mg. The precision of our previous spectroscopy measurements of the $^1S_0 \rightarrow {}^3P_0$ clock transition [1] was limited by the line broadening (order of 10's of kHz) due to tunneling in the relatively shallow optical lattice, and spatial inhomogeneity of the magnetic field used to induce mixing between $^3P_0$ and $^3P_1$ states. We overcome these limitations by going to deeper lattice potential and hence reducing the atomic tunneling between the lattice sites. Further improvements in magnetic field stability and clock laser frequency distribution have allowed us to reduce the linewidth of the clock transition to around 100 Hz. This higher Q-factor enables a more precise measurement of the magic wavelength and the other systematic shifts.

[1] A. Kulosa et al., Phys. Rev. Lett. **115**, 240801 (2015).

Q 53.43 Thu 17:00 P OGs

Towards cavity enhanced magnetometry based on the infrared transition of NV centers in diamond — Himadri Chatterjee[1], •Andrew Edmonds[2], Alexander Bommer[1], Benjamin Kambs[1], and Christoph Becher[1] — [1]Universität des Saarlandes, Fakultät NT, Fachrichtung-Physik, Campus E2.6, 66123 Saarbrücken — [2]Element Six Ltd., Global Innovation Centre, Fermi Avenue, Harwell Oxford, Didcot OX11 0QR, UK

In recent years the nitrogen vacancy (NV) centers in diamond became a prime candidate for sensing applications. It can work e.g. as a sensor of electric and magnetic fields, pressure and temperature. The commonly used technique for sensing purposes is Optically Detected Magnetic Resonance (ODMR), which uses the red fluorescent light from the NV centers. The challenge in such a method is the low collection efficiency of fluorescence due to high refractive index of diamond, which traps most of the red fluorescence light inside the diamond sample by total internal reflection. Improving sensitivity thus requires improvement of the detection of spin selective fluorescence from the NV centers. To circumvent this problem and to achieve higher sensitivity alternative approach is to use the optical absorption of the infrared transition (1042 nm) in the singlet spin sates of the NV centers. At room temperature the homogeneous broadening of the infrared resonance reduces the absorption of an infrared probe laser. In this work we present work towards using a monolithic cavity to enhance the IR absorption in order to achieve highly sensitive magnetometer operation at room temperature.

Q 53.44 Thu 17:00 P OGs

Automatization of a spaceborne iodine frequency reference based on a diode laser at 1064 nm — •Franz Gutsch[1], Klaus Döringshoff[1], Vladimir Schkolnik[1,2], Markus Krutzik[1], Achim Peters[1,2], and The JOKARUS Team[1,2,3,4,5,6] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]FBH, Berlin — [3]ZARM U Bremen — [4]DLR Bremen — [5]JGU Mainz — [6]Menlo Systems GmbH

Spaceborne laser-based frequency references can deliver high accuracy and stability needed to further explore the foundational principles of General Relativity in future experiments, such as tests of the gravitational redshift or gravitational wave astronomy (e.g. eLISA).

We present a compact frequency reference based on Doppler-free MTS of molecular iodine at 532 nm, which is optimized for autonomous operation onboard a TEXUS sounding rocket starting fall 2017. Utilizing an externally frequency-doubled ECDL MOPA system, the JOKARUS mission poses new challenges on the automatization and reliable operation in harsh environments as well as providing a proof of concept for spaceborne operation. In this poster, we focus on system control and autonomy concepts as well as their possible merit for controlling similar optical clock setups.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy under grant number DLR 50WM 1646.

Q 53.45 Thu 17:00 P OGs

Near-field microwave control of trapped ions for scalable quantum simulation and quantum information processing — •G. Zarantonello[1,2], H. Hahn[1,2], S. Grondkowski[1], T. Dubielzig[1], F. Ude[1], M. Wahnschaffe[2,1], A. Bautista-Salvador[2,1], and C. Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]PTB, Bundesallee 100, 38116 Braunschweig

Recent experiments have shown promising approaches to quantum simulation and information processing with trapped ions using microwave fields rather than the commonly used focused laser beams. In one approach [1], the ion's internal states are coupled to motional states by means of microwave near-field gradients [2]. Here, we integrate a single conductor in a surface-electrode trap to generate the required near-field gradient [3]. We present finite element simulations of the magnetic field and show agreement with experimental results at the sub-micron and few-degree level within an intuitive field model [4]. We show the current experimental setup, present an enhanced, multi-layer ion trap and corresponding field simulations with improved near-field characteristics. We also discuss a new vacuum system with built-in Ar^+ bombardment for surface electrode cleaning to suppress motional heating.

[1] C. Ospelkaus *et al.*, Nature **476**, 181 (2011).
[2] C. Ospelkaus *et al.*, Phys. Rev. Lett. **101**, 090502 (2008).
[3] M. Carsjens *et al.*, Appl. Phys. B **114**, 243 (2014).
[4] M. Wahnschaffe *et al.*, arXiv:1601.06460v2 [quant-ph] (2016).

Q 53.46 Thu 17:00 P OGs

Anticoherence measures for spin states — •Dorian Baguette and John Martin — Institut de Physique Nucléaire, Atomique et de Spectroscopie, CESAM, Université de Liège, Bât. B15, B - 4000 Liège, Belgium

Among all possible spin states, spin-coherent states are the most classical because the spin expectation value in these states yields a vector of maximal norm pointing in a well defined direction $\mathbf{n}$. In contrast, anticoherent spin states to order t are such that $\langle(\mathbf{J}\cdot\mathbf{n})^k\rangle$ is independent of the unit vector $\mathbf{n}$ for $k=1,\ldots,t$ [1]. By construction, coherent and anticoherent spin states are at both ends of the spectrum of classicality. The aim of this work is to position all possible spin states on such a spectrum, that is to provide measures of anticoherence. To this aim, we introduce an axiomatic definition of anticoherence measures to any order t. In particular, we show that the total variance of a pure spin state, first introduced in [2], can be used to define a measure of anticoherence to order 1. We describe a systematic way of constructing anticoherence measures to any order that relies on the mapping between spin-j states and symmetric states of $2j$ spin-1/2. In particular, we exploit the fact that anticoherent spin states to order t have maximally mixed t-spin-1/2 reduced density matrices in the symmetric subspace [3].

[1] J. Zimba, Electron. J. Theor. Phys. **3**, 143 (2006). [2] A. A. Klyachko, B. Öztop, and A. S. Shumovsky, Phys. Rev. A **75**, 032315 (2007). [3] D. Baguette, T. Bastin, and J. Martin, Phys. Rev. A **90**, 032314 (2014).

