HL 59: Quantum Dots and Wires, Optical Properties V

Time: Thursday 16:00–17:45 Location: H14

HL 59.1 Thu 16:00 H14

How to watch a pulse become coherent — •Marc Assmann[1], Franziska Veit[1], Manfred Bayer[1], Christopher Gies[2], Frank Jahnke[2], Stephan Reitzenstein[3], Sven Höfling[3], Lukas Worschech[3], and Alfred Forchel[3] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]Institute for Theoretical Physics, University of Bremen, 28334 Bremen, Germany — [3]Technische Physik, Physikalisches Institut, Universität Würzburg, 97074 Würzburg, Germany

Ultrafast changes of the statistical properties of light emission are studied for quantum-dot micropillar lasers. Using pulsed excitation with varying power we follow the time-evolution of the output intensity as well as the second-order correlation function $g^{(2)}(t,\tau{=}0)$ reflecting two-photon coincidences. Due to the previously impossible time resolution of 2 picoseconds we can study the dynamical transition between thermal and coherent light emission. The build-up and breakdown of coherence during a pulsed emission occurs with the same time dependence as the variation of the output intensity in the emission pulse and broadens with increasing excitation. This shows that the same physical mechanisms, the interplay of stimulated emission and cavity losses, determines both, the mean photon number and two-photon coincidences. Results of a microscopic theory confirm the experimental findings.

HL 59.2 Thu 16:15 H14

Quantum Kinetics of Multiple Exciton Generation in Quantum Dots — •Franz Schulze, Carsten Weber, and Andreas Knorr — Institut für Theoretische Physik, Technische Universität Berlin, Germany

The simultaneous generation of multiple excitons in quantum dots by a single photon, called multiple exciton generation (MEG), is of special interest for increasing the photovoltaic conversion efficiency [1,2]. We investigate the quantum kinetics of the creation of multiple excitons in multilevel quantum dots within a density matrix approach and present corresponding numerical results. We focus on the Auger-type Coulomb processes of impact ionization and Auger recombination to derive the equations of motion for exciton densities, electron densities and coherences.

[1] R. J. Ellingson *et al.*, Nano Lett. **5**, 865 (2005)
[2] P. Kowalski, P. Machnikowski, Acta Phys. Pol. A **114**, 1187 (2008)

HL 59.3 Thu 16:30 H14

Theory of phonon assisted relaxation in quantum dot systems — •Matthias-René Dachner, Janik Wolters, Felix Schlosser, Marten Richter, and Andreas Knorr — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin

We investigate microscopically the phonon assisted relaxation channels in an electrically pumped quantum dot (QD) system consisting of 0D QD states, 2D wetting layer (WL) states and 3D bulk states. For the WL–QD scattering multiphonon processes are included by a higher order Markovian approach based on a projection operator theory. Subsequently applying an effective second quantization treatment many body effects like Pauli blocking are included in the calculated scattering rates.

Furthermore, we investigate the population dynamics in the WL and observe carrier heating of the pumped system, where the temperature and current dependence is discussed [1].

[1] J. Wolters et al., Phys. Rev. B (accepted).

HL 59.4 Thu 16:45 H14

Coherent spectroscopy of single GaAs/AlGaAs quantum dots — •Christian Wolpert[1,2], Lijuan Wang[3], Paola Atkinson[3], Armando Rastelli[3], Oliver G. Schmidt[3], and Markus Lippitz[1,2] — [1]Max-Planck Institut für Festkörperforschung, Stuttgart, Germany — [2]4. Physikalisches Institut, Universität Stuttgart, Germany — [3]Institut für Integrative Nanowissenschaften, IFW Dresden, Germany

Semiconductor quantum dots (QDs) are a promising candidate for the realization of qbits for quantum computation. With coherence times of below 1 ns, writing, manipulation and read-out of a qbit requires ultrafast laser pulses interacting coherently with the system. A key experiment in this context is the observation of Rabi oscillations, where the population of a two-level system can be driven coherently back and forth between the ground state and the excited state. An almost shot-noise limited reflection pump-probe technique was employed by which we accomplished to measure Rabi oscillations in one of the fine structure split ground state excitonic states of our QDs, monitoring its population by the bleaching it imposes on the second ground state exciton transition. The first period of these population oscillations yields a dipole moment of about 10 Dy for the s-shell exciton. A second period is still visible, but stretched and shifted to higher pulse areas, which could be due to screening processes caused by carriers that are optically excited in the GaAs substrate.

