Magnetooptical study and theoretical description of anisotropy of exciton - cobalt system at CdTe quantum dots

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We report on magnetooptical study and theoretical description of individual cobalt ion in CdTe/ZnTe quantum dot (QD). Using molecular beam epitaxy we have grown self assembled CdTe/ZnTe QDs with small amount of Co^{2+} ions introduced by delta doping in the middle of CdTe layer. The low temperature magneto-photoluminescence (PL) measurements and modelling allow us to identify PL lines related to QDs containing exactly one cobalt ion. Exciton and biexction lines are split by 4 due to 4 spin possible projection of Co^{2+}: ±3/2, ±1/2 [1], similarly to QDs with single Mn^{2+} where exciton and biexciton are split by 6 due to 6 spin projection of Mn^{2+}: ±5/2, ±3/2, ±1/2 [2,3]. However, the intensity of the lines related to Co^{2+} spin projections ±3/2 (outer lines) can be significantly different from those related to the spin projections ±1/2 (inner lines). In contrast to Mn^{2+} the Co^{2+} ion has non-zero orbital momentum and Co^{2+} incorporated to the crystal is very sensitive to a local anisotropy and the strain, which lead to the splitting of ±3/2 and ±1/2 states and a difference in their occupancy [1]. Moreover, we have found experimentally that the sign of Co^{2+} strain can be positive and negative. Therefore, depending on strain both ±3/2 and ±1/2 spin state can be the ground state of Co^{2+} in QD.

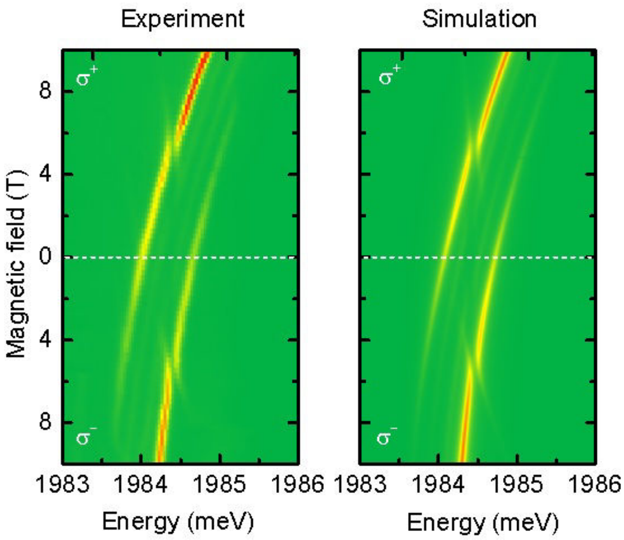

Fig. 1: Perfect agreement of magneto-optical spectroscopy and simulation of neutral exciton in a QD with a single cobalt ion.

In order to obtain a deeper understanding of the impact of local strain on the ground state of cobalt ion we performed theoretical simulations (Fig. 1). We were able to achieve perfect agreement between experiment and simulation when we took into account that the quantization direction of the cobalt ion ground state does not have to be parallel to the quantization axis of the quantum dot which is the ion environment. Through the simulations, we determine parameters related not only to the cobalt ion, but also to quantum dots such as anisotropic splitting, light-holes and heavy-holes mixing, or exchange integrals between carriers and magnetic ion.

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[3] M. Goryca, T. Kazimierczuk, M. Nawrocki, A. Golnik, J.A. Gaj, and P. Kossacki, *Phys. Rev. Lett.* **103**, 087401 (2009).