Q 53.47 Thu 17:00 P OGs

Exact zeros of entanglement for arbitrary rank-two mixtures derived from a geometric view of the zero polytope — •Andreas Osterloh — Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg

Here I present a method how intersections of a certain density matrix of rank two with the zero-polytope can be calculated exactly. This is a purely geometrical procedure which thereby is applicable to obtaining the zeros of SL- and SU-invariant entanglement measures of arbitrary polynomial degree. I explain this method in detail for a recently unsolved problem. In particular, I show how a three-dimensional view, namely in terms of the Boch-sphere analogy, solves this problem immediately. To this end, I determine the zero-polytope of the three-tangle, which is an exact result up to computer accuracy, and calculate upper bounds to its convex roof which are below the linearized upper bound. The zeros of the three-tangle (in this case) induced by the zero-polytope (zero-simplex) are exact values. I apply this procedure to a superposition of the four qubit GHZ- and W-state. It can however be applied to every case one has under consideration, including an arbitrary polynomial convex-roof measure of entanglement and for arbitrary local dimension.

Q 53.48 Thu 17:00 P OGs

Continuous-variable quantum teleportation can enhance probabilistic discrete-variable quantum gates — •Fabian Ewert and Peter van Loock — Johannes Gutenberg-Universität Mainz

We propose a linear optical generalization of the probabilistic nonlinear sign-shift gate, presented by KLM [Nature 409, 46-52 (2001)] that approximates a strong self-kerr interaction up to the d-photon Fock state. Applying this highly probabilistic gate to the resource state of a continuous-variable quantum teleportation and replacing the standard correcting operation, i.e. a displacement, by a nonlinear displacement yields a nonlinear sign-shift gate on the input mode of the teleportation setup. By choosing d large enough and conditioning the teleportation accordingly, the success probability of this gate can be pushed above the 25% limit of the KLM gate while maintaining a near-unit fidelity. This can also be used to implement a controlled-SIGN gate with a probability higher than the current linear-optics maximum of 2/27.

Q 53.49 Thu 17:00 P OGs

Long-range Rydberg-blockade entangling gate mediated by auxiliary atoms — •Alexandre Cesa and John Martin — Institut de Physique Nucléaire, Atomique et de Spectroscopie, CESAM, Université de Liège, Bât. B15, B - 4000 Liège, Belgium.

Arrays of qubits encoded in the ground state manifold of trapped neutral atoms appear as a promising platform for the realisation of a scalable quantum computer. Indeed, such physical qubits have a long coherence time and allow for high-fidelity single-qubit operations [1]. In such a platform, entangling two-qubit gates can be implemented by exploiting the Rydberg-blockade mechanism to produce a phase shift or a flip of the state of a target atom conditioned on the state of a control atom [2]. However, because dipole-dipole interactions fall off rapidly with the interatomic distance, such entangling gates based on Rydberg-blockade are impractical between distant qubits. In this work, we propose a protocol to implement long-range Rydberg-blockade gates (CZ or CNot) using auxillary non-coding atoms to transfer the Rydberg excitation from the control to the target qubit. The dependence of the fidelity on the number of auxillary atoms, the blockade strength and the decay rates of the Rydberg states are determined. When compared to a sequential application of nearest neighbours entangling gates, our protocol leads to a larger fidelity and a reduction of the overall gate duration (which scales linearly with the number of auxillary atoms).

[1] M. Saffman, J. Phys. B: At. Mol. Opt. Phys. 49, 202001 (2016).
[2] D. Jaksch, J. I. Cirac, P. Zoller, S. L. Rolston, R. Côté, and M. D. Lukin, Phys. Rev. Lett. 85, 2208 (2000).

Q 53.50 Thu 17:00 P OGs

Entangling atoms over a large distance — •Robert Garthoff[1], Daniel Burchardt[1], Kai Redeker[1], Norbert Ortegel[1], Wenjamin Rosenfeld[1,2], and Harald Weinfurter[1,2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck-Institut für Quantenoptik, Garching

Entanglement between widely separated quantum systems is a key resource in various quantum communication protocols. These include the recently performed conclusive tests of Bell's inequality [1], quantum repeaters and device-independent quantum key distribution.

We present the experimental details on our system of two single Rb-87 atoms trapped in laboratories separated by a distance of 400 meters. Starting with atom-photon entanglement we employ the entanglement swapping protocol to generate heralded entanglement between the atoms. We discuss the issues of coherence time, long-term stability, quality of two-photon interference, and atomic state fidelity which are critical for using this system as a testing platform for a quantum repeater or device-independent protocols.

[1] arXiv:1611.04604 [quant-ph]

Q 53.51 Thu 17:00 P OGs

Quantum Receivers for Coherent Communication — •Sourav Chatterjee[1,2,3], Christian R. Müller[1,2], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]MPI for the Science of Light, Erlangen, Germany — [2]Department of Physics, FAU, Erlangen, Germany — [3]School in Advanced Optical Technologies, Erlangen, Germany

The impossibility of perfectly discriminating non-orthogonal states is vital for quantum key-distribution. In classical communication, however, it imposes strict constraints on the channel capacity. Along with the technological progress, the average optical power per symbol has been continuously decreasing and conventional receiver designs are approaching their sensitivity limit - the standard quantum limit (SQL). Quantum mechanics allows for a much lower error probability compared to SQL, the Helstrom bound. Optimal and near-optimal strategies have been experimentally demonstrated for binary phase-shift keying (PSK) [1]. For quadrature PSK, a hybrid receiver, based on a combination of homodyne- and single photon detection, was demonstrated to outperform the SQL for any signal power [2]. Moreover, a feedback supplemented strategy with photon number resolution technology was proposed [3], and research is in progress to realize it experimentally using FPGAs for real-time feedback. We review the recent progress on quantum receivers and compare different strategies on performance and robustness against technical imperfections.

[1] C. Wittmann et al., Phys. Rev. Lett. 101, 210501 (2008)
[2] C. R. Müller et al., New J. Phys. 14, 083009 (2012)
[3] C. R. Müller et al., New J. Phys. 17, 032003 (2015)

Q 53.52 Thu 17:00 P OGs

Integration of a high-speed continuous-variable quantum random number generator — Imran Khan[1,2], Christoph Pacher[3], •Jonas Pudelko[1,2], Momtchil Peev[4], Bernhard Schrenk[3], Winfried Boxleitner[3], Edwin Querasser[3], Christoph Varga[3], Philipp Grabenweger[3], Christoph Marquardt[1,2], and Gerd Leuchs[1,2,5] — [1]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [2]Institut of Optics, Information and Photonics, Friedrich-Alexander University Erlangen-Nuremberg (FAU), Staudtstr. 7/B2, 91058 Erlangen, Germany — [3]AIT Austrian Institute of Technology, Donau-City-Strasse 1, 1220 Vienna, Austria — [4]Huawei Technologies Duesseldorf GmbH, German Research Center, Riesstrasse 25, 80992 München — [5]Department of Physics, University of Ottawa, 25 Templeton, Ottawa, ON, Canada

Random numbers play an essential role in many applications, such as quantum key distribution, simulations and classical cryptography. In this work, we discuss the photonic and electronic integration of a quantum random number generator (QRNG) based on measurements on the quantum mechanical vacuum state. The experimental setup is based on an InP photonic integrated circuit, containing all required components on a 4 x 4.6 mm chip. This could give access to a portable and reliable QRNG potentially achieving rates in the GHz regime.

