ISS 1: Micro Mechanical Oscillator 1 (Q, TT)

Micro- and nanomechanical ocsillating systems can be fabricated in various sizes and shapes and provide unique properties like very high Q-values and high mechanical frequencies. Only recently such devices have been cooled into the quantum regime of few, eventually zero phonons. Here, wÃŋth a genuine solid state system, the current goal is implementing concepts of quantum optics such as sideband cooling, electromagnetically induced transparency, and shot noise limited detection. Even more striking, such mechanical systems are coupled to cold atomic ensembles. The common session of Q and TT discusses recent experimental progress and novel theoretical concepts.

Time: Monday 10:30–13:00 Location: HSZ 02

ISS 1.1 Mon 10:30 HSZ 02

Listening to the Quantum Drum: Mechanics in its Ground State — •Tobias Donner[1,2], John Teufel[3], Ray Simmonds[3], and Konrad Lehnert[2] — [1]Institute for Quantum Electronics, ETH Zurich, CH-8093 Zurich, Switzerland — [2]JILA, University of Colorado and National Institute of Standards and Technology, Boulder, CO 80309, USA — [3]National Institute of Standards and Technology, Boulder, CO 80305, USA

A mechanical resonator is a physicist's most tangible example of a harmonic oscillator. If cooled to sufficiently low temperatures a mechanical oscillator is expected to behave differently to our classical perception of reality. Examples include entanglement and superposition states where a macroscopic, human made object can be in two places at once. Observing the quantum behavior of a mechanical oscillator is challenging because it is difficult both to prepare the oscillator in a pure quantum state of motion and to detect those states. I will present experiments in which we couple the motion of a micro-fabricated oscillator to the microwave field in a superconducting high-Q resonant circuit. The displacement of the oscillator imprints a phase modulation on the microwave field which we detect with a nearly shot-noise limited interferometer. We employ the radiation pressure force of the microwave photons to cool the mechanical oscillator to its motional ground state.

ISS 1.2 Mon 10:45 HSZ 02

Optomechanical Coupling of Ultracold Atoms and a Membrane Oscillator — •Maria Korppi[1,2,3], Andreas Jöckel[1], Stephan Camerer[2,3], David Hunger[2,3], Theodor W. Hänsch[2,3], and Philipp Treutlein[1,2,3] — [1]Universität Basel, Switzerland — [2]Ludwig-Maximilians-Universität, München, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

We report the recent results of our experiment, where we couple a single mode of a high-Q membrane-oscillator to the motion of laser-cooled atoms in an optical lattice. The optical lattice is formed by retroreflection of a laserbeam from the membrane surface. The coupling is mediated by power modulation of the lattice beam due to the vibrations of the atoms in the lattice. If the trap frequency of the atoms in the lattice is matched to the eigenfrequency of the membrane, we observe resonant energy transfer between the two systems.

In the long term, such coupling mechanism could be exploited to develop hybrid quantum systems between atoms and solid-state devices. As another intriguing perspective, a new generation of optical lattice experiment is in sight, where the mirrors creating the laser standing waves are micromechanical oscillators interacting with the atoms on a quantum level.

ISS 1.3 Mon 11:00 HSZ 02

Tuning the quality factor of a miromechanical membrane oscillator — •Andreas Jöckel[1], Maria Korppi[1,2,3], Stephan Camerer[2,3], Matthias Mader[2], David Hunger[2,3], Theodor W. Hänsch[2,3], and Philipp Treutlein[1,2,3] — [1]Departement Physik, Universität Basel, Switzerland — [2]Ludwig-Maximilians-Universität, München, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

We report on the characterization and tuning of the mechanical modes of high-Q SiN-membrane oscillators. Such membranes are used in many optomechanical experiments and have Q-factors up to 10^7 with frequencies in the hundreds of kHz regime and masses of a few ng, resulting in rather large ground state and thermal amplitudes.
We show that the membrane eigenfrequencies can be tuned by locally heating the membranes with laser light, resulting in a release of intrinsic stress. The frequencies of several modes were measured with a Michelson interferometer. We observe that the Q-factor changes dramatically while tuning and reveals resonances in the mechanical dissipation, which allows us to tune the Q-factor over two orders of magnitude. With this technique we achieve an improvement over the bare membrane Q-factor.
Another way of improving the properties of these membranes lies in structuring them with a focused ion beam (FIB) in order to reduce their mass, or applying mirrors to increase the reflectivity.

ISS 1.4 Mon 11:15 HSZ 02

A closed-cycle dilution refrigerator with free-space and fiber optical access for quantum optomechanics experiments at 20mK — •Witlef Wieczorek[1], Simon Gröblacher[1], Matthias Bühler[2], Peter Christ[2], Jens Höhne[2], Doreen Wernicke[2,3], and Markus Aspelmeyer[1] — [1]University of Vienna, Faculty of Physics, A-1090 Vienna, Austria — [2]VeriCold Technologies GmbH, Bahnhofstr. 21, D-85737 Ismaning, Germany — [3]Entropy GmbH, Gmundner Str. 37a, D-81379 Munich, Germany

We report on the operation of a closed-cycle dilution refrigerator for quantum optomechanics experiments at 20mK. The sample chamber of the dilution fridge is optically accessible both via optical windows as well as optical fibers, allowing us to perform a variety of optical experiments at low temperatures. It is designed to vibrationally isolate the sample chamber allowing for stable operation of a high-finesse optical cavity. This enables us to perform cavity-optomechanics experiments at ultra-low temperatures.

ISS 1.5 Mon 11:30 HSZ 02

Optomechanical cooling close to the ground state — •Rémi Rivière[1], Stefan Weis[1,2], Samuel Deléglise[1,2], Emanuel Gavartin[2], Olivier Arcizet[3], Albert Schliesser[1,2], and Tobias Kippenberg[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [3]Institut Néel, 38042 Grenoble, France

Optomechanical cooling of a mechanical oscillator mediated by the radiation pressure of the light enables preparing a macroscopic system in its quantum ground state. In our experiment, the vehicle used is a silica microtoroid resonator, hosting both optical and mechanical degrees of freedom within the same device. Combining both cryogenic and optomechanical cooling, we demonstrate an occupancy as low as 9 ± 1 phonons, for which limitations to further phonon occupation reduction are only technical. The forthcoming ground state will then enable the study of quantum effects in a macro-object.

ISS 1.6 Mon 11:45 HSZ 02

Cavity optomechanics with nonlinear mechanical resonators in the quantum regime — •Simon Rips, Martin Kiffner, Ignacio Wilson-Rae, and Michael Hartmann — Technische Universität München, Germany

The coupling of light and a mechanical resonator within an optomechanical setup can have significant effects on both the light field inside the cavity and the motion of the mechanical resonator. A prominent example is the cavity assisted side-band cooling of the mechanical motion, leading to low phonon occupation and thereby inducing the quantum regime.

Here, we consider the physics of a nonlinear mechanical resonator, coupled to different cavity modes that are each driven by a detuned laser. We show that the mechanical nonlinearity can be used to prepare a *nonclassical steady state* of mechanical motion. The nonclassicality criterion we use is the appearance of a negative Wigner function.

The open coupled quantum system is treated analytically with the projection operator technique. By tracing out the cavity modes, a master equation for the mechanical motion is derived. The structure of that master equation allows to understand the underlying physics and thereby to identify parameters (especially for detuning) that will produce the nonclassical steady state. The results are verified in a numerical treatment of the full coupled optomechanical system.

ISS 1.7 Mon 12:00 HSZ 02

Stochastically activated opto-mechanical coupling — •Andrea Mari and Jens Eisert — Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam, Germany

We study the effect of stochastic noise on the standard opto-mechanical setup: an optical cavity with a vibrating mirror. We show how to engineer an effective bath for the mechanical resonator by using only incoherent thermal light. Thanks to the non-linear interaction Hamiltonian, optical stochastic noise can activate the coupling between a mechanical mode of the mirror and an optical mode of the cavity. This interaction can generate several non-trivial effects, e.g. the counter-intuitive process of cooling with thermal noise. This is another instance - different from stochastic resonance - where somewhat counterintuitively, incoherent noise helps to generate coherent quantum effects.

ISS 1.8 Mon 12:15 HSZ 02

Optomechanically Induced Transparency — •Stefan Weis[1,2], Rémi Rivière[2], Samuel Deléglise[1,2], Emanuel Gavartin[1], Olivier Arcizet[3], Albert Schliesser[1,2], and Tobias Kippenberg[1,2] — [1]Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [3]Institut Néel, 38042 Grenoble, France

Electromagnetically induced transparency is a quantum interference effect observed in atoms and molecules, in which the optical response of an atomic medium is controlled by an electromagnetic field. We demonstrate a form of induced transparency enabled by radiation-pressure coupling of an optical and a mechanical mode. A control optical beam tuned to a sideband transition of a micro-optomechanical system leads to destructive interference for the excitation of an intracavity probe field, inducing a tunable transparency window for the probe beam. Optomechanically induced transparency may be used for slowing and on-chip storage of light pulses via microfabricated optomechanical arrays.

ISS 1.9 Mon 12:30 HSZ 02

Quantum dynamics in optomechanical arrays — •Florian Marquardt[1,2], Max Ludwig[1], Georg Heinrich[1], Andreas Kronwald[1], Michael Schmidt[1], Jiang Qian[3], and Björn Kubala[1] — [1]Institut für Theoretische Physik, Universität Erlangen-Nürnberg — [2]Max-Planck Institut für die Physik des Lichts — [3]Arnold Sommerfeld Center, Center for NanoScience, Department Physik, LMU München

Optomechanical arrays consist of a number of localized vibrational and optical modes coupled to each other via radiation forces. First versions of such structures have been realized recently based on photonic crystal designs. Future setups are projected to enter the quantum regime. We present our theoretical analysis of the linear and nonlinear quantum dynamics of interacting photons and phonons in such arrays.

ISS 1.10 Mon 12:45 HSZ 02

Shot noise limited displacement measurement of a high Q micromechanical oscillator below the peak value of the SQL — •Henning Kaufer, Daniel Friedrich, Andreas Sawadsky, Tobias Westphal, Kazuhiro Yamamoto, and Roman Schnabel — Albert-Einstein-Institut, MPI für Gravitationsphysik, QUEST, Leibniz Universität Hannover

The standard quantum limit (SQL) is a classical limit for measurement precision of a test mass position. Using a SiN membrane with a Q-factor of 10^6 and a mass of 100 ng we achieved a displacement sensitivity of $3 \cdot 10^{-16}$ m/$\sqrt{\text{Hz}}$ in a Michelson-Sagnac interferometer and thereby beat the peak value of the SQL at resonance. The interferometer topology allows implementation of advanced interferometer techniques such as power- or signal recycling. The latter can enhance the displacement sensitivity by a factor of 10 in the first step and reveal thermal noise of the oscillator over a broad frequency range.

ISS 2: Micro Mechanical Oscillator 2 (Q, TT)

This session continues ISS 1.

