HL 18 Symposium Quantum optics in semiconductors II

Time: Tuesday 15:15–17:15 Room: HSZ 01

Keynote Talk HL 18.1 Tue 15:15 HSZ 01

Light Matter Interaction Effects in Quantum Dot Microcavities
— •S. Reitzenstein[1], C. Hofmann[1], A. Löffler[1], J. P. Reithmaier[1], M. Kamp[1], A. Forchel[1], G. Sek[2], V. D. Kulakovskii[3], A. Bazhenov[3], A. Gorbunov[3], L. V. Keldysh[4], and T. L. Reinecke[5] — [1]Technische Physik, Universität Würzburg, Am Hubland, D 97074 Würzburg,Germany — [2]University of Technology, Wroclaw, Poland — [3]Institute for Solid State Physics, Rus. Acad. of Science, Chernogolovka, Russia — [4]Lebedev Institute, Rus. Acad. Of Science, Moscow, Russia — [5]Naval Research Laboratory, Washington DC , USA

Using high quality factor microcavities with quantum dots and long photon lifetimes the weak and strong interaction regimes between single quantum dot excitons and electric fields given by single photons are investigated by photoluminescence spectroscopy. The cavities are based on undoped GaAs/AlAs VCSEL structures with embedded InGaAs quantum dots from which micropillars with diameters between 1.0 μm and 4 μm are realized by reactive etching. The cavity photon lifetimes range from about 2 to close to 20 ps. In the weak coupling regime we observe e.g. an enhancement of the exciton and biexciton emission probability due to the Purcell effect. By using dots with large dipole moment we observe clear anticrossing effects due to strong interaction characterized by a vacuum Rabi splitting of up to 140 μeV.

Keynote Talk HL 18.2 Tue 15:45 HSZ 01

CQED with II-VI nanocrystals
— •Ulrike Woggon[1], Nicolas LeThomas[1], Oliver Schoeps[1], and Mikhail Artemyev[2] — [1]FB Physik, University Dortmund, Otto-Hahn-Str. 4, 44227 Dortmund — [2]Minsk State University, Minsk, Belarussia

Cavity QED concepts stimulated a tremendous technological development towards solid-state based, compact, and scalable cavity QED systems. In this contribution we report on a strongly coupled cavity QED system consisting of a CdSe nanocrystal coupled to a single photon mode of a polymer microsphere. The strong exciton-photon coupling is manifested by the observation of a cavity mode splitting of $\hbar\omega \approx 37\mu$eV and photon lifetime measurements of the coupled exciton-photon state. The single photon mode is isolated by lifting the mode degeneracy in a slightly deformed microsphere and addressing it by high-resolution imaging spectroscopy. This cavity mode is coupled to a localized exciton of an anisotropically shaped CdSe nanocrystal on the microsphere surface that emits highly polarized light in resonance to the mode. With colloidal CdSe NRs we add a new material class for which solid-state based cavity QED was implemented.

Keynote Talk HL 18.3 Tue 16:00 HSZ 01

Deutsch-Jozsa Algorithm using Triggered Single Photons from a Single Quantum Dot
— •Oliver Benson[1], Matthias Scholz[1], Thomas Aichele[2], and Sven Ramelow[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, Hausvogteiplatz 5-7, 10117 Berlin, Germany — [2]CEA/Université J. Fourier, Laboratoire Spectrométrie, Grenoble, France

Recently, wide attention has been drawn to the implementation of quantum algorithms by solely using linear optics. Previous experimental demonstrations along this line focused on coherent photon states from attenuated laser pulses [1] or spontaneous parametric down-conversion [2] in order to simulate simple quantum algorithms or to demonstrate concepts of noise resistant quantum computation [3]. We realize the on-demand operation of the two-qubit Deutsch-Jozsa algorithm using a triggered single-photon source. Our experimental setup resembles a classical Mach-Zehnder interferometer that is combined with a single-photon source realized by an exciton transition in a single quantum dot [4]. A variation of our experimental setup enables us to implement ideas of the concept of decoherence-free subspaces [5] in a triggered quantum algorithm on the single-photon level.

[1] S. Takeuchi, Phys. Rev. A 62, 032301 (2000)
[2] M. Bourennane et al., Phys. Rev. Lett. 92, 107901 (2004)
[3] M. Mohseni et al., Phys. Rev. Lett. 91, 187903 (2003)
[4] V. Zwiller et al., Appl. Phys. Lett. 82, 1509 (2003)
[5] P. Zanardi and M. Rasetti, Phys. Rev. Lett. 79, 3306 (1997)

Keynote Talk HL 18.4 Tue 16:30 HSZ 01

Imaging the Local Density of Photonic States in Photonic Crystal Nanocavities
— •Michael Kaniber, Felix Hofbauer, Simon Grimminger, Max Bichler, Gerhard Abstreiter, and Jonathan J. Finley — Walter Schottky Institut, Am Coulombwall 3, 85748 Garching

We present investigations of the coupling of InGaAs quantum dots (QDs) to both extended and strongly localised optical modes in 2D photonic crystal (PC) nanostructures. The samples consist of a 180nm thick GaAs membrane into which a PC is formed by etching a triangular lattice of air holes. By measuring the local QD spontaneous emission rate (R_{spon}) we "image"the photonic DOS at frequencies throughout the photonic bandgap (PBG) and close to localised modes at single missing hole defects (Q$\sim$10000, $V_{mode} < 0.5(\lambda/n)^3$). For QDs emitting into the PBG but detuned from the cavity mode, we observe a strong suppression of R_{spon} compared to its value in a homogenous photonic environment (R_0/R_{spon}=30$\pm$6) due to the reduced photon DOS. In contrast, for QDs coupled to the cavity modes we measure $1/R_{spon} \sim$ 50ps, corresponding to a large Purcell enhancement (R_{cavity}/R_0=18x).
Single dot measurements reveal clear photon anti-bunching when the emission frequency is detuned from the cavity mode and enhanced photon extraction efficiency ($\sim$30%) due to the PBG which suppresses inplane emission. Most surprisingly, anti-bunching is not observed for QDs coupled to the cavity modes possibly due to the onset of low threshold lasing.
Supported financially via Sonderforschungsbereich-631

Keynote Talk HL 18.5 Tue 16:45 HSZ 01

Theory of optical properties for quantum dots in microcavities
— •Frank Jahnke, Jan Wiersig, Norman Baer, and Christopher Gies — Institute for Theoretical Physics, University of Bremen

Semiconductor quantum dots are of strong current interest due to their application potential in light-emitting devices and single photon sources. The emission properties can be controlled to a high degree by embedding the quantum dots in a semiconductor microcavity. We present a microscopic theory for this system. In addition to carrier-photon interaction, also carrier-carrier and carrier-phonon interaction are included, which are the sources of scattering and dephasing processes. We investigate the photoluminescence dynamics for weak excitation and the laser regime for elevated pumping. The influence of the Purcell effect and of large spontaneous emission coupling on the optical properties is demonstrated. Signatures of carrier and photon correlations due to various interaction processes are analyzed.