Q 53.53 Thu 17:00 P OGs

Generating entanglement between a trapped ion and the time-bin of a photon — •Konstantin Friebe[1], Moonjoo Lee[1], Dario A. Fioretto[1], Markus Teller[1], Klemens Schüppert[1], Florian R. Ong[1], Pierre Jobez[1], Florian Kranzl[1], Rainer Blatt[1,2], and Tracy E. Northup[1] — [1]Institut für Experimentalphysik, Universität Innsbruck, Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Innsbruck, Österreich

While small-scale quantum computers, e.g., based on trapped ions, are already in existence, scaling up to larger numbers of qubits proves technically challenging. One possible solution to this problem is a distributed quantum computer, consisting of several small-scale quantum computers, linked together in a quantum network. Such linking of separate quantum nodes is also a requirement for building quantum repeaters for long-distance quantum communication.

Here, we describe the current status of our quantum node at the Universität Innsbruck: we report on the implementation of a laser beam for addressing single ions in a crystal of multiple trapped ions, and describe a protocol and its implementation for the generation of entanglement between the electronic state of one trapped ion and the time-bin degree of freedom of a single photon. This protocol is an alternative to the more standard encoding of quantum information in the polarization degree of freedom of photons and can thus be used for systems in which well-defined photon polarization can not be achieved.

Q 53.54 Thu 17:00 P OGs

Silicon-Vacancy Color Centers in Diamond at Millikelvin Temperatures — •Alexander Stahl[1], Max Hettrich[1], Mathias Metsch[2], Michael Kern[2], Lachlan J. Rogers[2], Fedor Jelezko[2], and Ferdinand Schmidt-Kaler[1] — [1]WA Quantum, Johannes Gutenberg - Universität Mainz — [2]Institut für Quantenoptik, Universität Ulm

Color centers in diamond represent excellent qubits without the need for ultrahigh vacuum and complex lasersystems[1,2]. In particular, silicon-vacancy color centers feature very narrow optical transitions due to the conservation of the diamond crystal's inversion symmetry. This makes them excellent sources for indistinguishable photons, which can be used for entanglement distribution. However, the phonon-induced dynamic Jahn-Teller effect severely limits the ground-state spin coherence time to about 35 ns[3,4]. We are setting up an apparatus featuring a dilution refrigerator, which is able to cool a diamond sample together with a single-site resolving confocal microscope to Millikelvin temperatures, which is expected to increase that coherence time by several orders of magnitude. Possibilities for future extensions include photonic structures of the diamond around the color center for enhanced coupling and CQED applications.

[1] D. D. Awschalom et al., Science 339, 1174 (2013
[2] F. Jelezko et al., Phys. Rev. Lett. 92, 076401 (2004)
[3] L. J. Rogers et al., Phys. Rev. Lett. 113, 263602 (2014)
[4] B. Pingault et al., Phys. Rev. Lett. 113, 263601 (2014)

Q 53.55 Thu 17:00 P OGs

Generation and evaluation of entangled multipartite nuclear spin states — •Stefan Jesenski, Sebastian Zaiser, Johannes Greiner, Philipp Neumann, Durga Dasari, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Multipartite entangled states are key for many quantum information protocols. Generation of these states and their protection against various noise sources is quintessential for successful quantum computing and sensing applications. Here we discuss the generation and minimally invasive characterization of multipartite entangled nuclear spin states coupled to a single Nitrogen-Vacancy center (NV) in diamond. At low temperatures, resonant optical excitation of the NV becomes possible allowing for high fidelity projective spin readout and spin initialization. In combination with spin-lifetimes many orders of magnitude higher compared to ambient conditions, generation of multipartite entangled states becomes plausible by optical methods possibly assisted by microwave fields. We present a scheme and evaluate the fidelities involved in optimal generation and measurement of five qubit entangled states for realistic parameters.

Q 53.56 Thu 17:00 P OGs

Towards the realisation of an atom trap in the evanescent field of a microresonator — •Luke Masters, Elisa Will, Michael Scheucher, Adèle Hilico, Jürgen Volz, and Arno Rauschenbeutel — VCQ, Atominstitut, TU Wien, 1020 Vienna, Austria

Whispering-gallery-mode (WGM) resonators guide light by total internal reflection and provide ultra-high optical quality factors in combination with a small optical mode volume. Coupling a single atom to the evanescent field of a WGM microresonator thus allows one to reach the strong coupling regime [1]. Furthermore, such resonators provide chiral light-matter coupling which can be employed for realising novel quantum protocols [2] as well as nonreciprocal quantum devices [3]. However, trapping atoms in the evanescent field of such resonators has not yet been demonstrated, which severely limits the atom-resonator interaction time. We aim to trap single $85Rb$ atoms in the vicinity of a bottle-microresonator - a highly prolate type of WGM resonator. A standing wave optical dipole trap is created by retroreflecting a tightly focussed beam on the BMR surface (method similar to [4]). In order to load atoms into the trap, we employ an FPGA-based electronics which allows us to react in 150 ns to an atom arriving in the resonator field and thus to switch on the dipole trap. We will present first characterizations of our trap.

[1] C. Junge et al. Phys. Rev. Lett. 110, 213604 (2013),
[2] I. Shomroni et al. Science 345, 903 (2014),
[3] M. Scheucher et al. arXiv:1609.02492v1,
[4] J. D. Thompson et al. Science 340, 1202 (2013).

Q 53.57 Thu 17:00 P OGs

Fabrication of micro resonator mirrors using CO_2 laser — •Max Deisböck, Stefan Häussler, Andrea Kurz, Riccardo Cipolletti, and Alexander Kubanek — Institute for Quantum Optics, Ulm University, D-89081 Ulm, Germany

Cavity QED is a highly innovative and fast growing field. It investigates the interaction between optical transitions of single atoms and light within an optical resonator. In former times this would just have been a textbook example. In the meantime there was tremendous technological progress e.g. in stabilizing cavities, producing mirrors with the required quality and control of atomic systems, so that the example becomes reality. In order to reach cavity QED regime the coupling rate g needs to be optimized. Therefore either the mode volume V has to be kept small or the quality factor Q has to be large.
Production of resonator mirrors faces many challenges in order to achieve high quality. This includes the control of inhomogeneities, impurities and surface roughness.
Here, we want to achieve small V for high finesse cavities. Therefore, we need good surface quality and high radius of curvature (ROC). We want to realize the goal using a CO_2 laser that is tightly focused. We aim to create structures with ROC fundamentally limited by CO_2 laser wavelength.

Q 53.58 Thu 17:00 P OGs

Strong coupling between nanofiber-trapped atoms and fully fiber-integrated Fabry-Perot microresonator — •Martin Blaha, Sarah M. Skoff, and Arno Rauschenbeutel — Vienna University of Technology, Stadionallee 2, A-1020 Vienna, Austria

For building key components of optical quantum networks, such as quantum memories, an efficient interaction between light and suitable quantum emitters is required. Moreover, the latter is a prerequisite for establishing interactions between individual photons by means of an optical nonlinearity.