Time: Monday 14:30–15:15 Location: HSZ 02

ISS 2.1 Mon 14:30 HSZ 02

Synchronization in optomechanical arrays — •Georg Heinrich[1], Max Ludwig[1], Jiang Qian[2], Björn Kubala[1], and Florian Marquardt[1,3] — [1]Institute for Theoretical Physics, University of Erlangen-Nuremberg, Germany — [2]Department of Physics, LMU Munich, Germany — [3]Max Planck Institute for the Science of Light, Erlangen, Germany

The motion of nano- and optomechanical systems can be coupled to electromagnetic fields. Beside the ultimate goal to measure and control the quantum state of mechanical motion, these systems allow to study elaborate dynamics due to the light-mechanics interaction. Recent developments have demonstrated systems comprising several coupled optical and vibrational modes, such as optomechanical crystals. Here we investigate the collective dynamics of arrays of coupled optomechanical cells, each consisting of a laser-driven optical and a mechanical mode. Beyond a certain threshold of the laser input power, each cell shows a Hopf bifurcation towards a regime of self-induced oscillations. We show that the phases of many such cells, even with different bare initial frequencies, can lock to each other, synchronizing the dynamics to a collective oscillation frequency. We present different regimes for the dynamics and describe the system in terms of an effective Kuramoto model. This allows to connect our optomechanical results to the general field of nonlinear science where synchronization constitutes an important, universal feature finding applications in fields ranging from physics over chemistry to biology.

ISS 2.2 Mon 14:45 HSZ 02

Optomechanical entanglement and teleportation in a pulsed scheme — •Sebastian Hofer[1,2], Markus Aspelmeyer[1], and Klemens Hammerer[2] — [1]Faculty of Physics, University of Vienna, Austria — [2]Institute for Theoretical Physics and Institute for Gravitational Physics, Leibniz University Hannover, Germany

We analyze the creation of optomechanical EPR entanglement in a pulsed scheme. Furthermore we apply the standard CV teleportation protocol to optomechanical systems, analyze its Fidelity under the influence of thermal noise and determine the optimal parameter regime.

ISS 2.3 Mon 15:00 HSZ 02

Quantum theory of light scattering for dielectric objects in optical cavities — •Anika C. Pflanzer, Oriol Romero-Isart, and J. Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany

We develop a full quantum theory to describe the coupling of light to the motion of general dielectric objects in high-finesse optical cavities. In particular, we derive a master equation to describe the center-of-mass motion of the dielectric object, the cavity mode and their coupling to the other modes of the electromagnetic field via photon scattering. Focusing on massive particles here, this general theory is in particular applied to the recent proposal of using an optically levitating dielectric as a cavity opto-mechanical system [1,2]. Furthermore, we explore the range of applicability of this theory with respect to the size of the dielectric object and investigate limitations on possible cavity-cooling schemes. By comparing our findings to results from classical Mie scattering theory, we investigate differences arising from a fully quantum mechanical treatment of the system.

[1]Romero-Isart, New J. Phys. 12:033015 (2010)
[2]Romero-Isart, Pflanzer et al., arXiv:1010.3109 (2010)

ISS 3: Solid State Photon Sources (Q, HL)

Reliable and scalable low-cost single-photon sources would constitute a giant step forward towards quantum information technologies such as quantum cryptography and quantum computing. Among the most promising candidates are several solid-state light sources including nitrogen-vacancy color centers in diamond and semiconductor quantum dots coupled to optical fibers. The intersectional session at the interface of semiconductor physics and quantum optics presents different successful realizations invoking either optical or electrical pumping and experimental studies of the emission properties.

Time: Tuesday 10:30–13:00 Location: HSZ 02

ISS 3.1 Tue 10:30 HSZ 02

Optical Processes in OLEDs: Molecular Photonics — •Michael Flämmich, Dirk Michaelis, and Norbert Danz — Fraunhofer Institute for Applied Optics and Precision Engineering, 07745 Jena, Germany

Following the OLED display market take-off, huge world wide efforts are spent to develop OLEDs towards competitive sources for general lighting applications. In this context, the light outcoupling problem is well known as the key parameter to improve OLED efficiency in order to tackle existing lighting schemes. From the optical point of view, the device performance is driven (i) by the architecture of the OLEDs layered system and (ii) by the internal features of the emissive material. Studies in recent years have shown that the latter attributes (which are the internal electroluminescence spectrum, the profile of the emission zone, the orientation of the transition dipole moments and the internal luminescence quantum efficiency q) can be determined in situ by measurements of the far-field emission pattern generated by active OLEDs (i.e. in electrical operation) and corresponding optical reverse simulations. Starting from basic considerations of the dipole radiation characteristics, we elaborate specifically how the orientation distribution of the dipole transition moments in the layered system can be analyzed in situ, providing insight into the internal photo-physical processes on the molecular scale of the emitter.

ISS 3.2 Tue 11:00 HSZ 02

Single Photon Source with Diamond Nanocrystals on Tapered Optical Fibers — •Almut Tröller[1], Juliane Hermelbracht[1], Markus Weber[1], Wenjamin Rosenfeld[1], Ariane Stiebeiner[3], Arno Rauschenbeutel[3], James Rabeau[4], and Harald Weinfurter[1,2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck-Institut für Quantenoptik, Garching — [3]Johannes-Gutenberg-Universität, Mainz — [4]Macquarie University, Sydney

The development of reliable devices generating single photons is crucial for applications in quantum information as well as for fundamental experiments in quantum optics. Due to its properties the nitrogen-vacancy (NV) color center in diamond is considered a promising candidate for the implementation of such a device. Those properties include an optical transition at 637 nm with a fluorescence lifetime of 11.6 ns, high photostability and the possibility to work at room temperature.

However, the collection efficiency of the fluorescence light in bulk diamond is limited by the high refractive index of diamond. To resolve this issue we use diamond nanocrystals, which – being smaller than the wavelength of the fluorescence light – are not subject to refraction. In order to further enhance the single photon collection efficiency we aim at coupling the emission of a single NV center to the evanescent field of a tapered optical fiber. Here we present data on diamond nanocrystals containing NV centers and the first attempts towards their application to tapered fibers.

ISS 3.3 Tue 11:15 HSZ 02

Fiber-integrated diamond-based single photon source — •Tim Schröder, Andreas Wolfgang Schell, Günter Kewes, Thomas Aichele, and Oliver Benson — Nano Optics Group, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

The most direct approach to fabricate a reliable single photon source is to mount a single quantum emitter on an optical fibre. It integrates easily into fibre optic networks for quantum cryptography or quantum metrology applications . For the first time such a fibre-integrated single photon source operating at room temperature is demonstrated. It consists of a single nitrogen vacancy defect centre in a nanodiamond which is directly near-field coupled to the guiding modes of a commercial optical fibre. The coupling is achieved in a bottom-up approach by placing a pre-selected nanodiamond directly on the fibre facet. This configuration is ultra-stable and realignment-free. Its high photon collection efficiency is equivalent to a far-field collection via an objective with a numerical aperture of 0.82. Furthermore, simultaneous excitation of the single defect centre and recollection of its fluorescence light through the fibre is possible introducing a fibre-connected single emitter sensor.

ISS 3.4 Tue 11:30 HSZ 02

Near-field infrared spectroscopy of single InAs quantum dots — Rainer Jacob[1], •Stephan Winnerl[1], Harald Schneider[1], Manfred Helm[1], Marc Tobias Wenzel[2], Hans-Georg v. Ribbeck[2], and Lukas M. Eng[2] — [1]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, Postfach 51 01 19, 01314 Dresden, Germany — [2]Institut für Angewandte Photophysik, TU Dresden, George-Bähr-Straße 1, 01069 Dresden, Germany

Scattering-type scanning near-field optical microscopy (s-SNOM) is a versatile technique in optical sciences. It provides optical resolution in the nanometer range, while offering spectroscopic application when combined with a tunable light source. Here, we exploit the combination of a s-SNOM with a widely tunable free-electron laser. With this setup, we were able to perform optical spectroscopy of single InAs quantum dots by means of their near-field signature in the mid infrared. The sample was composed of a single layer of self-assembled InAs quantum dots that were capped by a 70 nm thick GaAs layer. In the s-SNOM-measurements we could obtain a clear near-field contrast between the dots and the surrounding medium at 10.2 um which corresponds to 120 meV. Another clear contrast could be obtained for 85 meV. Both signatures could be attributed to intersublevel transitions in the quantum dot [1]. To our knowledge this is the first time that an optical near-field signature of an intersublevel transition could be demonstrated at a single InAs quantum dot.

[1] P. Boucaud et al., C. R. Physique 9, 840 (2008)

ISS 3.5 Tue 11:45 HSZ 02

Quantum-Dot Pyramidal Microcavities as Candidates for Electrically Pumped Efficient Single-Photon Sources — •Daniel Rülke, Christoph Reinheimer, Florian Stockmar, Daniel M. Schaadt, Heinz Kalt, and Michael Hetterich — Institut für Angewandte Physik and DFG Center for Functional Nanostructures, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Straße 1, 76131 Karlsruhe (Germany)

We have investigated InAs-QDs embedded in reversed pyramidal GaAs microcavities in order to fabricate optically and electrically pumped single-photon sources. As a great advantage of the pyramidal shape the total number of QDs inside the cavity can be controlled by the position of the QD layer during molecular-beam epitaxial growth. Thus, by placing the QD layer close to the tip of the reversed pyramid, a very low number of QDs in the cavity can be achieved, while the facets act as a retroreflector for the emitted light. The pyramidal cavities were fabricated by a a combination of e-beam lithography and a selective wet-chemical etching process. In order to pump QDs electrically they have been embedded in the intrinsic layer of a pin-junction and individual cavities have been connected via bridges to a larger contact pad. To this end, a second non-critical e-beam alignment step had to be added after the wet-chemical etching process before metalisation and a subsequent lift-off process.

ISS 3.6 Tue 12:00 HSZ 02

Realisation of a robust and compact fibre-coupled diamond based single photon source implemented with gradient-index lenses — •Philip Engel, Tim Schröder, and Oliver Benson — Nano Optics Group, Institut für Physik, Humboldt-Universität zu

Berlin, Newtonstr. 15, 12489 Berlin

Single photons play an important role for many quantum information technologies. Quantum cryptography schemes and other experiments with single photons have already been implemented in rather large laboratory setups. To reduce the size and cost and increase the scalability of such experiments we designed a diamond based single photon source which uses gradient-index (GRIN) lenses with integrated thin film filters to collect and couple single photons into a single-mode fibre. GRIN lenses can be fabricated in such a way that a collimated incoming beam has its focal plane overlaying with the surface of the lens where nanodiamonds containing single defect centres can be deposited via spin-coating. In this manner the GRIN lens serves as holder for single photon emitters as well as light collection objective. Furthermore a solid immersion lens like behaviour increases the emission of a dipole into the direction of the GRIN lens. Depending on the defect centre type we expect more than 100 kcts/s of fibre coupled single photons. This high count rate combined with its easy experimental realisation, moderate cost for components and its small dimensions of about 3 mm by 3 mm by 30 mm makes this device interesting for robust and low cost single photon implementations.

ISS 3.7 Tue 12:15 HSZ 02

A spintronic circularly-polarized single-photon source — •Andreas Merz, Pablo Asshoff, Robin Schwerdt, Heinz Kalt, and Michael Hetterich — Karlsruhe Institute of Technology (KIT)

Diluted magnetic semiconductors (DMS) are among the most promising materials for efficient spin-injection into semiconductors. They are thus ideal materials for designing a spin-polarized single photon source pumped by an electrical current. As a model system we investigate a spin light-emitting diode with the DMS ZnMnSe and an InGaAs quantum dot as single photon source. With an applied magnetic field of 2 T, a pronounced spin-polarization of $\sim 65\,\%$ is achieved, while at B = 6 T it even approaches 95 %. Autocorrelation measurements in pulsed operation mode prove the light emitted being non-classical.