HL 59.5 Thu 17:00 H14

Polarization and coherence properties of semiconductor micropillar lasers — •Jean-Sebastian Tempel[1], Ilya Akimov[1], Christian Schneider[2], Sven Höfling[2], Alfred Forchel[2], and Manfred Bayer[1] — [1]Experimentelle Physik II, Technische Universität Dortmund, D-44221 Dortmund — [2]Technische Physik, Universität Würzburg, D-97074 Würzburg

We present systematic, polarization selective investigations on the coherence properties of AlGaInAs quantum-dot micropillar lasers. The study of the first-order field-correlation function $g^{(1)}(\tau)$ reveals a polarization splitting of the fundamental mode of nominally circular pillars. It can be shown that the two orthogonally polarized components of the fundamental mode differ in both strength and coherence time. At excitation powers well above the lasing threshold, one mode is dominating the emission with an extinction ratio of more than 99 %. The stronger mode reveals an increase of the coherence time up to a record value of about 20 ns.

HL 59.6 Thu 17:15 H14

Coherent manipulation of the exciton phase via the AC-Stark effect — •Simon Gordon[1], Steffen Michaelis de Vasconcellos[1], Max Bichler[2], Torsten Meier[1], and Artur Zrenner[1] — [1]CeOPP, Universität Paderborn, Paderborn, Germany — [2]WSI, TU München, Garching, Germany

Excitons in InGaAs/GaAs quantum dots are an interesting implementation of qubits, especially concerning the interaction with photons. To achieve universal coherent control over a single qubit, a quantum phase gate is fundamental requirement. In our current contribution, we show that a quantum phase for an exciton qubit can be manipulated coherently by a non-resonant light field via the AC-Stark effect.

The effect of this non-resonant light field is investigated experimentally as well as theoretically by calculations based on the optical Bloch equations. In the experimental realization we used a Ramsey-like setup [1] to detect the phase shift and possible effects on the population of the qubit. Thereby, a first resonant laser pulse creates an coherent superposition of the exciton state and a second laser pulse after a fixed time delay probes the phase and population of the exciton qubit. During the delay time, the quantum phase is manipulated with either a non-resonant cw laser or a non-resonant ps laser pulse. We could demonstrate, that under selected conditions only the phase of the exciton qubit and not its population is influenced. The phase shift is thereby a function of the amplitude and the detuning of the non-resonant light field.

[1] Stufler et al. Phys. Rev. Lett. **96**, 037402 (2006)

HL 59.7 Thu 17:30 H14

Coherent Coupling of Two Different Semiconductor Quantum Dots via an Optical Cavity Mode — •Arne Laucht, José M. Villas-Bôas, Norman Hauke, Felix Hofbauer, Gerhard Böhm, Michael Kaniber, and Jonathan J. Finley — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, D-85748 Garching, Germany

We present a combined experimental and theoretical study of a strongly coupled system consisting of two spatially separated self-assembled InGaAs quantum dots and a single optical nanocavity mode. Due to their different size and strain profile, the two dots exhibit markedly different electric field dependences due to the quantum confined Stark effect. This allows us to tune them into resonance simply by changing the applied bias voltage and to independently tune them into the photonic crystal nanocavity mode. Photoluminescence

measurements show a characteristic triple peak during the double anticrossing, which is a clear signature of a coherently coupled system of three quantum states. We fit the emission spectra of the coupled system to theory and are able to investigate the coupling between the two quantum dots directly via the cavity mode. Furthermore, we investigate the coupling between the two quantum dots when they are detuned from the cavity mode in a V-system where dephasing due to incoherent losses from the cavity mode can be reduced.