In order to realize such an efficient light-matter interface, we plan to couple cold Cesium atoms to a fully fiber-integrated high-Q microresonator. The backbone of this experiment is a tapered optical fiber containing a sub-wavelength diameter waist. Using a two-color optical dipole trap, we interface an ensemble of laser-cooled atoms via the nanofiber waist, which is enclosed by two fiber Bragg gratings. They form a high-Q resonator for the D2 line of Cesium, while transmitting the trapping light.

This scheme combines cavity enhancement and collective coupling in a single system and thus allows one to reach a very large collective light-matter coupling strength, required to implement, e.g. an inherently fiber-coupled quantum memory. Further, we aim to use the strong coupling between the atoms and the light to observe cross-phase modulation of a probe pulse by the intensity of a signal pulse. This photon-photon interaction would then be a key ingredient for optical quantum information processing.

Q 53.59 Thu 17:00 P OGs

Quantum simulators for open quantum systems using quantum Zeno dynamics — •Sabrina Patsch and Christiane P. Koch — Universität Kassel, Deutschland

A watched quantum arrow does not move. This effect, referred to as the quantum Zeno effect, arises from a frequent measurement of a quantum system's state. In more general terms, the evolution of the quantum system can be confined to a subspace of the system's Hilbert space leading to quantum Zeno dynamics. Resulting from the measurement process, a source of dissipation is introduced into the systems dynamics. However, different than for a common open quantum system, we can choose the strength of the dissipation by changing the parameters of the Zeno measurement.

We capitalise on the property of tunable dissipation to create a quantum simulator for open quantum systems. Due to the formal analogy of the measurement process and the theory of open quantum systems, we can derive a Lindblad master equation to describe the evolution of the open quantum system. Moreover, we extend the picture to enable also non-Markovian evolution in the quantum simulator.

The considered quantum system are photons inside a cavity being subject to a indirect measurement using circular Rydberg atoms. The setup is inspired by Zeno experiments proposed in the framework of cavity quantum electrodynamics [1].

[1] Raimond et al. Quantum Zeno dynamics of a field in a cavity.*Phys. Rev. A* 86, 032120 (2012)

Q 53.60 Thu 17:00 P OGs

Macrorealistic extensions of relativistic quantum theory — •Silas Bischoff and Klaus Hornberger — Fakultät für Physik, Universität Duisburg-Essen

Modifications of non-relativistic quantum mechanics, such as the well known GRW and CSL models [1], are already well understood. In contrast to purely interpretative approaches to quantum foundational problems, macrorealistic extensions yield quantitative predictions that allow for experimental falsification. However, the reconciliation of macrorealism with special relativity is laden with conceptual difficulties hitherto unresolved. We aim to understand and formalize the properties a macrorealistic modification of relativistic QFT is required to exhibit. To that end we critically analyse specific proposals [3-4].

[1] Bassi et al., Rev. Mod. Phys. 85, 471-527 (2013)
[3] Bedingham, Found. Phys. 41, 686 (2011)
[4] Pearle, Phys. Rev. D 91, 105012 (2015)

Q 53.61 Thu 17:00 P OGs

Master equations for disordered quantum systems — •Chahan Kropf and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, D-79104, Freiburg, Deutschland

Recent experimental implementations of finite-size disordered systems with cold atoms or photonic circuits allow to study the dynamics of the state obtained by averaging over all realizations of the disorder, on transient time scales, and/or far from the thermodynamic limit. In [1], we showed that, in these regimes, the effective decoherence arising from the ensemble averaging procedure can be efficiently characterized in terms of generalized master equations.

Here we show that, using perturbation theory, which is needed to diagonalize the Hamiltonians of the single realizations of the disorder prior to the ensemble average, we can now describe a wide range of systems such as disordered lattice (Anderson-like) models, disordered transport networks or disordered Bose-Hubbard models.

[1] C. Kropf, C. Gneiting, and A. Buchleitner, Phys. Rev. X **6**, 031032 (2016)

Q 53.62 Thu 17:00 P OGs

Operational description of a momentum observable — •Fabio Di Pumpo, Hannes Weber, and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, 89069 Ulm

We present the definition of an operational momentum operator. This definition is motivated by a classical time-of-flight measurement which we model by a Hamiltonian for a particle interacting with two quantum pointers at different times. We solve the corresponding dynamics in the Heisenberg picture. Our aim then is to calculate the optimized bipartite pointer state, so that the statistics of the operational momentum operator resembles the one of the original momentum operator describing the single-particle system.

Q 53.63 Thu 17:00 P OGs

Laser and cavity cooling of a mechanical resonator with a nitrogen-vacancy center in diamond — •Luigi Giannelli[1], Ralf Betzholz[1], Laura Kreiner[2], Marc Bienert[1], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Experimentalphysik, Universität des Saarlandes, 66123 Saarbrücken, Germany

We theoretically analyze the cooling dynamics of a high-Q mode of a mechanical resonator, when the structure is also an optical cavity and is coupled with a nitrogen-vacancy (NV) center. The NV center is driven by a laser and interacts with the cavity photon field and with the strain field of the mechanical oscillator, while radiation pressure couples the mechanical resonator and cavity field. Starting from the full master equation we derive the rate equation for the mechanical resonator's motion, whose coefficients depend on the system parameters and on the noise sources. We then determine the cooling regime, the cooling rate, the asymptotic temperatures, and the spectrum of resonance fluorescence for experimentally relevant parameter regimes. For these parameters, we consider an electronic transition, whose linewidth allows one to perform sideband cooling, and show that the addition of an optical cavity in general does not improve the cooling efficiency. We further show that pure dephasing of the NV center's electronic transitions can lead to an improvement of the cooling efficiency.

Q 53.64 Thu 17:00 P OGs

Recent progress in generating squeezed vacuum states in a nonlinear crystalline whispering gallery mode resonator — •Alexander Otterpohl[1,2], Gerhard Schunk[1,2], Ulrich Vogl[1,2], Florian Sedlmeir[1,2], Golnoush Shafiee[1,2], Dmitry Strekalov[1,2], Tobias Gehring[3], Harald G. L. Schwefel[4], Ulrik L. Andersen[3], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Staudtstr. 7 B2, 91058 Erlangen, Germany — [3]Department of Physics, Technical University of Denmark, Fysikvej, 2800 Kgs. Lyngby, Denmark — [4]The Dodd-Walls Centre for Photonic and Quantum Technologies, Department of Physics, University of Otago, 730 Cumberland Street, 9016 Dunedin, New Zealand

Macroscopic crystalline whispering gallery mode resonators (WGMR) made out of $LiNbO_3$ are a versatile source of non-classical light [1]. Here, we report on recent progress in generating squeezed vacuum states in WGMRs via parametric down-conversion near the degenerate point. For that, we performed a detailed mode-analysis and improved the long-term stability of the setup to allow for stable operation above and below threshold. We also discuss the prospects of producing frequency combs and realizing more elaborate proposals such as enhanced optomechanical position detection via intra-cavity squeezing [2].