ISS 3.8 Tue 12:30 HSZ 02

On-demand single photon source in (311)A GaAs quantum dots — •Snežana Lazić, Rudolf Hey, and Paulo Santos — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5–7, 10117 Berlin, Germany

We demonstrate the generation of single photons on demand using an acousto-electric effect in GaAs/AlGaAs quantum well (QW) grown by molecular beam epitaxy on pre-patterned (311)A GaAs substrates. In this process, a surface acoustic wave (SAW) is employed to control the transfer of carriers, photogenerated in the QW, to an array of quantum dots (QDs) embedded at well-defined positions within the high-mobility QW transport channel. The embedded QD arrays form during the growth at the edges of etched triangular trenches due to monolayer fluctuations of the QW thickness. The photoluminescence from these acoustically-pumped arrays of QDs consists of a series of sharp lines which are attributed to the recombination of carriers in discrete quantum states. Time-resolved studies show that the population of the emitting states within the array, as well as the subsequent emission of single photons is governed by the SAW. The photons are emitted when the electrons captured within the array recombine with holes brought in a subsequent SAW cycle. The mechanism for the emission of non-classical light from QD arrays was investigated by analyzing the statistics of the emitted photons using the Hanbury Brown and Twiss approach.

ISS 3.9 Tue 12:45 HSZ 02

Tunnel Injection in Electrically Pumped Single Photon Emitters — •Alexander Dreismann[1], Murat Öztürk[1], Ole Hitzemann[1], Erik Stock[1], Waldemar Unrau[1], Askhat K. Bakarov[2], Aleksandr I. Toropov[2], Ilia A. Derebezov[2], Vladimir Haisler[2], and Dieter Bimberg[1] — [1]Institut für Festkörperphysik, TU-Berlin, 10623 Berlin, Germany — [2]Institute of Semiconductor Physics, 630090 Novosibirsk, Russia

Electrically pumped InGaAs/GaAs quantum dot (QD) based Resonant-Cavity LEDs (RC-LEDs) represent powerful semiconductor based single photon and potential entangled photon emitters with high out-coupling efficiencies as required for quantum key distribution [1]. To achieve high photon emission rates the exciton luminescence intensity should be as high as possible; in the case of entangled photon sources exciton and biexciton luminescence intensities should be comparable.

To optimize the operation of our RC-LED in this regard we investigate the dependence of the luminescence intensity on the applied bias as well as on the temperature. We observe resonant tunneling injection of charge carriers into the QDs before the flat band condition of the diode structure is reached [2]. The influence of the dark state of the exciton on the luminescence is studied by comparing experimental data with a rate equation model. This work was partly funded by the SFB 787.

[1] D. Bimberg et. al., IEEE Photonics Journal, 1, 58 (2009)
[2] A. Baumgartner et. al., Phys. Rev. Lett. accepted (2010)

ISS 4: Intersectional Poster Session

This intersectional session presents about 150 posters, half from the KM section and half from the AMOP section. The participating divisions have selected topics at the interface of both sections and those of mutual interest. A recurring theme are transport phenomena: charge transport in molecular devices including solar cells, transport in molecular nanostructures and entanglement dynamics, as well as explicitly time-dependent transport phenomena. Quantum information in general and its realization is of common interest to both sections and prominently represented in this poster session which is completed by quantum coherence, ultracold few- and many body phenomena. The intersectional poster session is an excellent opportunity to have informal discussions with colleagues from the "other section" who one normally does not meet at DPG meetings.

Time: Tuesday 18:00–21:00 Location: P1

See sessions A 13, Q 23, MO 11 / CPP 18, DY 15, HL 45, and TT 29 for contributions to this intersectional poster session.

ISS 5: Transport and Spectroscopy in Molecular Nanostructures I (CPP, MO, related to SYMN)

Energy transfer in complex molecular aggregates is a very challenging topic with contributions from quite diverse fields certainly including those of molecular and chemical physics. In this section the aggregates range from biological to artificial complexes showing the large range of systems as well as the progress this field has achieved during the last years. The examples range from single molecule experiments over atomistic simulations to complex hybrid aggregates.

Time: Wednesday 14:00–17:00 Location: ZEU 160

ISS 5.1 Wed 14:00 ZEU 160

Site-specific assembly of DNA-based photonic wires using programmable polyamides — Wu Su[1], •Markus Schuster[2], Clive Bagshaw[3], Ulrich Rant[2], and Glenn A. Burley[1] — [1]Department of Chemistry, University of Leicester, Leicester, UK — [2]Walter Schottky Institut, TU München, Garching, Germany — [3]Department of Biochemistry, University of Leicester, Leicester, UK

DNA constitutes a unique programmable scaffold for nanotechnological applications where the assembly of functional materials with nanoscale precision is an essential requirement. Of particular interest is the development of nanophotonic sensors and devices where DNA's addressable architecture enables the precise arrangement of fluorophores to produce an optical output. Various approaches for the construction of DNA photonic wires have been investigated; however current methods lack the ability to achieve well-defined and reproducible assemblies with high energy transport efficiency.

Here we show the construction of a site-specific, programmable DNA photonic wire model system by the utilization of fluorophore-tethered-pyrrole-imidazole polyamides (PAs) which inserts a fluorophore at a precise location within a DNA duplex. We demonstrate for the first time the construction of site-directed fluorophore assemblies along a pre-formed DNA duplex and reveal the importance of such control by the demonstration of efficient energy transport over distances in excess of 27 nm.

ISS 5.2 Wed 14:15 ZEU 160

Single molecule fluorescence-excitation and emission spectroscopy on the same individual light harvesting 2 complexes from *Rps. acidophila 10050* — •Ralf Kunz[1], Kõu Timpmann[2], Arvi Freiberg[2], Richard J. Cogdell[3], and Jürgen Köhler[1] — [1]Experimental Physics IV, University of Bayreuth — [2]Institute of Physics, University of Tartu — [3]Institute of Molecular, Cell & Systems Biology College of Medical, Veterinary and Life Sciences, University of Glasgow

Fluorescence-excitation and emission spectra from the same individual light harvesting 2 complexes from *Rps. acidophila strain 10050* measured at low temperature will be presented. The combination of both spectroscopic techniques provides information about the absorbing and emitting electronic states within the same LH2 complex.
To our surprise we find different types of emission spectra (with/without zero-phonon line) which do not correlate with different types of fluorescence-excitation spectra. The shape of the emission spectra, however, shows a clear correlation with the spectral position.

ISS 5.3 Wed 14:30 ZEU 160

Photocurrent of a single Photosystem I — •Daniel Gerster[1], Simone M. Kaniber[2], Johannes V. Barth[1], Alexander W. Holleitner[2], Itai Carmeli[3], and Joachim Reichert[1] — [1]Physik Department E20, TU München, James-Franck Str, D-85748 Garching — [2]Walter Schottky Institut and Physik-Department, TU München, Am Coulombwall, D-85748 Garching — [3]Center for NanoScience and Nanotechnology and School of Chemistry, Tel Aviv University, Israel 69978 Tel Aviv

Photosynthesis in plants and bacteria is driven by photoactive biomolecular complexes. Such photosynthetic reaction centers have evolved approximately 3.5 billion years ago, and they serve as the ultimate source of energy in the biosphere. The photosynthetic process involves an efficient conversion of solar energy to stable chemical energy. Photo-excitation of photosystem I (PS I) causes an electron transfer through a series of redox reactions. We report on the directed photo-current which is generated by a single PS I. The PS I is situated on an Au substrate, and it is electronically contacted by an apertureless scanning near-field optical microscope tip. The tip acts as a light source and counter-electrode at the same time. The PS I is covalently bound to the electronic circuit via cysteine mutation groups located at both ends of the electron transfer path.

ISS 5.4 Wed 14:45 ZEU 160

Atomistic modeling of light-harvesting complexes: dissipation, correlation and spectra — •Carsten Olbrich[1], Thomas Jansen[2], Jörg Liebers[1], Mortaza Aghtar[1], Johan Strümpfer[3], Klaus Schulten[3], Jasper Knoester[2], and Ulrich Kleinekathöfer[1] — [1]Jacobs University Bremen, Germany — [2]University of Groningen, Netherlands — [3]University of Illinois, Urbana, USA

The light absorption in light-harvesting complexes is performed by chlorophyll molecules. Recent experimental findings in some of these complexes suggest the existence of long-lived coherences between the individual pigments at low temperatures. In this context the question arises if the bath-induced fluctuations at different chromophores are spatially correlated or not. To this end we performed classical MD simulations and semi-empirical quantum chemistry calculations on some light-harvesting systems [1]. In these investigations at ambient temperatures, only weak correleted movement of the atoms and none for the sites could be observed [2]. Ensemble-averaged wave packet dynamics will be used to study the transfer of energy, i.e., excitons, in light-harvesting systems. On top of this, the same techniques can be employed to determine two-dimensional spectra which can be directly linked to experiment.

[1] C. Olbrich and U. Kleinekathöfer, J. Phys. Chem. B 114, 12427(2010).
[2] C. Olbrich, J. Strümpfer, K. Schulten and U. Kleinekathöfer, J. Phys. Chem. B. (in press).

ISS 5.5 Wed 15:00 ZEU 160

Excitons in Molecular Aggregates with Lévy Disorder: Anomalous Localization and Exchange Broadening of Optical Spectra — •Alexander Eisfeld[1], Sebastiaan Vlaming[2], Victor Malyshev[2], and Jasper Knoester[2] — [1]MPI-PKS Dresden — [2]University of Groningen

We predict the existence of exchange broadening of optical lineshapes in disordered molecular aggregates and a nonuniversal disorder scaling of the localization characteristics of the collective electronic excitations (excitons). These phenomena occur for heavy-tailed Lévy disorder distributions with divergent second moments - distributions that play a role in many branches of physics. Our results sharply contrast with aggregate models commonly analyzed, where the second moment is finite. They bear a relevance for other types of collective excitations as well.

Phys. Rev. Lett. **105**, 137402 (2010)

ISS 5.6 Wed 15:15 ZEU 160

Size-dependent Excitonic Properties of Perylene Bisimide Aggregates — •Steffen Wolter, Franziska Fennel, Henning Marciniak, and Stefan Lochbrunner — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18055 Rostock

The excitonic properties of J-aggregates made from substituted Perylene Bisimides are investigated by stationary and femtosecond spectroscopy. The high quantum yield of 82 % [1] and the recently shown long exciton diffusion length [2] make these aggregates promising candidates for applications like organic solar cells or optoelectronic switches. Here we focus on the excitonic properties in dependence of the aggregat size. Upon heating, a smooth transition from the J-aggregat to the monomer is observed in the absorption spectra. However, the emission shows a distinct minimum of the quantum yield at intermediate temperatures, indicating the existence of a weakly emitting species. Further information on this species is obtained by femtosecond pump probe and fluorescence lifetime measurements. For J-aggregates, pronounced annihilation is observed, indicating that the excitons are highly mobile. In contrast, almost no remaining annihilation dynamic remains and the fluorescence life time rises abruptly for the weakly emitting state. We discuss the possibility, that the weakly emitting state might be a short H-type aggregate.

