Effect of magnetic field on the excitation spectrum of single GaAlAs quantum dots

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The discrete nature of the energy levels ("atomic like") in semiconductor quantum dots (QDs) has been subject of many studies. Previous research on type II GaAs/AlAs bilayer showed the existence of GaAlAs islands which form in the GaAs layer with an extremely low surface density of 10^6 cm^{-2}. A spectrally separated set of lines related to the emission from a single GaAlAs/AlAs QD were observed in the micro-photoluminescence (μ-PL) spectrum [1]. However, the complicated potential structure of their environment makes the understanding of their properties a challenging task. Reconstruction of the excitation structure of the QDs can be obtained from the magnetic-field dependence of the micro-photoluminescence excitation spectra (μ-PLE).

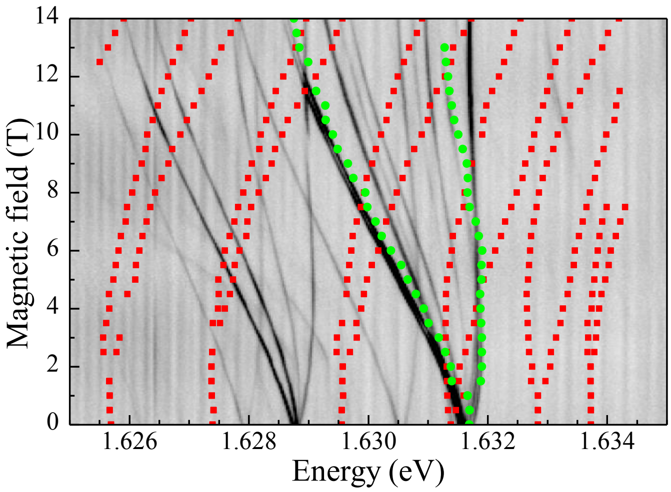

Fig.1 Magnetic-field evolution of resonances of the X (red points) and the X^+ (green points) lines from the μ-PLE spectra of a single GaAlAs QD compared with the p-shell-related μ-PL spectrum.

We report on the low-temperature (T=4.2 K) μ-PL and μ-PLE measurements of single GaAlAs QDs in magnetic field up to 14 T in Faraday configuration. The μ-PL was excited using a continuous wave tuneable Ti:sapphire laser, which allowed us to measure the μ-PLE spectra from the same QD.

Several resonances in the μ-PLE spectra of the neutral exciton (X) and the charged exciton (X^+) emission lines were observed and their magnetic field dispersion was followed up to 14T. Two types of dispersion of excitation resonances were detected in the PLE spectra. Most resonances exhibited the *s*-shell like diamagnetic shift – (see red points in Fig. 1), which was tentatively attributed to a complicated process with symmetry breaking (e.g. the excitation of the valence *p*-shell electron to the *s*-shell in the conduction band of confined QD levels) [2]. Only resonance detected for the X^+ emission line had a characteristic *p*-shell like behaviour in magnetic field – (see green points in Fig. 1). Most interestingly this resonance corresponds to the emission line detected in the μ-PL spectrum in the whole range of magnetic field.

Our results give us access to the detailed description of the complicated energy structure of the QDs. We demonstrate that the resonant symmetry breaking transitions very often determine the population of particular QD states.

[1] M. R. Molas, et al, *Acta Phys. Pol. A* **124**, 785 (2013).
[2] Y. Benny, et al, *Phys. Rev. B* **84**, 075473 (2011).