[1] J. U. Fürst et al., Phys. Rev. Lett. **106**, 113901(2011).
[2] V. Peano et al., Phys. Rev. Lett. **115**, 243603(2015).

Q 53.65 Thu 17:00 P OGs

Feedback cooling of an optically levitated silica nanosphere in a Michelson-Sagnac interferometer — •Manuel Reisenbauer, Ralf Riedinger, and Markus Aspelmeyer — Universität Wien, Vienna, Austria

A Michelson-Sagnac interferometer is well suited for the position readout of low reflectivity mechanical oscillators [1], as the non-interacting light leaves the interferometer through the bright port, while the reflected light interferes like in a Michelson interferometer, yielding a position dependent phase quadrature in the dark port. We show in a proof-of-principle experiment that by introducing two lenses in the interferometer mode, a dielectric nanoparticle can be trapped optically in one of the standing wave fringes of the Sagnac-mode near the focus. Feedback cooling of the particle is demonstrated, using the radiation pressure of an auxiliary laser beam.

Q 53.66 Thu 17:00 P OGs

Narrow-band single-photon source by resonant excitation of a nitrogen-vacancy center coupled to a microresonator —

•Florian Böhm[1], Christoph Pyrlik[2], Jan Schlegel[2], Andreas Thies[2], Andreas Wicht[2], and Oliver Benson[1] — [1]AG Nanooptik, Humbodt-Universität zu Berlin, Germany — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Berlin, Germany

Efficient and bright integrated solid-state single photon sources, preferably with narrow-bandwidth emission are a crucial prerequisite for future applications in quantum information science.

We report on our approach towards an integrated microresonator-enhanced single-photon source, consisting of nano-sized quantum emitters evanescently coupled to resonant photonic structures. In our proposed system we make use of single quantum emitters coupled deterministically [1] to a monolithic add-drop ring microresonator configuration. This hybrid system locally enhances the intensity of the excitation light and allows easy separation of the resonant excitation light from the emitted single photons via the two well-defined polarisations of the guided modes. Resonant excitation of the quantum emitters at the zero-phonon line promises a strong suppression of spectral diffusion and therefore a narrow spectral emission [2].

The proposed system has a narrow-bandwidth emission of single photons coupled to a single optical mode and is promising as a source e.g. in quantum information and quantum cryptography.

[1] Schell A.W., et al. (2011). Rev. Sci. Instrum., 82(7), 073709.
[2] Wolters J., et al. (2013). Phys. Rev. Lett., 110(2), 027401.

Q 53.67 Thu 17:00 P OGs

Efficient solid-state light-matter interfaces based on dielectric slot waveguides and diamond colour centers — •Martin Zeitlmair[1], Philipp Altpeter[1], Peter Fischer[1], Markus Weber[3], and Harald Weinfurter[1,2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck-Institut für Quantenoptik, Garching — [3]Max-Planck-Institut für die Physik des Lichts, Erlangen

Future applications in applied quantum information science and ultrasensitive spectroscopy rely on efficient interaction between light and matter. Such light-matter interfaces require two key components: A waveguiding structure to control the propagation of photons and a quantum light source emitting single photons. Here, we present major progress towards a novel on-chip interface based on broadband dielectric slot waveguides for evanescent coupling of nanophotonic emitters and nitrogen-vacancy centers in nanodiamonds.

We choose Ta_2O_5 as a material platform due to its high dielectric contrast and low autofluorescence. By applying a lithographic top-down fabrication process, single-mode waveguides with low propagation losses of about 1dB/mm are created. A subsequent ion-beam milling process enables the production of air slots providing the strong confinement of optical waveguide modes, which should make high coupling efficiencies of optical waveguide structures possible. By choosing an optimised waveguide geometry coupling efficiencies over 50% for the whole spectrum of the NV-center can be expected.

Q 53.68 Thu 17:00 P OGs

Strong coupling between two optical $\lambda/2$ Fabry-Pérot resonators — •Achim Junginger[1], Felix Blendinger[2], Michael Metzger[2], Alexander Konrad[1], Marc Brecht[1], and Alfred J. Meixner[1] — [1]Institute of Physical and Theoretical Chemistry, University of Tübingen — [2]Fakulty Mechanical and Medical Engineering (MME), Furtwangen University

A $\lambda/2$ Fabry-Pérot resonator is made of two parallel mirrors and has a transmission maximum for light with a wavelength, corresponding to twice the mirror separation divided by the refraction index of the medium inside the resonator. We have investigated the resonance condition for a system of three parallel mirrors, separated by half an optical wavelength, while one outer mirror can be moved. For on axis illumination of the coupled resonators with white light, anticrossing of the wavelengths of the transmission maximum can be observed for the detuning of the adjustable resonator over the length of the fixed resonator. The occurrence of the anticrossing behavior can be adjusted when changing the thickness and therefore the reflectivity of the central silver mirror. With this experiment, we can model strong coupling with different coupling strengths.

Q 53.69 Thu 17:00 P OGs

Temperature dependent measurements of spin relaxation times of NV centers in nanodiamonds — •Lukas Antoniuk[1], Andreas Dietrich[1], Stefan Häussler[1], Kobinian Kottmann[1], Ilai Schwarz[2], Christoph Müller[1], Fedor Jelezko[1], and Alexander Kubanek[1] — [1]Institute for Quantum Optics, Ulm University, D-89081 Ulm, Germany — [2]Institute for Theoretical Physics, Ulm University, D-89081 Ulm, Germany

Nitrogen-vacancy (NV) color centers in nanodiamonds (<100nm) are promising candidates for nanoscale sensing and for hyperpolarization techniques, which are based on the transfer of the NV center's electron spin polarization to surrounding nuclear spins. However, both applications are limited by the spin relaxation time of the NV centre spin, which is relatively short compared to NV centers in bulk diamond. The spin relaxation time is dominated by interactions with a bath of paramagnetic impurities on the diamond surface [1]. Here we present spin relaxation time measurements in nanodiamonds of different sizes over a broad range of cryogenic temperatures, which allow to gain a better understanding on the ongoing interactions. The nanodiamond size and therefore the distance from NV centres to the surface thereby determines the interaction strength and temperatures changes are influencing the dynamics in the surrounding bath.

[1] J.-P. Tetienne, et al. Phys.Rev. B. 87, 235436 (2013)

Q 53.70 Thu 17:00 P OGs

An optical nanofiber-based interface for single molecules — •Hardy Schauffert[1], David Papencordt[1], Sarah M. Skoff[1], Bernhard C. Bayer[2], and Arno Rauschenbeutel[1] — [1]Vienna Center for Quantum Science and Technology, Institute of Atomic and Subatomic Physic, Vienna University of Technology, Stadionallee 2, A-1020 Vienna, Austria — [2]Electron Microscopy Group, Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria

Integrated optical interfaces for quantum emitters are a prerequisite for implementing quantum networks. In this context, tapered optical fibers with a nanofiber waist recently received significant attention as an efficient means of light-matter interaction. Due to the subwavelength diameter of the waist, a large fraction of the light propagates outside of the fiber as a high-intensity evanescent wave. An emitter brought close to the surface of the nanofiber has a large effect on the guided light field. Here, we couple single organic dye molecules to the guided modes of an optical nanofiber. The molecules are embedded in a nano-crystal host that provides photostability and due to the resulting inhomogeneous broadening, a means to spectrally address single molecules. The molecules are optically excited and their fluorescence is detected solely via the nanofiber interface without the requirement of additional optical access. In this way, we realize a fully fiber-integrated system that is scalable and may become a versatile constituent for quantum hybrid systems.