[1] Li X.-Q., Zhang X., Ghosh S., Würthner F., Chem. Eur. J. 14, p.8074 - p.8078 (2008)

[2] Marciniak H., Li X.-Q., Würthner F., Lochbrunner S., submitted to J. Phys. Chem.

15 min. break

ISS 5.7 Wed 15:45 ZEU 160

Demonstration of an organic photonic gate — •Martti Pärs[1], Christiane Hofmann[1], Peter Bauer[2], Mukundan Thelakkat[2], and Jürgen Köhler[1] — [1]Experimental Physics IV, University of Bayreuth, 95440 Bayreuth, Germany — [2]Applied Functional Polymers, University of Bayreuth , 95440 Bayreuth, Germany

We demonstrate the function of an organic photonic gate, that consists of a photochromic switch that is covalently linked to two chromophores. As switch we use dithienylcyclopentene (DCP) that can reversibly be converted by light between two bistable states. As chromophores we employ perylene bisimide, whose fluorescence is monitored as a function of the state of the switch. We present results with respect to the modulation depth of the fluorescence, the quantum yield of the device, and its fatigue resistance.

ISS 5.8 Wed 16:00 ZEU 160

Spectral shifts and energy transfer in dye-functionalized nanostructures on silicon substrates — •Thomas Baumgärtel, Harald Graaf, and Christian von Borczyskowski — Center for Nanostructured Materials and Analytics, Institut für Physik, TU Chemnitz, 09107 Chemnitz, Germany

We use local anodic oxidation (LAO) via atomic force microscopy (AFM) to generate silicon oxide nanostructures with a height of a few nanometers and lateral dimensions below 50 nm on alkyl-terminated silicon. These structures can be selectively functionalized by anchoring optically active materials such as dye molecules or semiconductor nanoparticles via a chemical bottom-up approach. This controlled immobilization of fluorophores on a semiconductor surface with a high positioning accuracy in the nanometer regime is a promising step towards the creation of new types of optical nanoscopic devices and model systems. Especially interesting are the optical properties (e.g. spectral emission, excited state lifetime, transition dipole orientation) of the bound emitters which can show a rather large difference compared to a solution or randomly oriented molecules on a surface. These differences will be discussed as a result of the anchoring mechanism, the close proximity of the emitters to the underlying silicon, intermolecular aggregation and alignment and thus an efficient energy transfer.

ISS 5.9 Wed 16:15 ZEU 160

Förster Resonant Energy Transfer (FRET) in Orthogonal Chromophores — •Igor Pugliesi[1], Heinz Langhals[2], and Eberhard Riedle[1] — [1]LS BioMolekulare Optik, LMU München — [2]Dept. Chemie, LMU München

FRET has become a process of ubiquitous importance in chemistry and biochemistry. While proximity measurements of light absorbing and fluorescent structures still rely on the basic theory of FRET, recent results from 2D electronic spectroscopy on light harvesting complexes show, that a more refined model is required for an accurate description of this photophysical process [1]. We investigate the very principles of FRET on a set of perylene bisimide dyads by pump-probe spectroscopy, chemical variation and calculations. These dyad undergo transfer with near unit quantum efficiency although the transition dipole moments of donor and acceptor are in a perfectly orthogonal arrangement to each other in the equilibrium geometry. According to the point dipole approximation used in Förster theory no energy transfer should occur. Experimentally we do, however, observe ultrafast transfer times ranging from 1 ps up to 45 ps. With the transition density cube approach, the change of the spacer both in length and chemical character and temperature variations we demonstrate that energy transfer is enabled through low frequency ground state vibrations, which break the orthogonal arrangement of the transition dipole moments. The dyads presented here therefore are a first example that shows with extreme clarity the decisive role vibrational motion plays in energy transfer processes [2].

[1] Yuan-Chung Cheng and Graham R. Fleming, *Annu. Rev. Phys. Chem., 241*, 60, **2009**.

[2] Heinz Langhals, Andreas J. Esterbauer, Andreas Walter, Eberhard Riedle, and Igor Pugliesi, *J. Am. Chem. Soc.*, 16777, 132, **2010**.

ISS 5.10 Wed 16:30 ZEU 160

Electronic transport through organophosphonate monolayers on silicon/silicon dioxide substrates — •Achyut Bora[1], Anshuma Pathak[1], Kung-Ching Liao[2], Anna Cattani-Scholz[3], Gerhard Abstreiter[3], Jeffrey Schwartz[2], and Marc Tornow[1] — [1]Institut für Halbleitertechnik, TU Braunschweig, Germany — [2]Department of Chemistry, Princeton University, NJ, USA — [3]Walter Schottky Institut, TU München, Germany

Understanding the electronic transport through layered systems of organic functional layers on semiconductor surfaces is of major importance for future applications in nanoelectronics, photovoltaics and sensors. We have prepared self-assembled monolayers (SAMs) of 9,10-diphenyl-2,6-diphosphono-anthracene and 11-hydroxyundecyl phosphonic acid precursors on highly p-doped silicon surfaces coated with a ~1 nm SiO_2 layer. Contact angle, AFM and ellipsometry evidenced the homogeneity of the formed SAMs, and their thickness was determined to be 0.82 ± 0.07 nm and 1.13 ± 0.09 nm, respectively. We provided large area electrical contacts on top of the SAMs by a hanging Hg drop electrode. The measured I-V characteristics revealed an enhanced conductance of the aromatic vs. the aliphatic compounds, with current densities of the order of $10A/m^2$ and $0.01A/m^2$, at 0.5 V, respectively. We analyzed the data in terms of non-resonant tunneling through the combined oxide-SAM barrier and found good qualitative agreement up to 0.2 V bias. Preliminary measurements on organized bilayers of anthracene bisphosphonates that were grown using techniques of coordination chemistry will be discussed, too.

ISS 5.11 Wed 16:45 ZEU 160

Excited states dynamics of two-dimensional donor-acceptor systems — Juliane Köhler[1], •Ingo Fischer[1], Tatjana Quast[1], Johannes Buback[1], Tobias Brixner[1], and Christoph Lambert[2] — [1]Institut für Physikalische und Theoretische Chemie, Universität Würzburg — [2]Institut für Organische Chemie, Universität Würzburg

Since electron transfer (ET) is one of the fundamental steps in the working principle of optoelectronic devices, the aim of our work is the systematic study of the optically induced ET in donor-acceptor compounds. Our interest lies in the excited states dynamics that is associated with the subsequent back-electron transfer which can be determined by time-resolved transient absorption spectroscopy on a fs- and ps- timescale. Here, we present our recent experimental results on donor-substituted truxenones which are interpreted in the framework of the Marcus theory. As donor we chose the triarylamine because of its low reorganization energy. The truxenone itself is known to be a good acceptor and its C_3h symmetry allows the substitution of three donor branches. Hence, the ET dimension is extented from one to two. Furthermore we investigated the fluorenone which is the central building block of the acceptor to distinguish their excited state dynamics from the CT state.

ISS 6: Transport and Localization of interacting Bosons 1 (DY, Q)

Cold quantum gases or Bose Einstein condensates may be exposed to dynamical forces. The Bose model systems allow for detecting localization, transport, decoherence and relaxation under conditions that are tunable in a wide range. A toolbox of convenient methods contains dynamic light forces, optical lattices or gradient fields. The systems of ultracold Bosons may be enriched by impurities of other atomic species and disorder. The two common sessions of Q and DY present this field with a series of experimental and theoretical contributions, joining communities and their different approaches and different foci of their research for mutual inspiration.

Time: Wednesday 16:30–18:00 Location: HSZ 02

ISS 6.1 Wed 16:30 HSZ 02

Observation of Absolute Negative Mobility in Driven Quantum Systems — •Tobias Salger[1], Sebastian Kling[1], Sergey Denisov[2], Alexey Ponomarev[2], Peter Hänggi[2], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Wegelerstrasse 8, 53115 Bonn — [2]Institut für Physik, Universitätsstrasse 1, 86135 Augsburg

Here we report on the observation of absolute negative mobility (ANM) of a Bose-Einstein condensate in an ac-driven quantum system. This effect describes the paradoxial situation, when the motion of a particle is always in oppositve direction to an applied external gradient field. Based on successful experiments, demonstrating a directed motion of a Bose-Einstein condensate in a Hamiltonian quantum ratchet, we investigate the dynamics of atoms when exerted to an external bias field [1].

Up to now, the presence of strong decoherence mechanisms has been considered to be crucial for absolute negative mobility [2]. However here we demonstrate for the first time that this phenomenon can also be observed in a coherent quantum system. Our experimental results are in good agreement with a theoretical model, based on numerical simulations.

[1] T. Salger et al., Science **326**, 1241 (2009)
[2] A. Ros et al., Nature **436**, 928 (2005)

ISS 6.2 Wed 16:45 HSZ 02

Direct observation of quasi-local relaxation with strongly correlated bosons in an optical lattice — •Stefan Trotzky[1,2,3], Yu-Ao Chen[1,2,3], Andreas Flesch[4], Ian P. McCulloch[5], Ulrich Schollwöck[1,6], Jens Eisert[6,7], and Immanuel Bloch[1,2,3] — [1]Ludwig-Maximilians Universität München — [2]MPI für Quantenoptik, Garching — [3]Johannes-Gutenberg Universität Mainz — [4]Forschungszentrum Jülich — [5]University of Queensland — [6]Institute for Advanced Study, Berlin — [7]Universität Potsdam

The question of how closed quantum systems far from equilibrium come to rest lies at the heart of statistical mechanics. We report the experimental observation of the relaxation dynamics of a one-dimensional bosonic density wave in an optical lattice. Using an optical superlattice, we are able to load Bose-Hubbard chains with each second lattice site occupied. Furthermore, the superlattice allows us to monitor the non-equilibrium dynamics emerging after rapidly switching on the tunnel coupling along the chain in terms of quasi-local densities, currents and correlations. We find a rapid relaxation of all these quantities to steady-state values compatible with those of a maximum entropy state. We compare the experimental results to parameter free time-dependent DMRG simulations, finding excellent agreement. The system thus can be seen as an accurate dynamical quantum simulator for the systematic study of equilibration phenomena in strongly correlated many-body systems.

ISS 6.3 Wed 17:00 HSZ 02

Observation of subdiffusion of a disordered interacting system — •Eleonora Lucioni[1], Benjamin Deissler[1], Luca Tanzi[1], Chiara D'Errico[1], Giacomo Roati[1], Matteo Zaccanti[1,2], Michele Modugno[1,3], Massimo Inguscio[1], and Giovanni Modugno[1] — [1]LENS and Università di Firenze, and CNR-INO, Italy — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria — [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

We study the transport dynamics of matter-waves in the presence of disorder and non-linearity. A Bose-Einstein Condensate of 39K atoms is let free to expand in a quasiperiodic lattice realized by superimposing two laser beams of incommensurate wavelength in standing wave configuration. By means of a broad magnetic Feshbach resonance it is possible to tune the scattering length between atoms at will. In the noninteracting case this system is an experimental realization of the Aubry-André model: if the disorder is strong enough, the system is localized and no expansion is permitted (Anderson localization).

