HL 12 Quantenpunkte und -drähte: Optische Eigenschaften II

Zeit: Freitag 15:00–16:30 Raum: TU P-N201

HL 12.1 Fr 15:00 TU P-N201

Biexciton Rabi oscillations in a single InGaAs/GaAs quantum dot — •Stefan Stufler[1], P. Ester[1], A. Zrenner[1], P. Machnikowski[2], V. M. Axt[2], T. Kuhn[2], and M. Bichler[3] — [1]Universität Paderborn, Warburger Straße 100, D-33098 Paderborn, Germany — [2]Institut für Festkörpertheorie, Westfälische Wilhelms-Universität, 48149 Münster, Germany — [3]Walter Schottky Institut, Technische Universität München, Am Coulombwall, D-85748 Garching, Germany

We report coherent control of the ground state biexciton in a single InGaAs/GaAs quantum dot. Excitation is achieved by resonant two-photon absorption of ps laser pulses. The occupancy of the quantum dot then is measured via the photocurrent. We observe Rabi oscillations which, in contrast to single-exciton oscillations, are not purely sinusoidal in excitation amplitude. This behavior is due to the two-photon excitation process. The experimental data show good qualitative agreement to theoretical curves derived for the assumption that sequential creation of the individual excitons is negligible. We have furthermore investigated the phase stability of coherent superposition states by quantum interference experiments. The observed dephasing times are only slightly shorter than those in according single exciton measurements. We thus are able to prove the feasibility of quantum gates based on the biexciton energy renormalization.

HL 12.2 Fr 15:15 TU P-N201

Absorption and Emission Spectroscopy on a Single Charge-Tunable Quantum Dot — •Martin Kroner[1], Alexander Högele[1], Stefan Seidl[1], Richard J. Warburton[2], Brian D. Gerardot[3], Pierre M. Petroff [3], and Khaled Karrai[1] — [1]Center for NanoScience and Department für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Department of Physics, Heriot-Watt University, Edinburgh, UK — [3]Materials Department, University of California, Santa Barbara, California 93106, USA

We have recently reported resonant interband absorption in the excitonic ground state of a single self-assembled InAs/InGaAs quantum dot [1]. The resonant interband transitions are observed directly as a reduction in the transmission signal when the exciton energy is tuned into resonance with a narrow band laser. This fairly new high-resolution laser spectroscopy technique profits from coherent creation of excitonic states in a single quantum dot, hence providing information about the oscillator strength as well as the lifetime. The excitonic state in the dot can be tuned from neutral to charged, simply by applying a gate voltage, as the dots are embedded in a field effect structure [2]. We measured absorption as well as photoluminescence spectra of the same quantum dot. Comparing these datasets reveals new insight into the electronic states of a quantum dot.

[1] A. Högele et al., Physica E 21 (2004); A. Högele et al., to appear in PRL (2004). [2] R. J. Warburton et al., Nature 405 (2000).

HL 12.3 Fr 15:30 TU P-N201

Heterodyne Four-Wave Mixing on Single Excitonic States — •Brian Patton[1], Wolfgang Langbein[2], and Ulrike Woggon[1] — [1]Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Straße 4, 44221 Dortmund — [2]School of Physics and Astronomy, Cardiff University, Cardiff, Wales, UK

Coherent optical spectroscopy on excitonic states allows insights into the underlying physics and opens up the possibility of manipulation of individual quantum states. Non-degenerate four-wave mixing and pump-probe spectroscopy are currently the main techniques. Instead, we use a novel heterodyne four-wave mixing technique which, by spectral interference with a reference signal, allows us to recover both the amplitude and phase of the third-order nonlinear polarisation of the single state. High-NA imaging of the sample allows the recovery of the resonant transient nonlinearity of single localized excitons. Furthermore, the knowledge of the phase of our signal allows subsequent analysis in both time and frequency domains. We have also narrowed the excitation to a single state and used a strong pump pulse to allow us to coherently drive the polarisation of the individual exciton by a desired angle in the Bloch sphere. We analyse the observed Rabi oscillations in the exciton polarisation with regard to the polarisation decay of the transition and we were able to rule out excitation induced dephasing as the source for observed deviations in the behaviour of the oscillations from the ideal 2-level system.