Q 53.71 Thu 17:00 P OGs

Creation of Color Centers in Diamond by Focused Ion Implantation — •Johannes Lang, Philipp Vetter, Boris Naydenov, and Fedor Jelezko — Institute for Quantum Optics, University Ulm, Germany

The color centers in diamond formed by a substitutional nitrogen or silicon and an adjacent vacancy (NV or SiV center) are amongst the most studied defects in diamond. They are promising candidates for different applications such as e.g. qubit spin registers in future quantum computation [1], or for different sensing applications [2] as well as quantum communication. The on demand creation of these color centers is required for the applications mentioned above [3].

Here, we present a home built, low energy, UHV ion implantation setup and show the creation of single, shallow (< 10 nm) color centers with well controllable properties regarding their implantation depth, density and position.

[1] M. W. Doherty et al., Physics Reports 528 1-45 (2013)
[2] C. Müller et al., Nat. Comm. 5 4703 (2014)
[3] J. Meijer et al., Appl. Phys. Lett. 87 261909 (2005)

Q 53.72 Thu 17:00 P OGs

Coherent control of free-electron beams on attosecond time scales — •Christopher Rathje, Katharina E. Priebe, Armin Feist, Sascha Schäfer, and Claus Ropers — IV. Physical Institute - Solids and Nanostructures, University of Göttingen, Germany

Ultrafast transmission electron microscopy (UTEM) is a recently developed approach to investigate dynamics with both nanometer spatial and femtosecond temporal resolution. Here, we use the highly coherent free-electron beam of our UTEM [1] to study inelastic electron-light scattering [2]. In particular, we manipulate the quantum state of single electrons using intense tailored light fields [3,4]. The optical near-field imprints a sinusoidal phase modulation on the electron wavefunction, which is manifest in a comb of sidebands in the electron kinetic energy distribution [3]. In a recent experiment [4], we demonstrated the quantum coherence and reversibility of this process by employing two spatially separated near-fields, such that the final quantum state sensitively depends on the relative near-field phase. Here, we describe our progress towards measuring the predicted self-compression of the initial wavefunction into a train of attosecond bursts [3]. The quantum coherent electron-light interaction is a promising approach for temporal structuring of free-electron beams with attosecond precision. [1] Feist et al., arXiv:1611.05022 (2016) [2] Barwick et al., Nature 462, 902 (2009) [3] Feist et al., Nature 521, 200-203 (2015) [4] Echternkamp et al., Nat. Phys. 12, 1000-1004 (2016)

Q 53.73 Thu 17:00 P OGs

Frequenzverdopplung in β-Bariumborat (β -BBO) unter Anwendung elliptischer Fokussierung in einem externen Resonator für den Einsatz zur Ionenstrahlkühlung — •Daniel Preissler, Daniel Kiefer, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser- und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Am ESR der GSI (Darmstadt, Deutschland) werden Experimente mit relativistischen, kalten Ionenstrahlen durchgeführt. Um die dafür nötige Reduktion der Impulsverteilung der Ionen zu erreichen [1], wurde ein Lasersystem bestehend aus einem ECDL, einem Faserverstärker und zwei aufeinanderfolgenden Frequenzverdopplungsstufen entwickelt, welches Dauerstrich-Strahlung im UV-Bereich emittiert [2]. Da der in der zweiten Frequenzverdopplungsstufe verwendete BBO-Kristall eine UV-induzierte Degradierung erfährt, wird ein neuer Resonator konstruiert, der eine elliptische Fokussierung in den Kristall ermöglicht. Dadurch kann einerseits eine höhere Konversionseffizienz, andererseits aber auch eine niedrigere Spitzenintensität erreicht werden [3], um die Degradierung zu verhindern. Im Beitrag werden Simulationen zum Aufbau des Resonators sowie der Stand der experimentellen Realisierung diskutiert.

[1] J. S. Hangst et al., Phys. Rev. Lett. 74, 4432-4435 (1995).
[2] T. Beck, Dissertation, TU Darmstadt (2015).
[3] A. Steinbach et al., Opt. Commun. 123, 207-214 (1996).

Q 53.74 Thu 17:00 P OGs

Q-switched Yb:YAG channel waveguide laser using low-dimensional carbon nanomaterials — •Sun Young Choi[1], Mi Hye Kim[3], Fabian Rotermund[4], Christian Kränkel[1,2], and Thomas Calmano[1,2] — [1]Institut für Laser-Physik, Universität Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany — [3]Center for Quantum-Beam-based Radiation Research, KAERI, Republic of Korea — [4]Department of Physics, KAIST, Republic of Korea

Graphene and single-walled carbon nanotubes (SWCNTs) are frequently used for saturable absorbers which can be applied for short pulse lasers. Intrinsic nonlinear absorption in a broad spectral range and few ps response time of these materials guarantee good performance. Moreover, their relatively simple fabrication process provides flexibility and makes these devices suitable for integrated systems such as waveguide lasers. We demonstrate efficient pulsed Yb:YAG channel waveguide lasers using low-dimensional carbon nanomaterials. A 9 mm-long, fs-laser-inscribed Yb:YAG channel waveguide laser delivers stable Q-switched pulses around 1030 nm output wavelength utilizing graphene or SWCNT-coated output coupling mirrors. In this way, a maximum average output power of 80 mW and 79 ns pulse duration were obtained at a efficiency of up to 33% using a graphene-coated 20% output coupler under pumping with 285 mW from a laser diode. In additional experiments, atomically thin layered graphene was applied directly on the end-facet of the channel waveguide to achieve a compact and monolithic Q-switched waveguide laser system.

Q 53.75 Thu 17:00 P OGs

Efficient high repetition rate difference frequency generation in PPLN for MIR sum frequency microscopy — Christoph Kölbel, •Lukas Ebner, Martin Winterhalder, and Andreas Zumbusch — Universität Konstanz

High repetition rate mid-infrared (MIR) optical parametric oscillators (OPOs) are used for sum frequency generation (SFM) microscopy [1]. In this work, we present an alternative cost and conversion efficient processes to generate ultrashort, bandwidth limited MIR-Laser pulses via difference frequency generation (DFG) in periodically poled Lithium Niobate (PPLN). The use of a synchronised 80 MHz dual output fs-Laser source with a fixed output at 1037 nm and a tunable (680-1300 nm) output allows the generation of MIR-Light between (3,1-5,5 μm). Based on this source and a collinear excitation geometry we present first sum frequency generation (SFM) microscopy images.

[1]. Raghunathan, V. et al., Optics Letters, 36(19), 3891-3893 (2011).