The presence of a weak repulsive interaction allows the coupling between orthogonal localized single particle states and destroys localization. In this case we observe a change of shape of the atomic cloud during the expansion and a slow increase of the width σ of the sample that follows a subdiffusive law: $\sigma(t) \propto t^{\alpha}$, with $\alpha = 0.2 - 0.4$. We find that the exponent increases with the initial interaction energy and the localization length.

ISS 6.4 Wed 17:15 HSZ 02

Coherent transport of a BEC in the presence of disorder and nonlinearity — •Tobias Geiger, Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut der Universitaet Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

For a dilute cloud of weakly interacting ultracold bosons subject to a random disorder potential, the Gross-Pitaevskii equation, in its limits, produces reliable results. However, for increasing amounts of disorder and interaction, the stationary solution of the mean field description [1] – and eventually also the mean field description itself – breaks down.

In our approach, we treat the full bosonic N-body problem microscopically in a nonlinear scattering setup. By employing a diagrammatic technique relying on the assumption of a weakly scattering disorder potential [2], one is in principle able to sum up all different orders of the nonlinear scattering series.

Here, we present first preliminary results of different scattering orders and compare them to findings predicted by the Gross-Pitaevskii equation.

[1] T. Paul, M. Albert, P. Schlagheck, P. Leboeuf, and N. Pavloff, Phys. Rev. A **80**, 033615 (2009)
[2] T. Wellens and B. Grémaud, Phys. Rev. A **80**, 063827 (2009)

ISS 6.5 Wed 17:30 HSZ 02

Interaction-based reduction of weak localization in coherent transport of Bose Einstein Condensates — •Josef Michl[1], Timo Hartmann[1], Juan Diego Urbina[1], Cyril Petitjean[2], Thomas Wellens[3], Peter Schlagheck[4], and Klaus Richter[1] — [1]Institute of Theoretical Physics, University of Regensburg, Germany — [2]SPSMS-INAC-CEA, Grenoble, France — [3]Physics Department, University of Fribourg, Switzerland — [4]Physics Department, University of Liège, Belgium

Based on the Gross-Pitaevskii-equation, we investigate reflection amplitudes and reflection probabilities in the transport of coherent bosonic matter waves through a fully-chaotic two-dimensional billiard-system. Like in the case of electronic transport, one can observe the effect of weak-localization in this setting. Our interest lies now in the influence of a weak interaction between particles on the weak-localization-peak and its behaviour in the presence of a weak magnetic field in the billiard.

Numerical results on this topic predict a reduction of the weak-localization-peak for small magnetic fields and a vanishing influence of the interaction with an increasing one. Trying to explain that, an analytical technique based on a semiclassical treatment in form of a diagrammatic perturbation theory in the parameter representing the interaction will be presented. Its results are compared to the numerical findings.

ISS 6.6 Wed 17:45 HSZ 02

Anderson orthogonality catastrophe in ultracold quantum gases — •Daniel Kotik[1], Martina Hentschel[1], and Walter Strunz[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 83, 01187 Dresden — [2]Institut für Theoretische

Physik, TU Dresden, 01062 Dresden

Ultracold quantum gases have attracted a lot of attention in recent years, not least due to their exquisite experimental control and the resulting versatile possibilities to manipulate them.

Here, we study impurity potentials in ultracold bosonic quantum gases and specifically in their Bose-Einstein condensed phase, that result, e.g., from unavoidable defects contained in the material or from deliberately placed perturbations. Our emphasis will be on spatio-temporal perturbations that are suddenly switched-on and spatially localized, as can be realized by switching on an additional laser beam. The many-body response of the quantum gas to this impurity potential is studied numerically and analytically.

We will pay particular attention to the consideration of the bosonic analogue known from solid state theory as Anderson orthogonality catastrophe.

ISS 7: Transport and Spectroscopy in Molecular Nanostructures II (CPP, MO, related to SYMN)

Charge and energy transfer and the respective spectroscopic techniques for molecular nanostructures are the topic of this session. Many of these processes take place on an ultrafast time scale and in a huge variety of different systems ranging from relatively simple molecular to polymeric systems and nanowires bridging the gap between molecular, chemical and solid state physics.

Time: Thursday 10:30–13:00 Location: TOE 317

ISS 7.1 Thu 10:30 TOE 317

Ultrafast electronic dynamics in a polyfluorene based guest-host system — •Henning Marciniak, Maik Teicher, and Stefan Lochbrunner — Institut für Physik, Universität Rostock

Guest-host systems are frequently used for organic solid state lasers to achieve tunability of the emission wavelength and low lasing thresholds. Efficient excitation energy transfer from the host to the guest material and the behavior at high exciton densities are thereby important. We investigate a polyfluorene based guest-host system that shows optically pumped lasing in a distributed feedback structure [1]. Combined analysis of steady state and time resolved spectroscopic studies gives rise to a complex picture of the photoinduced dynamics. Steady state and time resolved fluorescence measurements on the nanosecond timescale show emission signatures from the guest material pointing to efficient excitation transfer from the hostto the guest. However, femtosecond pump probe absorption measurements find no signatures of stimulated emission from the guest material but pronounced nonlinear dynamics on the picoseconds timescale. As one quenching mechanism amplified spontaneous emission from the host system is identified, which arises under high excitation densities. However, since the excitation parameters are similar to the nanosecond fluorescence measurements, additional mechanisms have to be taken into account.

[1] T. Riedl, T. Rabe, H.-H. Johannes, W. Kowalsky, J. Wang, T. Weimann, P. Hinze, B. Nehls, T. Farrell, and U. Scherf, *Appl. Phys. Lett.* **88** (2006), 241116.

ISS 7.2 Thu 10:45 TOE 317

Molecular aggregates: handling a complicated vibrational quasi-continuum with non-Markovian quantum state diffusion — •Gerhard Ritschel, Jan Roden, and Alexander Eisfeld — MPI-PKS Dresden

The electronic excitation transfer and the optical processes in molecular aggregates, e.g. light harvesting systems or H-aggregates, are strongly influenced by the coupling to vibrational degrees of freedom – these are internal vibrational modes of the monomers as well as vibrations of the environment. For an adequate theoretical description, that allows us to understand the dynamics of these systems, it is therefore essential to include the vibrations in the calculations.

To this end we apply a new approach, that is based on a non-Markovian quantum state diffusion treatment: a time-dependent stochastic Schrödinger equation for an electronic wave function is solved numerically and the reduced density operator is obtained by averaging over many realizations of the stochastic noise.

This efficient method enables us to calculate spectra and energy transfer dynamics in a non-perturbative way. It is now possible to capture the whole range from coherent dynamics to incoherent diffusion and to investigate the influence of a complicated structured quasi-continuum of vibrations.

Phys. Rev. Lett. **103**, 058301 (2009)

ISS 7.3 Thu 11:00 TOE 317

Time-resolved electron-transfer properties of a low-band-gap neutral mixed-valence polymer — •Florian Kanal[1], Tatjana Quast[1], Martin Kullmann[1], Stefan Ruetzel[1], Johannes Buback[1], Sabine Keiber[1], Dörte Reitzenstein[2], Christoph Lambert[2], and Tobias Brixner[1] — [1]Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]Institut für Organische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg

We present measurements of the electron-transfer properties of a polyradical consisting of alternating triarylamine donor and triarylmethyl radical acceptor moieties. This first polymeric neutral mixed-valence compound is attractive for applications due to its low band gap. It shows an intervalence charge transfer (IVCT) band in the near infrared. The polyradical and a reference monomer were investigated by liquid-phase fs pump–probe spectroscopy in two different solvents. Excited in the visible spectral range and probed with a whitelight supercontinuum, the transient spectra of the polyradical feature two bands around 550 nm and 650 nm. These bands are assigned to characteristic transitions of the anion and the radical cation, respectively, formed upon optically induced electron transfer. The decay curves exhibit a biexponential decay in the ps time regime. The short-living – solvent dependent – component refers to the direct decay from the IVCT state to the ground state. The long-living – solvent independent – component is tentatively attributed to an equilibrium formation of the IVCT state and a completely charge-separated state.

ISS 7.4 Thu 11:15 TOE 317

Electronic properties of semiconducting polymer nanotubes — •Thomas Plocke[1], Matthias Müller[1], Janina Maultzsch[1], Christian Thomsen[1], Andreas Stefopoulos[2], Souzana Kourkouli[3], Elina Siokou[3], Kostas Papagelis[3], and Joannis Kallitsis[2,3] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Foundation for Research and Technology Hellas, Institute of Chemical Engineering and High Temperature Processes (FORTH-ICEHT), 26504, Patras, Greece — [3]University of Patras, 26504, Patras, Greece

Single-walled carbon nanotubes were functionalized with different polymeric quinoline chains using the "'grafting from"' approach in order to combine the properties of the semiconducting polymers with those of the carbon nanotubes [1]. We perform a resonant Raman spectroscopy analysis to study the influence of the functionalization on the electronic properties and the optical transitions of the modified tubes. We observe that the electronic properties of the nanotube derivatives change due to doping effects caused by charge transfer between the tubes and the polymers. Interestingly, our results on different functionalized single-walled carbon nanotubes show frequency shifts for the Raman G-mode in both directions compared to the pristine material. The preparation pathway of the studied samples allows us to distinguish structural from electronic effects caused by the polymer and the metal ion.[1] A. A. Stefopoulos, S. N. Kourkouli, E. Siokou, K. Papagelis, M. Müller, T. Plocke, J. Maultzsch, C. Thomsen, J. K. Kallitsis; in preparation (2010).

ISS 7.5 Thu 11:30 TOE 317

Conductance enhancement of InAs/InP heterostructure nanowires by surface assembly of oligo-phenylenevinylene molecular wires — •Muhammed Ihab Schukfeh[1], Kristian Storm[2], Roar Søndergaard[3], Anna Szwajca[1], Allan Hansen[1], Peter Hinze[4], Thomas Weimann[4], Claes Thelander[2], Frederik C. Krebs[3], Lars Samuelson[2], and Marc Tornow[1] — [1]Institut für Halbleitertechnik, TU Braunschweig — [2]Lund University, Solid State Physics, Sweden — [3]Risø DTU, Technical University of Denmark — [4]PTB, Braunschweig

The direct combination of organic molecules with semiconductor nanostructures provides an appealing approach towards possible future nanoelectronic systems. In this context, indium-arsenide is a material of particular interest due to the presence of an electron inversion layer at the surface. We have prepared 50 nm diameter InAs nanowires comprising a 5 nm long InP segment, and contacted them by Ti/Au metallic leads on a planar Si/Si-oxide substrate. Electronic transport measurements at 77 K confirmed the presence of the potential barrier of the InP segment. After investigation of the assembly of 12 nm long, dithiolated oligo-phenylenevinylene (OPV) derivative molecules from solution onto planar InAs surfaces the same recipe was applied to the InAs/InP nanowires, which led to a pronounced, non-linear I-V characteristic, with significantly increased currents of up to 1 μA at 1 V bias, for a back-gate voltage of 3 V. We attribute this effect to the OPV molecules tethered to the nanowire surface, thereby increasing the surface conductance across the InP barrier.

