# TT 65: Quantum Dots: Optical Properties II (organized by HL)

Time: Wednesday 11:30–13:00 Location: POT 251

TT 65.1 Wed 11:30 POT 251

**Revealing the local environment noise of a quantum dot through resonance fluorescence intensity statistics** — •Megan Stanley, Clemens Matthiesen, and Mete Atatüre — Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, UK

The electronic level structure and optical transitions of quantum dots are subject to fluctuating electric fields from nearby charge traps and a noisy Overhauser field from local nuclear spins [1]. The resultant inhomogeneous electron spin dephasing and reduced photon spectral purity are detrimental to the use of dots in quantum information processing [2]. We combine the intensity autocorrelation of resonance fluorescence (RF) and full photon counting statistics to capture the amplitudes and timescales of environment-induced fluctuations. Full counting statistics offer a robust and technically undemanding method to quantify steady-state spectral diffusion. In particular, it allows us to distinguish blinking or switching from continuous spectral shifts when this is not obvious from RF timetraces. Charge and nuclear spin contributions to noise are distinguished in autocorrelations via a detailed exploration of detuning and excitation power dependent sensitivities in comparison to a theoretical model. We find electric field noise to dominate down to timescales of 100us. Finally, we expose nuclear spin noise exclusively by decoupling the fluorescence from the electric field fluctuations using a two-colour noise compensation technique. [1] A. V. Kuhlmann et al., Nature Phys. 9, 570-575 (2013) [2] C. Santori et al., Nature 419, 594-597 (2002)

TT 65.2 Wed 11:45 POT 251

**cQED-controlled anticorrelation between axial and lateral emission of quantum dot - micropillar cavities** — •Caspar Hopfmann[1], Micha Strauss[2], Christian Schneider[2], Sven Höfling[2,3], Martin Kamp[2], Alfred Forchel[2], and Stephan Reitzenstein[1] — [1]Institute of Solid State Physics, Technische Universität Berlin, D-10623 Berlin, Germany — [2]Technische Physik, Universität Würzburg, D-97074 Würzburg, Germany — [3]University of St Andrews, North Haugh, KY16 9SS United Kingdom

Cavity quantum electrodynamics (cQED) in high quality quantum dot (QD) microcavities has been subject of extensive research interest in recent years. This includes the study of fundamental cavity effects in the weak and strong coupling regime as well as their application in non-classical light sources. Here, we present an advanced optical characterization method to obtain comprehensive insight into the relevant cQED effects in QD-micropillar cavities. In contrast to conventional approaches in which the micropillar is addressed only in axial direction via its top facet, we implement additionally an in-plane excitation and detection scheme. In this unique configuration, excitation and detection capabilities are available synchronously in the axial and in-plane direction which opens up appealing opportunities for a broad study of cQED effects. For instance, it allows one to investigate the interplay between coupling emission from the QDs into resonator modes and leaky modes, respectively. Indeed, we demonstrate a cQED-controlled anti-correlation between single-QD emission through the top facet via resonator modes and emission through the side-walls via leaky modes.

TT 65.3 Wed 12:00 POT 251

**Stark shifts in single and vertically stacked GaAs QDs** — •Arne Ungeheuer, Achim Küster, Andreas Graf, David Sonnenberg, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

We study the optical properties of single GaAs quantum dots (QDs) and quantum dot molecules (QDMs) in vertical electrical fields. The QDs and QDMs are fabricated using molecular beam epitaxy in combination with the local droplet etching (LDE) technique [1]. Using Al-droplets on AlGaAs substrates, nanoholes of some ten nanometers depth are drilled and subsequently filled with GaAs to form QDs or with a GaAs/AlGaAs/GaAs sequence to form QDMs. Here, we report on the electric field-dependent energy-shift of the excitonic states due to the quantum-confined Stark-effect. Using a Schottky-diode structure and a micro-photoluminescence setup we observe a red-shift up to 25 meV.