Q 53.76 Thu 17:00 P OGs

Autonomously operating laser systems for quantum sensors in space - from sounding rockets to small satellites — •Aline Dinkelaker[1], Max Schiemangk[1], Vladimir Schkolnik[1], Andrew Kenyon[1], Markus Krutzik[1], Achim Peters[1,2], and The KALEXUS MAIUS and LASUS Teams[1,2,3,4,5,6,7] — [1]Humboldt-Universität zu Berlin — [2]FBH Berlin — [3]JGU Mainz — [4]LU Hannover — [5]U Bremen — [6]U Hamburg — [7]Menlo Systems GmbH

Laser systems are key technology for fundamental and applied physics experiments on space platforms - from quantum optical communication to tests of general relativity with quantum sensors. Such laser systems have to fulfill demanding requirements on frequency stability and output power, while being compact and rugged in order to operate reliably after launch into space. As interaction from ground will be limited, automated experiment control is desired. To demonstrate their functionality in space, we have flight-proven different laser system for atomic physics experiments on sounding rockets: the KALEXUS and LASUS experiments are technology demonstrators for frequency stabilized micro-integrated extended cavity diode lasers (ECDLs) at rubidium and potassium wavelengths. We now aim to test laser systems on small satellites where radiation effects, UHV compatibility and long term stability can be studied. We present results of our sounding rocket missions with an outlook on future laser system experiments on small satellites. This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant numbers 50WM1237/1345/1132 .

Q 53.77 Thu 17:00 P OGs

Zerodur-based optical systems for dual-species atom interferometry in space — •Moritz Mihm[1], Kai Lampmann[1], André Wenzlawski[1], Ortwin Hellmig[6], Klaus Doeringshoff[2], Markus Krutzik[2], Achim Peters[2], Patrick Windpassinger[1], and the MAIUS Team[1,2,3,4,5] — [1]Institut für Physik, JGU Mainz — [2]Institut für Physik, HU Berlin — [3]IQO, LU Hannover — [4]FBH, Berlin — [5]ZARM, Bremen — [6]ILP, UHH Hamburg

The precision of inertial measurements has been tremendously increased with the advent of cold atom-based interferometers. Space missions which allow higher precision of such instruments rely on the laser system, dedicated to cool and manipulate the atoms.

Subsequent to successful previous sounding rocket missions, we report on a laser system for rocket missions performing dual-species atom interferometry with BECs. Core elements of the laser system are optical benches and fiber-optical elements used on the one hand to distribute, overlap and switch the laser beams and on the other hand to stabilize the laser frequencies. In order to withstand the harsh conditions during flight, we use the glass ceramic Zerodur providing high mechanical and thermal stability. A Zerodur-based test bench for the qualification of new components has been assembled, characterized and tested under flight conditions. Currently, the flight hardware is built and characterized prior to integration.

MAIUS is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant number 50 WM 1133 and 50 WP 1433.

Q 53.78 Thu 17:00 P OGs

Ionisationsstudie mit Beryllium — •Sebastian Wolf, Frederic Wagner, Dominik Studer, Klaus Wendt und Ferdinand Schmidt-Kaler — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz

Einfach geladene Beryllium Ionen sind für sympathetisches Kühlen in Ionenfallenexperimenten hervorragend geeignet [1,2]. Für die Ionisation von neutralem Beryllium kann die Elektronen-Ionisation verwendet werden, führt jedoch in Mikrofallen zu unkontrollierten Aufladungen. Für die resonante Photoionisation wird ein kommerzielles vervierfachtes cw-Diodenlasersystem verwendet [3]. Wir untersuchen alternative Ionisationsverfahren die auf gepulsten Laserlichtquellen beruhen: Zum Einsatz kommen eine kostengünstige Nd:YAG Laserquelle, bei der die 2. (10 ns, 15 mJ) bzw. die 4. (10 ns, 2 mJ) Harmonische über einen nicht-resonanten Multi-Photonenprozess ins Kontinuum ionisiert, und alternativ die 4. (100 ns, 1 μJ) Harmonische eines gepulsten Ti:Sa-Lasers um in einem resonanten Prozess bei 235 nm zu ionisieren.

[1] P. Perez et al., Class. Quantum Grav. 29, 184008 (2012)
[2] T. Murböck et al., Phys. Rev. A 94, 043410 (2016)
[3] Hsiang-Yu Lo et al., Appl. Phys. B 114:17-25 (2014)

Q 53.79 Thu 17:00 P OGs

Dispersion engineering of integrated photon pair sources at telecommunication wavelength — •Mahnaz Doostdar, Matteo Santandrea, Vahid Ansari, Christof Eigner, Raimund Ricken, Helge Rütz, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Parametric Down Conversion (PDC) is widely used as the source of pairs of single photons in quantum information science. The properties of this nonlinear optical process, however, have to be tailored to generate the desired state. Here we focus on engineering the dispersion properties of the PDC process to generate spatially single-mode and spectrally decorrelated PDC states at telecommunication wavelengths. Periodically poled potassium titanyl phosphate (PPKTP) can provide those required features. Here we present our recent advances in fabrication of such waveguided PDC sources.

Q 53.80 Thu 17:00 P OGs

Low Noise Fast Multichannel Arbitrary waveform Generator for the Segmented Trap — •Vidyut Kaushal, Heinz Lenk, Ulrich G. Poschinger, and Ferdinand Schmidt-Kaler — QUANTUM, Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Noisy trap electrode potentials have always been a fundamental source of decoherence in ion-trap based studies of quantum systems. Scaling up the number of electrode in modern segmented traps, this becomes even more challenging, as fast and simultaneous real-time control of the segment voltages with high signal integrity and sampling rate is required. We present a functional design of low noise(<-70dbm), high precision, fast AWG featuring 80 independent analog channels. Additionally, the delay between consecutive samples can be controlled in steps of 20 ns, resolving typical trap oscillation periods - a crucial feature for the control of fast shuttling operations [1,2]. The output voltage range of +/- 40 V allows for tight confinement of trapped ions and compensation of signal distortion.

We describe the details of the architecture and thorough characterization of the relevant signals.The implementation of a toolset of shuttling operations for scalable quantum computing is shown. We also discuss future extensions towards a complete real-time control system including feedback capabilities.

[1] A. Walther et al., PRL 109, 080501 (2012)
[2] T. Ruster et al., PRA 90, 033410 (2014)

Q 53.81 Thu 17:00 P OGs

Modified dipole-dipole interaction and dissipation in an atomic ensemble near a surface — •Ryan Jones and Beatriz Olmos — School of Physics and Astronomy, The University of Nottingham, University Park, NG7 2RD, United Kingdom

Particularly in the area of imaging, surfaces of different materials and shapes are used to manipulate the electromagnetic field experienced atoms in order to change their spontaneous decay rate. As well as interference effects one can manipulate the system in other ways, for example in a metal the presence of surface plasmon polaritons can also drastically change how the system decays.