ISS 7.6 Thu 11:45 TOE 317

Modeling the blinking dynamics of single CdSe/ZnS quantum dots probing their local environment — •Cornelius Krasselt[1], Robert Schmidt[1], Jörg Schuster[1,2], and Christian von Borczyskowski[1] — [1]Institute of Physics and nanoMA (Center for nanostructured Materials and Analytics), Chemnitz University of Technology, Germany — [2]now: Fraunhofer Institute ENAS

Fluorescence intermittency, also known as blinking, appears to be a common feature of many different classes of individual emitters like semiconductor quantum dots. Generally it is characterized by inverse power law distributions for both the on- and off- times [1] which are due to trapping and detrapping processes of charges in- and outside the quantum dots, respectively.

This contribution discloses the influences of the local environment surrounding ZnS coated CdSe quantum dots on silicon oxide on their blinking dynamics. We present atypical distributions for the on-time statistics which show deviations from the expected power law behaviour only seen at the beginning of the statistics. These deviations correlate to the local density of hydroxyl groups on silicon oxide but are also measured in polymers such as PS and PVA. Furthermore we are able to resolve the intensity levels of quantum dot time traces via intensity-changepoint analysis observing an increasing density of bright intensity levels in case of enhancing on-time deviations accompanied by longer exciton lifetimes. All results are discussed in terms of a model concerning hole trapping processes within the quantum dots.

[1] F. Cichos et al.: COCIS 12 (2007), 272

ISS 7.7 Thu 12:00 TOE 317

Off-time distribution in blinking quantum dots: theoretical investigation — •Peter Reineker[1], Thomas Hartmann[1], and Vladimir Yudson[1,2] — [1]Institute of Theoretical Physics, Ulm University, Albert-Einstein-Allee 11, 89069 Ulm, Germany — [2]Institute for Spectroscopy, Russian Academy of Sciences, Troitsk, Moscow region, 142190, Russia

The understanding of blinking quantum dots (QDs) is an open problem since more than a decade. We have investigated the off-time distribution of a semiconductor QD on the basis of an Auger-induced release process of an electron deeply trapped in the QD shell. This release process has not yet been treated in the literature explicitly and starts with the optical generation of an additional electron-hole pair in the off-state of a QD, characterized by a valence band hole in the core and a trapped electron in the shell. This additional pair subsequently recombines and the recombination energy is transferred by an Auger process to the trapped electron. We discuss the efficiency of the release process as compared to the quenching process. For a deep trap occupation density $\sim 1/r_0^6$ (r_0 is the trap distance from the QD center) and a Förster-like release rate, we arrive at an off-time distribution $\sim 1/t_{off}^{\alpha}$ with $\alpha = 3/2$ in agreement with experimental findings in many QDs.

ISS 7.8 Thu 12:15 TOE 317

Novel Multi-Chromophor Light Absorber Concepts for DSSCs for Efficient Electron Injection — •Robert Schütz[1], Christian Strothkaemper[1], Carlo Fasting[2], Inara Thomas[1,2], Andreas Bartelt[1], Thomas Hannappel[1], and Rainer Eichberger[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin, Germany — [2]Institut für Organische Chemie, Freie Universität Berlin, Takustraße 3, 14195 Berlin, Germany

Dye sensitized solar cells (DSSCs) operate by injecting electrons from the excited state of a light-harvesting dye into the continuum of conduction band states of a wide bandgap semiconductor. The light harvesting efficiency of pure organic dyes is limited by a narrow spectral electronic transition. A beneficial broad ground state absorption in the VIS region can be achieved by applying a single molecular dye system with multiple chromophors involving a Förster resonance energy transfer (FRET) mechanism for an efficient electron injection. A model donor acceptor dye system capable for FRET chemically linked to colloidal TiO_2 and ZnO nanorod surfaces was investigated in UHV environment. We used VIS/NIR femtosecond transient absorption spectroscopy and optical pump terahertz probe spectroscopy to study the charge injection dynamics of the antenna system. Different chromophors attached to a novel scaffold/anchor system connecting the organic absorber unit to the metal oxide semiconductor were probed.

ISS 7.9 Thu 12:30 TOE 317

Single molecule diffusion in columnar functionalized mesoporous rods — •Florian Feil, Valentina Cauda, Jens Michaelis, Thomas Bein, and Christoph Bräuchle — Physikalische Chemie, LMU München, Germany

Mesoporous silica materials are ideally suited as host-guest systems in nanoscience with applications ranging from molecular sieves, catalysts, nanosensors to drug delivery systems. For all these applications a thorough understanding of the interactions between the mesoporous host system and the guest molecules is vital. Here, we investigated fluorescent dyes as guest molecules acting as molecular probes that were loaded into the channels of mesoporous filaments. The dye AS-TDI was used as a tool to explore the nanoporous channel structure. By sputtering the sample with a very thin layer of gold, which quenches all molecules on the surface, we could show that the molecules were diffusing inside the structure along the columnar channels. Additionally, we could measure the orientation of the TDI molecules, as the channels have such a small diameter that the molecules are not able to rotate freely but have to align parallel to the channels. In a further approach we also succeeded in loading fluorescently labelled DNA into such a mesoporous host system. As mentioned above, we ensured by gold-sputtering that the DNA resides inside the channels and not on the surface of the filaments. Finally, it could be shown by using FRET measurements that the DNA is still intact inside the mesopores. Moreover, we were able to observe DNA diffusion inside the filament channels.

ISS 7.10 Thu 12:45 TOE 317

Characterization of non-covalently modified carbon nanotubes by Raman spectroscopy — •Daria Kovalenko[1,2], Anindya Majumder[2], and Jörg Opitz[1,2] — [1]Fraunhofer Institute for Non-Destructive Testing, 01109 Dresden — [2]Institute for material science, Dresden University of technology, 01062 Dresden

Raman spectroscopy is a technique which allows getting information about chemical structure of the molecules. Recently it got widely used for examinations of carbon based materials. In this study Raman and UV/VIS spectroscopic techniques were used to characterize the process of modification of carbon nanotubes. Single walled carbon nanotubes were non-covalently bounded using different surfactants. By UV/VIS spectroscopy it was established what surfactants react better with the nanotubes and therefore they become more soluble in water. Raman spectra of the dispersions were obtained. Using them, we got information about the structure of the carbon nanotubes. By the wavenumber of RBM-modes in spectra of the CNT dispersions diameter of the nanotubes were calculated and possible chiralities were proposed. By comparing G- and D-band intensities presence and amount of semiconducting and metallic carbon nanotubes were determined.

ISS 8: Quantum Optics of Solid State Photon Sources (Q, HL)

Recently, several solid-state photon sources have been realized providing with good efficiency highly non-classical light such as single-photons on demand or entangled photon pairs. The intersectional session at the interface of semiconductor physics and quantum optics explores in a series of experimental and theoretical talks the generation of photons and their coupling to fibers or nano antennas as well as the characterization of the photon field and its potential utilization for quantum information technologies. Different approaches based on, e.g., nitrogen- or silicon-vacancy color centers in diamond, semiconductor quantum dots, and microcavity polaritons are presented.

Time: Thursday 10:30–13:00 Location: HSZ 02

ISS 8.1 Thu 10:30 HSZ 02

Solid state single photon sources based on color centers in diamond — •Elke Neu[1], David Steinmetz[1], Christian Hepp[1], Janine Riedrich-Möller[1], Roland Albrecht[1], Jan Meijer[2], Martin Fischer[3], Stefan Gsell[3], Matthias Schreck[3], and Christoph Becher[1] — [1]Universität des Saarlandes, FR 7.2 Experimentalphysik, D-66123 Saarbrücken — [2]RUBION, Ruhr-Universität Bochum, D-44780 Bochum — [3]Universität Augsburg, Lehrstuhl für Experimentalphysik 4, D-86135 Augsburg

Color centers in diamond are promising candidates for practical single photon sources due to room temperature operation and superior photostability. We observe single photon emission from various color centers, produced either by ion-implantation or in-situ doping during CVD-growth. Optimum results are obtained from Silicon-Vacancy (SiV)-centers in isolated nano-diamonds grown on Iridium layers. These centers feature emission predominantly (80-90 %) into the narrow (0.7 nm) zero-phonon-line and high brightness with up to 4.8 Mcps at saturation, thus being the brightest single color centers to date [1]. We observe for the first time the fine structure of a single SiV-center at cryogenic temperatures and perfom detailed spectroscopy investigating level structures, polarization and the influence of spectral diffusion. We discuss strategies for enhancing spectral and spatial emission properties by coupling color centers to micro-cavities e.g. fiber-based or photonic crystal cavities.

[1] E. Neu et al, ArXiv 1008.4736 accepted for publication in *New J. Phys.*

ISS 8.2 Thu 11:00 HSZ 02

Quantum Light from a Whispering Gallery Resonator — •Josef Fürst[1], Dmitry Strekalov[2], Dominique Elser[1], Ulrik L. Andersen[1,3], Andrea Aiello[1], Christoph Marquardt[1], and Gerd Leuchs[1] — [1]Max Planck Institute for the Science of Light, Institute for Optics, Information and Photonics, University Erlangen-Nuremberg, Erlangen, Germany — [2]Jet Propulsion Laboratory, California lnstitute of Technology, Pasadena, USA — [3]Department of Physics, Technical University of Denmark, Kgs. Lyngby, Denmark

Optical subharmonic generation, also referred to as parametric down-conversion (PDC) is mediated by an optically nonlinear dielectric medium and connects an optical field to its subharmonic. In this process, one pump photon is converted to two subharmonic photons, called signal and idler. Enclosing the nonlinear medium in a cavity, the setup is called an optical parametric oscillator (OPO). We use a whispering gallery mode (WGM) resonator for our OPO. These WGM cavities offer high quality factors, that enhance the conversion efficiency of the nonlinear process. With a WGM resonator made from Lithium Niobate, we were able to show extremely efficient PDC in our WGM OPO. As the signal and idler photon pairs originate from one pump photon in PDC, they are strongly correlated in photon number. Investigating the quantum properties of the interacting light fields, while driving the OPO above the pump threshold, we observed nonclassical parametric light [1]. We plan to further investigate these quantum properties and will present the latest results.

[1] J. U. Fürst et al., arXiv:1008.0594v6 (2010)

ISS 8.3 Thu 11:15 HSZ 02

Studying Photon Number Distributions of (NV-) Single-Photon Centres — •Waldemar Schmunk[1], Marco Gramegna[3], Giorgio Brida[3], Ivo P. Degiovanni[3], Marco Genovese[3], Helmuth Hofer[1], Stefan Kück[1], Lapo Lolli[3], Matteo G.A. Paris[4], Silke Peters[1], Mauro Rajteri[3], Mark Rodenberger[1], Andras Ruschhaupt[2], Emanuele Taralli[3], and Paolo Traina[3] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [2]Leibniz Universtität Hannover, 30167 Hannover, Germany — [3]L'Istituto Nazionale di Ricerca Metrologica INRIM, 10135 Torino, Italy — [4]Universita degli studi di Milano, 20122 Milano, Italy

Reconstruction of the optical density matrix provides information on photon number distributions of unknown quantum states. In the present work we focus on the photon statistics of different nitrogen vacancies centres in diamond. For that purpose, the diagonal elements of the density matrix were experimentally determined by using a transition-edge sensor (TES), which produces an output pulse proportional to the number of photons absorbed and is therefore capable to resolve the photon number. Additional measurements were performed by on/off-statistics using avalanche photodetection assisted by a maximum likelihood estimation. From the data of the two photon number resolving techniques, values of the second order correlation function $g^{(2)}(t=0)$ were determined and compared with the corresponding values measured by a Hanbury-Brown-Twiss interferometer. In the presentation, the three methods will be described and discussed in detail.