HL 12.4 Fr 15:45 TU P-N201

Demonstration of Phonon Bottleneck in Single Quantum Dot Molecules — •Ruth Oulton[1], Gerhard Ortner[1], Hannes Kurtze[1], Matthias Schwab[1], Dmitri Yakovlev[1], Manfred Bayer[1], Simon Fafard[2], Zbig Wasilewski[2], and Pawel Hawrylak[2] — [1]Experimentelle Physik II, Universität Dortmund, D-44221 Dortmund, Germany — [2]Institute for Microstructural Sciences, National Research Council, Ottawa, K1A 0R6, Canada

The dependence of emission intensity from the tunnel split exciton states in InAs/GaAs quantum dot molecules on their energy separation is studied. Even at the smallest excitation powers luminescence from both states appears in the spectra, when the splitting is smaller than the optical phonon energy. When the splitting becomes larger, emission from the antibonding states is observed only when the systems are optically pumped resulting in Pauli-blocking effects. This demonstrates the existence of an acoustic phonon relaxation bottleneck.

HL 12.5 Fr 16:00 TU P-N201

8-band k·p-theory for Wurtzite Crystals: Electronic Structure of InGaN Quantum Dots — •Momme Winkelnkemper, Andrei Schliwa, Robert Seguin, Sven Rodt, and Dieter Bimberg — Institut für Festkörperphysik, Technische UniversitätBerlin

We present an 8-band **k·p**-model for the calculation of single particle states in wurtzite-type semiconductor quantum dots. Special attention is paid to the influence of pyro- and piezoelectric effects since they have a large impact on electron and hole states, the oscillator strength, as well as the Coulomb interaction within few-particle states like excitons, biexcitons, trions, etc. To calculate all these effects (a) the classical 8-band **k·p**-model is extended to include strain as well as piezoelectric effects similar to the treatment of cubic semiconductors and pyroelectric effects and (b) a configuration interaction method is employed to account for all the few-particle effects like direct Coulomb interaction, exchange and correlation. Finally our results are compared to recent experimental results obtained by cathodoluminescence measurements on single InGaN quantum dots.

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HL 12.6 Fr 16:15 TU P-N201

Direct Observation of Controlled Coupling in an Individual Quantum Dot Molecule — •Emily C. Clark, H. J. Krenner, M. Sabathil, A. F. Kress, D. Schuh, M. Bichler, G. Abstreiter, and J. J. Finley — Walter Schottky Institut and Physik Department, TU Muenchen, Am Coulombwall 3, D-85748 Garching, Germany

The realization of robust and scalable hardware for quantum information processing is one of the most challenging goals of solid-state physics. Excitons in semiconductor quantum dots (QDs) represent a particularly attractive quantum bit because they can be coherently manipulated using ultrafast laser pulses.

We report the direct spectroscopic observation of quantum coupling in individual quantum dot molecules (QDMs) and its manipulation using static electric fields. We performed photoluminescence spectroscopy on single pairs of stacked, self assembled InGaAs/GaAs QDMs which were embedded in a n-i Schottky junction. A clear anti-crossing of spatially direct (e,h in same QD) and indirect (e,h in different QDs) excitonic states is observed as the electric field along the QDM axis is tuned. At the anticrossing the electron component of the wavefunction hybridizes into bonding and antibonding states split by the tunnel coupling energy of 1.6 meV. Comparison with realistic calculations, which include strain, piezo-electric and Coulomb effects, indicate a wetting layer separation of 11.9 nm. This is in very good agreement with the nominal growth separation of 10 nm. See: cond-mat/0410206