[1] D. Sonnenberg et al., Appl. Phys. Let. **101**, 183113 (2012)

TT 65.4 Wed 12:15 POT 251

**Robust population inversion using an excitonic V-type three level system in a single InGaAs quantum dot** — •Dirk Mantei[1], Jens Förstner[1], Simon Gordon[1], Yves Alexander Leier[1], Ashish Kumar Rai[2], Dirk Reuter[1], Andreas D. Wieck[2], and Artur Zrenner[1] — [1]Center for Optoelectronics and Photonics Paderborn (CeOPP), Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Ruhr-Universität Bochum, Universitätsstraße 150, Gebäude NB, 44780 Bochum, Germany

For the optical manipulation of a single quantum system, diverse approaches such as Rabi Oscillations and the Adiabatic Rapid Passage are well established techniques. For instance they are used to realize quantum gates or single photon sources. To achieve an inversion as complete as possible we present a new possibility by examining a single quantum system with V-type three level scheme, a common ground state and two distinguishable and separately excitable transitions. Their sequential, pulsed excitation allows for the preparation of a robust, fault-tolerant and phase-insensitive inversion. We experimentally demonstrate and theoretically describe this concept, which is based on the polarization-selective excitation of a fine structure split exciton ground state in a single InGaAs quantum.

TT 65.5 Wed 12:30 POT 251

**Photocurrent spectroscopy of single InAs quantum dots at 1500 nm** — •Simon Gordon[1], Matusala Yacob[2], Yves Alexander Leier[1], Dirk Mantei[1], Mohamed Benyoucef[2], Johann Peter Reithmaier[2], and Artur Zrenner[1] — [1]CeOPP, Universität Paderborn, Paderborn, Germany — [2]INA, Universität Kassel, Kassel, Germany

For long distance quantum communication it is essential to use flying qubits in the telecom wavelength bands. Quantum emitters or detectors in this wavelength regime can be realized with InAs quantum dots on InP substrate. In this work, such InAs quantum dots are investigated by low-temperature high resolution photocurrent spectroscopy. Suitable p-i-n diode structures with self-assembled quantum dots have been grown by molecular beam epitaxy on InP(100) substrates. The layer sequence of the diodes consists of an n-InP back contact, an intrinsic region of lattice-matched InAlGaAs, which contains the quantum dots, and a p-InP front contact. The quantum dots are resonantly excited by a tunable single-frequency diode laser. By changing the applied reverse voltage the resonance energy of the quantum dot is tuned by the quantum confined Stark effect with respect to the laser line. We observe clear ground state absorption of single dots over a large tuning range in the photocurrent response. The highly resolved absorption lines show for the investigated samples no fine-structure splitting. This behavior could be caused by single electron charging, which leads to the decay of trions.

TT 65.6 Wed 12:45 POT 251

**Excitons in InAs-quantum dots measured by capacitance-voltage spectroscopy** — Patrick Labud, •Arne Ludwig, Andreas D. Wieck, and Dirk Reuter — Ruhr-Universität Bochum, Lehrstuhl für Angewandte Festkörperphysik

Electron-electron and hole-hole interaction has been studied intensively on self-assembled quantum dot (QD) samples using capacitance-voltage spectroscopy (C-V) since two decades. The energetic positions of the charging peaks are considerably affected by the Coulomb interaction energies and in standard C-V spectra only the Coulomb repulsion is seen.

In this contribution, we present C-V data obtained under nonresonant illumination from a light emitting diode. Under these conditions, additional charging peaks appear due to attractive Coulomb interaction between illumination induced holes and electrons, tunnelling into the QD.

We are able to resolve up to five additional charging peaks belonging to an $X^0$, $X^{1+}$, $X^{2+}$, $X^{3+}$, $X^{4+}$-complex, formed upon electron charging. The individual Coulomb energies are calculated from the charging gate voltage and the charging dynamics is discussed.