ISS 8.4 Thu 11:30 HSZ 02

Realization of photonic crystal microcavities in single crystal diamond — •Janine Riedrich-Möller[1], Laura Kipfstuhl[1], Christian Hepp[1], Martin Fischer[2], Stefan Gsell[2], Matthias Schreck[2], and Christoph Becher[1] — [1]Universität des Saarlandes, Fachrichtung 7.2 (Experimentalphysik), Campus E2.6, 66123 Saarbrücken — [2]Universität Augsburg, Experimentalphysik IV, 86159 Augsburg

Microcavities in two-dimensional photonic crystal slabs allow to strongly confine light in volumes of about one cubic wavelength. They are expected to enable the realization of highly efficient emitters and control of spontaneous emission. Such photonic crystal microcavities are routinely fabricated in semiconductor materials. On the other hand, in recent years diamond has attracted significant interest as material for quantum information processing due to the extraordinary properties of optically active defect centers. These so called colour centers can be employed e.g. for cavity enhanced single photon sources that operate at room temperature or cavity-based atom-photon interfaces. We here investigate the fabrication of photonic crystal cavities in single crystalline diamond grown on an Iridium layer. We produce free-standing diamond membranes by dry-etching techniques and pattern them by focussed ion beam milling (FIB). We both realize 1D nanobeam cavities etched in a freestanding waveguide and 2D cavities with several missing holes in a triangular lattice. For the 2D cavities we experimentally obtain quality factors of Q = 300.

ISS 8.5 Thu 11:45 HSZ 02

Photon blockade in a strongly coupled quantum-dot cavity system — •Thomas Volz, Andreas Reinhard, and Atac Imamoglu — Institute of Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

A long-standing goal in the field of mesoscopic cavity quantum electrodynamics is the demonstration of photon blockade in a strongly coupled quantum-dot cavity system. While signatures of quantum correlations in resonant scattering have been observed previously, here we demonstrate for the first time strong photon blockade in such a device. Our system consists of a single self-assembled InGaAs quantum dot positioned at the field maximum of a photonic crystal L3 cavity (Q≈24000), leading to a coupling strength of g $\approx$ 150 μeV. In order to tune the cavity in resonance with the neutral quantum dot transition we employ a nitrogen tuning technique. We then probe the strongly coupled device with a resonant laser employing a cross-polarization technique to suppress the excitation-laser light. Due to strong classical blinking dynamics of the quantum dot we additionally use a repump laser to enhance the polariton signal. The photons scattered from the strongly-coupled system are analysed in a standard Hanbury-Brown-Twiss correlation setup. Due to the fast decay dynamics of the polaritons we carry out the experiment in pulsed mode. When the laser is resonant with the polaritons we observe strong antibunching - clear signature of photon blockade. Our results pave the way for the realization of non-linear photonic devices, such as a single-photon transistor or the quantum optical Josephson interferometer.

ISS 8.6 Thu 12:00 HSZ 02

Deterministic Coupling of Individual Quantum Systems to Photonic Crystal Structures — Janik Wolters[1], •Andreas W. Schell[1], Günter Kewes[1], Nils Nüsse[2], Max Schoengen[2], Bernd Löchel[2], Michael Barth[1], and Oliver Benson[1] — [1]Nano-Optics, Institute of Physics, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin — [2]Operator Centre Microtechnology, Helmholtz-Centre Berlin for Materials and Energy, Albert-Einstein-Straße 15, 12489 Berlin

The controlled and scaleable coupling of single quantum emitters to photonic crystal structures is one of the main challenges on the way towards integrated solid-state devices for optical quantum information processing. We tackle this problem by using a hybrid approach, which combines lithographic fabrication techniques with nanomanipulation methods, allowing the deterministic coupling of arbitrary emitters or other nanoscopic objects to the optical modes of photonic crystal cavities. Here we present recent experimental results on the controlled coupling of the zero phonon line emission from a single NV-center in a nanodiamond to such cavities. Our approach is well suited for the creation of improved single photon sources and also complex photonic devices with several emitters coupled coherently via shared cavity modes.

ISS 8.7 Thu 12:15 HSZ 02

Deterministic Coupling of Single Nitrogen Vacancy Centres in Diamond Nanocrystals to Bowtie Nanoantennas — •Günter Kewes, Andreas Schell, Thomas Aichele, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, Nanooptik

Surface plasmons polaritons provide the opportunity to concentrate electromagnetic energy in volumes much smaller than the wavelength of a photon with equal frequency, i.e. focussing beyond Abbe's limit, therefore giving large interaction between light and matter. This can be exploited in the construction of optical antennas which are designed to concentrate excitation energy at an emitter's location and further enhance the emitters output.

We present the coupling of single nitrogen vacancy (NV) centres in nanodiamond with a gold nanoantenna. The NV centres were systematically rearranged through AFM nanomanipulation around the nanoantenna, resulting in maps of excited state lifetime reduction. These maps can give great insight into the near-field properties of such structures allowing for optimization of hybrid emitter-antenna systems. We observe that this reduction is not solely a fluorescence quenching effect, and an overall enchancement of the photon rate by a factor 2.2 was found.

ISS 8.8 Thu 12:30 HSZ 02

Quantum key distribution using electrically triggered quantum dot-micropillar single photon sources — •Tobias Heindel[1], Markus Rau[2], Christian Schneider[1], Martin Fürst[2,3], Sebastian Nauerth[2,3], Matthias Lermer[1], Henning Weier[2,3], Stephan Reitzenstein[1], Sven Höfling[1], Martin Kamp[1], Harald Weinfurter[2,4], and Alfred Forchel[1] — [1]Technische Physik and Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 Munich, Germany — [3]qutools GmbH, 80539 Munich, Germany — [4]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

In 1984, Bennett and Brassard proposed a secret key-distribution protocol (BB84) that uses the quantum mechanical properties of single photons to avoid the possibility of eavesdropping on an encoded message. Due to the lack of efficient single photon sources however most quantum key distribution (QKD) experiments have been performed with strongly attenuated lasers. First experiments utilizing optically pumped solid state based single photon sources affirmed the great potential of QKD but still suffered from the drawbacks of this excitation scheme.

In this work we report on a QKD experiment using highly efficient electrically triggered quantum dot - micropillar single photon sources with $g^{(2)}(0)$-values below 0.5 and sifted key rates in the range of 10 kBit/s.

ISS 8.9 Thu 12:45 HSZ 02

Generation of entangled photon pairs from the polariton ground state in a switchable optical cavity — •Adrian Auer and Guido Burkard — Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

Intersubband cavity polaritons are the fundamental excitations of a planar microcavity embedding a sequence of doped quantum wells [1]. They arise from the interaction of cavity photons with intersubband excitations in the quantum wells. The ground state of the system, the polariton vacuum, contains a finite number of photons and, moreover, correlations of two photons having opposite in-plane wave vectors. It was proposed that these photons can be released by a non-adiabatic tuning of the light-matter interaction [1,2]. We theoretically investigate the polariton vacuum state in order to determine the entanglement between two photons, where we restrict our analysis to only two different modes. This could be carried out experimentally by a post-selective measurement. In this case we find that there is some entanglement for photon pairs having exactly opposite in-plane wave vectors which we quantify by the concurrence C. The amount of entanglement depends on the frequency of each photon and can be as high as $C = 0.7$ for experimentally reasonable values. The probability for a successful post-selection is determined to be on the order of 10^{-5}.

[1] C. Ciuti, G. Bastard and I. Carusotto, Phys Rev. B **72**, 115303 (2005).

[2] S. De Liberato, C. Ciuti and I. Carusotto, Phys. Rev. Lett. **98**, 103602 (2007).

ISS 9: Transport and Localization of interacting Bosons 2 (DY, Q)

This session continues ISS 6.

Time: Thursday 14:30–16:00 Location: BAR Schön

ISS 9.1 Thu 14:30 BAR Schön

Interband dynamics in a many-body Wannier-Stark system — •Carlos Parra Murillo[1], Javier Madroñero[2], and Sandro Wimberger[1] — [1]Institut fuer theoretische Physik, Heidelberg University, D-69120, Heidelberg, Germany — [2]Physik Department, Technische Universitaet Muenchen, D-85747 Garching, Germany

In the last years the dynamics of ultracold atoms, in particular Bose condensates loaded into optical lattices, have become amply studied in view of interesting phenomena like Landau-Zener tunnelling, resonantly enhanced tunnelling (RET) and Bloch oscillations. Regular and chaotic regimes can be reached by varying the parameters in the many-body description of ultracold bosons [1]. We present results obtained by studying the dynamical properties of a two-band Bose-Hubbard Hamiltonian for a one-dimensional tilted optical lattice [2]. We compare the interband dynamics for the single particle limit and for the fully interacting system, by computing the average occupation of the upper band. The spectral properties (avoided crossings) provide a comprehensive understanding of the dynamics close to RET as a control parameter is varied and the number of particles is increased. The dynamical correlations between the bands imply interesting perspectives for state-of-the-art experiments with ultracold bosons.

[1] A. Tomadin, R. Mannella, and S. Wimberger, Phys. Rev. Lett. 98, 130402 (2007). [2] P. Ploetz, J. Madroñero, and S. Wimberger, J. Phys. B 43, 081001(FTC) (2010).

ISS 9.2 Thu 14:45 BAR Schön

Stability and decay of Bloch oscillations in Bose-Einstein condensates with time-dependent atom-atom interactions — •Christopher Gaul[1], Elena Díaz[1,2], Cord A. Müller[3], Rodrigo Lima[4], and Francisco Domínguez-Adame[1] — [1]GISC, Departamento de Física de Materiales, Universidad Complutense, E-28040 Madrid, Spain — [2]Institute for Materials Science, Technische Universität Dresden, D-01062 Dresden, Germany — [3]Centre for Quantum Technologies, National University of Singapore, Singapore 117543, Singapore — [4]Instituto de Física, Universidade Federal de Alagoas, Maceió AL 57072-970, Brazil

Bose-Einstein condensates in tilted optical lattices allow the observation of Bloch oscillations (BOs). Generically, the interaction leads to dephasing and to the decay of the wave packet. By means of Feshbach resonances, however, experimentalists can tune the s-wave scattering length to zero or modulate it in time. We investigate the effect of such time-managed interactions on BOs. Additionally to the noninteracting case and a solitonic solution, we find an infinite family of modulations that preserve the Bloch oscillating wave packet [1]. In these cases, the stability follows from a time-reversal argument. In the unstable cases, we employ a collective-coordinates ansatz and a stability analysis, in order to quantify the decay of the BOs. In particular we show that in presence of external perturbations, an additional modulation of the interaction can enhance the lifetime of the Bloch oscillation [2].

