Optical spectroscopy on single quantum dots: Multi-exciton states and single electron charging

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Quantum dots, often referred to as artificial atoms, open the field of highly resolved spectroscopy to semiconductor physics. In the current contribution we report about optical experiments on single self-assembled quantum dots.

In power dependent low temperature magneto-photoluminescence experiments we have analysed the emission spectra of single dots for increasing exciton occupation numbers. Decays from different configurations (up to 4 excitons) lead to a renormalization of the emission lines in the region of the s- and p-shell of the dot. Photoluminescence excitation spectroscopy further allows us to explore the absorption properties of a single quantum dot. Both interband absorption and comparably strong phonon assisted absorption via InGaAs and GaAs LO phonons are observed, as well as sequential phonon assisted biexciton generation followed by sequential biexciton decay.

Further we report about controlled single electron charging of a single quantum dot investigated by magneto-photoluminescence spectroscopy on electric field tunable structures. We observe the emission lines of neutral, single, and double charged exciton states for different bias conditions. The application of high magnetic fields results in fully resolved Zeeman splittings and diamagnetic shifts. The upper Zeeman component of the single charged exciton is found to be quenched at higher electric fields. This behavior is explained in terms of an enhanced tunneling probability of the triplet versus the singlet configuration.