HL 97: Quantum dots and wires: Pillars and cavities

Time: Friday 9:30–11:00 Location: ER 164

HL 97.1 Fri 9:30 ER 164

Control of spontaneous emission by shaping the vacuum field in coupled cavity systems — •Robert Johne[1], Chao-Yuan Jin[2], Milo Y. Swinkels[2], Ron Schutjens[2], Sartoon Fattah poor[2], Thang B. Hoang[2], Leonardo Midolo[2], Peter J. van Veldhoven[2], and Andrea Fiore[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]COBRA Research Institute, Eindhoven University of Technology, P.O. Box 513, NL-5600MB Eindhoven, The Netherlands

The real-time control of spontaneous emission (SE) is needed to harness cavity quantum electrodynamics processes for quantum information processing. Here we report an approach to the control of spontaneous emission via the ultrafast moulding of the vacuum field in two or three coupled cavities. We provide a first demonstration of this concept in a two-cavity structure where the injection of free carriers in a control cavity changes the mode volume and quality factor seen by semiconductor quantum dots sitting in a target cavity, and report a change in SE intensity by over a factor of two over a 200 ps timescale [1]. In the three-cavity system, tuning of the cavity resonances allows for on/off switching of the light-matter interaction [2] paving the way towards advanced applications in quantum information processing as well as for a new class of gain modulated lasers.

[1] C.-Y. Jin et al., Nature Nanotechnology 9, 886 (2014)
[2] R. Johne et al., submitted

HL 97.2 Fri 9:45 ER 164

Light matter coupling between a site controlled quantum dot and a resonant laser field — •Sebastian Unsleber[1], Michael Dambach[1], Sebastian Maier[1], Sven Höfling[2], Christian Schneider[1], and Martin Kamp[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Present address: SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

Many new applications in the field of quantum information technology and photonics require single and indistinguishable photons. Since quantum dots act inherently as emitters of such photons, they are basically predestinated for this schemes. A much higher scalability can be achieved if these quantum dots have a controlled nucleation position. Furthermore, the indistinguishability of the emitted photons is directly linked to their coherence properties, which means that the quantum dot should be excited resonantly in order to suppress e.g. spectral diffusion and time-jitter effects. As a step towards the generation of indistinguishable photons out of resonantly pumped site controlled quantum dots, we present in this work fundamental effects that occur for the coupling of the QD-exciton to the driving laser field. This coupling splits the two excitonic states into four dressed states. Transitions between these states give rise to the well-known Mollow-triplet. Furthermore, we investigate the temperature depended splitting of the two sidepeaks and their dephasing properties.

HL 97.3 Fri 10:00 ER 164

Non-classical Light Emission from an On-chip Excited Quantum Dot Micropillar Cavity — •Pierce Munnelly[1], Matthias Karow[1], Tobias Heindel[1], Matthias Lermer[2], Christian Schneider[2], Sven Höfling[2], Martin Kamp[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Technische Physik and Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Nanophotonics has been rapidly developing in recent years as the quest for integrated devices enabling the generation, manipulation and detection of single photons for light-based quantum information processing and cryptography is heavily pursued. A huge step forward in this regard is the monolithic integration of an electrically driven excitation source driving a non-classical light source on a single chip. We report on recent progress with a novel device incorporating semiconductor quantum dots embedded in micropillar cavities, which can be excited optically through the in-plane whispering gallery mode laser emission of a nearby electrically driven micropillar. The feasibility of such an approach for on-demand single and indistinguishable photon generation utilizing cavity-quantum electrodynamic effects as well as on-chip resonance fluorescence is clearly demonstrated by recent results.

HL 97.4 Fri 10:15 ER 164

Single quantum dot lasing in the strong coupling regime — •Fabian Gericke[1], Steffen Holzinger[1], Leon Messner[1], Tobias Heindel[1], Janik Wolters[1], Andreas Löffler[2], Martin Kamp[2], Sven Höfling[2,3], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [3]Present address: School of Physics and Astronomy, University of St Andrews, St Andrews KY16 9SS, United Kingdom

Light-matter interaction of single semiconductor quantum dots coupled to optical modes of microcavities enables one to study different regimes of cavity quantum electrodynamics in solid state. Of particular interest is the coherent coupling regime which is crucial for a variety of applications in quantum information processing and for exciting effects such as single photon nonlinearities. In this contribution, we experimentally demonstrate the onset of laser oscillation in a quantum dot micropillar laser which operates in the strong coupling regime. Single quantum dot lasing effects are demonstrated within comprehensive optical studies comprising power dependent first order and second order photon autocorrelation measurements, and a comparison between axial and lateral emission of the micropillar. Our work has high potential to trigger further progress on experiments with single dot lasers, as well as their theoretical modeling.

HL 97.5 Fri 10:30 ER 164

Statistical study on strong coupling of single and multiple quantum dots in micropillar cavities — •Anna Musial[1,2], Caspar Hopfmann[1], Micha Strauss[3], Christian Schneider[3], Sven Höfling[3,4], Martin Kamp[3], and Stephan Reitzenstein[1] — [1]Institute of Solid State Physics, Berlin University of Technology, 10623 Berlin, Germany — [2]Laboratory for Optical Spectroscopy of Nanostructures Department of Experimental Physics, Wrocław University of Technology, 50-370 Wrocław, Poland — [3]Technische Physik, University of Würzburg, 97074 Würzburg, Germany — [4]Present address: SUPA, School of Physics, and Astronomy, University of St Andrews, United Kingdom

Coherent photonic coupling of multiple quantum dots (QDs) in micropillar cavities is a very promising platform for the realization of coherent interaction between distant qubits. We performed a statistical study on various cases of strong coupling (SC) from isolated QDs coupled to cavity mode (CM) to multiple QDs interacting coherently via the CM. Experimental results are supported by the results of calculations in the framework of a coupled oscillator model. A characteristic triple peak spectral feature, increased effective coupling constant and double anticrossing, beeing a fingerprint of coherent coupling between 3 quantum states (hybrid states of two excitons and a CM), have been observed at resonance in agreement with the Tavis-Cummings description. Moreover, the hybridization of the coupled states is also reflected in a characteristic change of their polarization properties.

HL 97.6 Fri 10:45 ER 164

Influence of acoustic phonons on strong coupling phenomena in quantum-dot micro pillars — •Max Strauss[1], Anna Musial[1,2], Caspar Hopfmann[1], Micha Strauss[4], Andreas Barth[3], Martin Glässl[3], Christian Schneider[4], Sven Höfling[4,5], Martin Kamp[4], Vollrath Martin Axt[3], and Stephan Reitzenstein[1] — [1]Technische Universität Berlin, Germany — [2]Wroclaw University of Technology, Poland — [3]Universität Bayreuth, Germany — [4]Universität Würzburg, Germany — [5]University of St Andrews, United Kingdom

Coupled quantum dot (QD)- microcavity systems are of great interest with respect to both, the fundamental study of cavity quantum electro dynamics (cQED) and possible applications (e.g. quantum information processing). In such systems, phonon-induced losses have recently become comparable to cavity losses and it is thus desirable to understand their influence on cQED phenomena. We investigate the influence of acoustic phonons on the exciton-photon interaction in the strong coupling regime. Examining more than 90 QD-micropillars, we comprehensively study the phonon-induced renormalization of the Rabi frequency in an extraordinary wide temperature range of up to 60 K.