[1] Gaul et al. PRL 102, 255303 (2009)
[2] Díaz et al. PRA 81, 051607R (2010)

ISS 9.3 Thu 15:00 BAR Schön

Wave packet surgery in driven optical lattices — •Stephan Arlinghaus and Martin Holthaus — Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg

The dynamics of particles in a periodic potential under the influence of homogeneous external forcing is governed by Bloch's acceleration theorem, provided the single-band approximation remains viable. However, interband transitions induced by strong time-periodic forces, which lie ouside the scope of this old approach, offer most interesting perspectives for coherent control. We show how a generalized acceleration theorem, based on the use of Floquet states, leads to novel control strategies, allowing one to selectively "cut out" certain parts from the particles' wave packets. Ultracold atoms in driven optical lattices provide experimentally accessible testing ground for these ideas.

ISS 9.4 Thu 15:15 BAR Schön

Weak (anti-)localization of Bose-Einstein condensates in two-dimensional chaotic cavities: numerical results — •Timo Hartmann[1], Juan Diego Urbina[1], Klaus Richter[1], and Peter Schlagheck[2] — [1]Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany — [2]Département de Physique, Université de Liège, 4000 Liège, Belgium

The possibility to induce artificial magnetic gauge potentials for matter waves [1] and to create almost arbitrarily shaped confinement potentials [2] makes it now interesting and feasible to study coherent transport of Bose-Einstein condensates through various mesoscopic structures. Previous theoretical studies have focused on the question how coherent backscattering in disordered potentials is modified by the presence of the atom-atom interaction [3]. We now study the analogous scenario of weak localisation in ballistic billiard geometries which exhibit chaotic classical dynamics. To this end we numerically investigate the quasi-stationary propagation of a condensate through such structures within the mean-field approximation. The transmission is measured as a function of the magnetic gauge field and of the non-linearity. With increasing non-linearity an inversion of the weak-localisation peak is visible and its origin will be discussed.

[1] Y.-J. Lin et al., Phys. Rev. Lett. **102** 130401 (2009)
[2] K. Henderson et al., New J. Phys. **11**, 043030(2009)
[3] M. Hartung et al., Phys. Rev. Lett. **101**, 020603 (2008).

ISS 9.5 Thu 15:30 BAR Schön

Destruction of localization in a nonlinear generalization of the quantum kicked rotor — •Goran Gligorić, Joshua Bodyfelt, and Sergej Flach — MPI für Physik komplexer Systeme

Quantum suppression of classically chaotic diffusion was first observed numerically in the quantum kicked rotor model. This phenomenon can be considered in many aspects as the dynamical version of Anderson localization in tight-binding disordered models [1]. In the case of the kicked rotor there is no true randomness and diffusion after an initial time interval appears, resulting from chaotic dynamics in the corresponding classical counterpart. The realization of Bose-Einstein condensates has opened a new opportunity for studying dynamical systems in the presence of many-body interactions. In the mean field approximation, these interactions can be represented by adding a quartic nonlinearity in the Schrödinger equation. Our aim is to utilize such a model, as introduced by Shepelyansky [2] in order to understand how nonlinearity generally affects the kicked rotor model. Particularly, we aim to understand the influence of nonlinearity on dynamical localization; of special concern is the possibility of a critical nonlinear strength above which localization is destroyed, and how this destruction comes about. Lastly, we will consider the corresponding anomalous subdiffusion law in this regime and test its universality.

[1] S. Fishman, D.R. Grempel and R.E. Prange, Phys. Rev. A 29 (1984) 1639
[2] D.L. Shepelyansky, Phys. Rev. Lett. 70 (1993) 1787

ISS 9.6 Thu 15:45 BAR Schön

Localization of two interacting bosons in a random potential — •Dmitry Krimer[1,2], Ramaz Khomeriki[1,3], and Sergej Flach[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01189 Dresden, Germany — [2]Institute for Theoretical Physics, University of Tuebingen, 72076 Tübingen — [3]Physics Department, Tbilisi State University, 0128 Tbilisi, Georgia

We study the dynamics of two interacting bosons in one-dimensional random lattices using the Bose-Hubbard model. In the absence of interaction all eigenstates are spatially localized and both particles follow the single particle dynamics corresponding to Anderson localization. Our study aims to clarify the interplay of disorder and interactions in few-body dynamics. In particular, we calculate the enhancement factor of the localization length l_2 in comparison to the single particle localization length l_1 for weak disorder performing rigorous numerical calculations. Previous studies based on the mapping of the two-particle problem onto a physically relevant matrix model contained different statements on this issue [1]. Our findings are in tact with predictions, which follow from the statistical properties of the overlap integrals of single particle eigenvectors [2].

[1] D.L. Shepelyansky, Phys. Rev. Lett. 73, 2607 (1994); K. Frahm, A. Müller-Groeling, J.-L. Pichard, D. Weinmann, Europhys. Lett., 31, 169 (1995)
[2] D.O. Krimer, S. Flach, Phys. Rev. E 82, 046221 (2010)

ISS 10: Nano Plasmonic (A, HL)

Plasmons are collective motions of electrons in different environments being exhibited by surface states and nanoparticles on a condensed matter substrate as well as in free nanoparticles, clusters, and fullerenes. Even a single atom displays the collective motion of its surrounding electrons in the form of electron correlation satellite excitations. This intersectional subject of overlapping interest between condensed matter and atomic, molecular, and optical physics should be presented in this session.

Time: Friday 10:30–13:00 Location: BAR 205

Invited Talk ISS 10.1 Fri 10:30 BAR 205

Plasmon Driven Higher Harmonics Generation — In-Yong Park, Seungchul Kim, Joon-Hee Choi, and •Seung-Woo Kim — Ultrafast optics for ultraprecision research group, KAIST, Daejeon, Republic of Korea

Plasmonic resonance enables field enhancement of a low-intensity fs pulse, permitting high harmonic generation without an additional amplifier. This new concept of generating ultrafast higher harmonic pulse was previously demonstrated using Au bow-tie antennas. The resulting intensity enhancement factor reached ~20 dB and successfully produced up to the 21st harmonic. Notwithstanding the high enhancement factor, the 2-dimensional configuration of the bow-tie nanostructure was found sensitive to thermal damages preventing practical usage. To cope with the problem, a 3-dimensional solid nanostructure is newly proposed and tested in this investigation. The newly designed nanostructure takes the shape of an ellipsoidal tapered waveguide fabricated in a cantilever micro-structure. The tapered waveguide functions as a plasmonic device that induces field enhancement by exploiting surface-plasmon polaritons being created as a femtosecond pulse propagates through. In comparison to bow-tie nano-antennas, the use of surface plasmon polaritons offers a much larger volume of enhanced laser field due to counter-propagating surface plasmon modes within the waveguide in response to the incident femtosecond pulse. The intensity of incident NIR pulses is enhanced by a factor of ~350, being strong enough to produce EUV harmonics up to the 43rd order directly from a modest input intensity of 1012 Wcm-2 in interaction with Xe gas.

Invited Talk ISS 10.2 Fri 11:00 BAR 205

Structure and Dynamics of Free Nanoparticles: From Charging to Time-Resolved Photoemission — •Eckart Rühl — Physikalische Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Nanoscopic systems prepared from nanoparticles as unique building blocks have the advantage that their properties depend critically on the single nanoscopic units and their assembly on substrates. Single nanoparticles show often size and composition dependent optical, electronic, structural, and dynamical properties. This includes quantum size effects, which are efficiently modified by the internal structure of the nanoparticles and their surroundings. Recent progress in chemical syntheses of structured nanoparticles as well as properties of single nanoparticles is presented. This includes controlled preparation of dimers or small aggregates of nanoparticles. Single, free nanoparticles without any contact to other particles or substrates are either prepared in traps or focused nanoparticle beams. These approaches allow us to study the intrinsic size- and composition dependent properties of isolated nanoscopic matter and their photon-induced dynamics. Results from a variety of different experimental approaches making use of synchrotron radiation and ultra-short laser pulses are presented. These provide specific information on the electronic structure, plasmonic excitations, the location of the emitted electrons in nanoparticles, the dynamics of electron emission and cation formation, as well as the dynamics of collective electronic excitations in the femtosecond time domain.

Invited Talk ISS 10.3 Fri 11:30 BAR 205

Terahertz Nano Plasmonics — •Dai-Sik Kim — Center for Subwavelength Optics, Department of Physics and Astronomy, Seoul National University, Seoul, Korea

In this talk, we will focus on how terahertz electromagnetic waves, with wavelengths in the millimeter scale, can funnel through nano slits and nano slot antennas. The field enhancement is enormous, three orders of magnitudes, which can be used for nonlinear processes and ultrasensitive probing of underlying structures. Optics in extreme subwavelength regime resembles electro-statics involving capacitors, in contrast to the electromangetic waves in free space.

Invited Talk ISS 10.4 Fri 12:00 BAR 205

Coulomb complexes: Electron emission from clusters in strong FEL pulses — •Ulf Saalmann — MPI for the Physics of Complex Systems

The response of atomic clusters to short intense pulses at extreme-ultraviolet (XUV) and Xray wavelengths — as available from short-wavelength free-electron laser (FEL) sources like FLASH in Hamburg/Germany, the SCSS in Japan or LCLS in Stanford/California — is studied theoretically. Due to the high photon flux the clusters become multiply charged by massive electron emission. We device a model, which we call Coulomb complexes [1], in order to investigate the emission process. It turns out that the electron spectra strongly depend on the ionization rate. For low rates the electron release occurs sequentially and our model allows for an analytical description of the plateau-like electron spectra [1]. At high rates a dense nanoplasma is formed and ionization occurs through energy-exchanging collisions resulting in exponential electron spectra [2]. Both mechanisms can be understand in terms of our model containing only very few parameters available from experiments.

[1] Gnodtke, Saalmann, Rost, New J. Phys. in press (2011).
[2] Bostedt et al., New J. Phys. 12, 083004 (2010).

Invited Talk ISS 10.5 Fri 12:30 BAR 205

Appearance of Surface and Volume Plasmons in Fullerenes — •Sanja Korica[1], Axel Reinköster[1], Markus Braune[1], Jens Viefhaus[1], Daniel Rolles[1], G. Fronzoni[2], D. Toffoli[2], M. Stener[2], P. Decleva[2], O. Al-Dossary[3], Burkhard Langer[4], and Uwe Becker[1,3] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Universitá di Trieste, Italy — [3]King Saud University, Riyadh, Saudi-Arabia — [4]Freie Universität Berlin

Since the discovery of the C_{60} molecule in 1985 many studies have been performed to investigate its fundamental properties. These properties are mainly driven by its unique molecular structure like its spherical shell. One of the important characteristics of this molecule is the collective response of its valence electron cloud to electromagnetic radiation. This collective behavior gives rise to the occurrence of the giant dipole resonance a surface plasmon in the absorption spectrum centered around 20 eV, which has been analyzed theoretically by various authors. In addition, our photoionization cross-section measurements reveal a resonance near 40 eV, a volume plasmon analogous to observations made for C_{60} ions. Time-dependent density functional calculations confirm the collective nature of this feature as corresponding plasmon excitation. A third excitation of this kind is predicted but not experimentally confirmed. Concerning photoelectron emission, plasmonic excitations are characterized by a particular intensity behavior near threshold. They follow the threshold behavior law predicted for the first time by Thomas Derrah. Our measurements of the C_{60} plasmon excitations above the C 1s ionization threshold confirm this law very well and are in unexpectedly good agreement with the corresponding behavior of K-shell satellite excitations in atoms such as neon.