Relatively little is known about how surfaces affect systems whose behavior is collective. Such effects, including a coherent dipole-dipole interaction (photon exchange) and collective decay, exist in ensembles of two-level atoms with atomic separations that are much smaller than the transition wavelength. These systems have become increasingly relevant in recent years as developments in atomic cooling and trapping have made them experimentally feasible.

In this work, through a Green's tensor formalism we investigate how collective properties are modified when a cold dense system is placed in proximity to surfaces of different materials. By scanning over a range of parameters, we identify regimes in which the collective behaviors of the system are modified considerably.

These results will be of value to current and future experiments investigating the dipole-dipole interaction, where surface interactions can provide an extra degree of control over the system.

Q 53.82 Thu 17:00 P OGs

Entangled photons triplets, produced via third order parametric down conversion in bulk materials — Cameron Okoth[1], •Andrea Cavanna[1], and Maria Chekhova[1,2] — [1]Max-Planck- Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]Faculty of Physics, M. V. Lomonosov Moscow State University, 119991 Moscow, Russia

Parametric down conversion (PDC) is a highly developed research field and is now commonly used in several areas of optics. Despite this PDC has only been observed when one considers the second order susceptibility term. We intend to experimentally observe seeded generation of triple photons, where the seed is collinear with the pump. In this way the entire process is can be thought as analogous to standard PDC but with the efficiency changed by a factor of $\chi^{(2)}/(\chi^{(3)}E_{seed})$, where E_{seed} is the seed field. Many of the recent attempts to observe triplet photons have been fiber based. Although fibers have some advantages over bulk materials, there are still many reasons to include crystals as promising candidates in which to generate triplet photons: high effective cubic susceptibility, no lowered efficiency due to modal overlap and tunable phase matching to name but a few. In our work we concentrate on calcite but can be readily extended to rutile, KTP etc.

Q 53.83 Thu 17:00 P OGs

Relativistic Quantum Information Experiments with a Geostationary Satellite — •Ömer Bayraktar[1,2], Kevin Günthner[1,2], Imran Khan[1,2], Dominique Elser[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany. — [2]Department of Physics, University of Erlangen-Nuremberg (FAU), Germany.

The current development in satellite-based quantum communication pushes quantum physics experiments into the relativistic regime [1]. While a theoretical description in terms of quantum field theory in curved space-time (or relativistic quantum information) is in progress, experimental evidence for the predictions are not existing yet [2]. In addition, the impact of relativistic effects on long-distance quantum communication needs to be quantified. We investigate potential realization of relativistic quantum information experiments with a satellite in the geostationary Earth orbit. Thereby, we aim to complement quantum field theory in curved space-time with experimental evidence and explore possible limitations of satellite-based quantum communication.

[1] D. Rideout *et al.*, Class. Quantum Gravity **29**, 224011 (2012).
[2] R. Howl *et al.*, arXiv:1607.06666 (2016).

Q 53.84 Thu 17:00 P OGs

2D layer of dipolarly coupled nuclear spins for a solid state quantum simulator — •Nikolas Tomek[1], Paz London[2], Timo Weggler[1], Kohei Itoh[3], Hideyuki Watanabe[4], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, Ulm University, Albert-Einstein-Allee 11, Ulm 89081, Germany — [2]Department of Physics, Technion, Israel Institute of Technology, Haifa 32000, Israel — [3]Department of Applied Physics and Physico-Informatics, Keio University, Hiyoshi, Yokohama, JapanDepartment of Applied Physics and Physico-Informatics, Keio University, Hiyoshi, Yokohama, Japan — [4]Natl Inst Adv Ind Sci & Technol, Res Inst Elect & Photon, Tsukuba, Ibaraki 3058562, Japan

Understanding and controlling a strongly correlated quantum many-body system is an essential step towards a large scale quantum simulator. Such a device would enable access to nonequilibrium dynamics of large systems where state of the art numerical simulations are quickly reaching their limits. To reach this goal we are studying a ^{12}C-enriched bulk diamond containing a few nanometer thick layer of ^{13}C nuclei. In order to access these nuclear spins we utilize nitrogen-vacancy (NV) centers grown into the diamond around the layer. The system stands out due to exceptional long coherence times even at room temperature. To expose the dipolar coupling inside the ^{13}C layer we are conducting experiments to show diffusion of spin polarization from one NV to another. A microwave assisted superresolution imaging reveals a distance between the NVs below 50 nm. Furthermore we will use this system to investigate multi-quantum coherences inside the nuclear spin lattice.

Q 53.85 Thu 17:00 P OGs

Pulse-to-pulse measurements on a broadband PDC source — •Thomas Dirmeier[1,2], Imran Khan[1,2], Georg Harder[3], Vahid Ansari[3], Johannes Tiedau[3], Ulrich Vogl[1,2], Gerd Leuchs[1,2,4], Christoph Marquardt[1,2], and Christine Silberhorn[3] — [1]Max Planck Institut für die Physik des Lichts, Staudtstr. 2, 91058 Erlangen — [2]Institut für Optik, Information und Photonik, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen — [3]Lehrstuhl für Angewandte Physik, Universität Paderborn, Warburgerstr. 100, 33098 Paderborn

— [4]Department of Physics and Max Planck - University of Ottawa Centre for Extreme and Quantum Photonics, University of Ottawa, Canada

PDC sources embedded in ppKTP waveguides have been shown to be stable sources of squeezed vacuum states with a broad versatility in the spectral mode structure. Recently, it has been demonstrated that by applying high pump powers, states with high mean photon numbers can be generated and measured [1], translating into high squeezing values.

In our work, we focus on the application of this type of source in the continuous-variable context, mainly focusing on the measurement of squeezed vacuum states in both, the spectral single and multimode case. We show the progress on the pulse-resolved homodyne detection in this system and its combination with photon counting measurements in quantum information protocols.

[1] G.Harder et.al.,Phys. Rev. Lett. 116, 143601 (2016)

Q 53.86 Thu 17:00 P OGs

Non-local currents in discrete planar Systems with spatial local symmetries — •Malte Röntgen, Christian Morfonios, and Peter Schmelcher — Zentrum f. Optische Quantentechnologien, Luruper Chaussee 149, 22761 Hamburg

Local symmetries are spatial symmetries that are only present in a spatially finite subdomain of a system. Contrary to global symmetries, the operators Σ_L describing local symmetries generally do not commute with the system's Hamiltonian and one cannot choose the eigenstates to be symmetric under Σ_L. We show that it is nevertheless possible to gain knowledge about the structure of a system's eigenstates, provided it possesses local symmetries. We use a new framework of so-called non-local currents which has recently been developed for one-dimensional discrete systems and extend it to two dimensions and the case of topological asymmetries. These asymmetries may be present if the system has a non-uniform connectivity. The framework may then be used as a basis for further investigations of the impact of local symmetries. In this paper, we investigate two special subsystems that feature local symmetries, so-called closed-loops and open ended chains. We use our framework to show that the all or some of the amplitudes of eigenstates within these subsystems are related to each other by a constant. Our results show that local symmetries in discrete systems may provide new insights into the behaviour of complex systems.