Excitation spectroscopy of a CdSe/ZnSe quantum dot with a single Fe^{2+} ion

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Semiconductors containing transitional metal ions with nonzero spin have been known to offer great potential for their use in the fields of spintronics and optoelectronics. Moreover, by accessing the spin degree of freedom of a single dopant, such systems could be potentially utilized in optoelectronics related to quantum information processing. Such motivation is the foundation for the field of solotronics (solitary dopant electronics) and the fuel for ongoing research of semiconductor quantum dots containing single transition metal ions. In the recent years many phenomena such as optical orientation [1], readout [2] and coherent precession of a single ion spin in a quantum dot has been demonstrated for II-VI systems [3].

Experimentally, optical spin manipulation in such nanostructures has been achieved by a number of different techniques [3,4]. Conceptually the easiest approach is to resonantly create spin-polarised excitons in either ground or excited states using a circularly polarised laser beam. It is important to mention that such optical methods are rather ineffective in orienting the dopant nuclear spin, which is proven to dramatically limit the spin relaxation time of the ion via the hyperfine interaction.

In this context, particularly interesting are recently created systems of CdSe/ZnSe QDs containing single Fe^{2+} ions with zero nuclear spin. A distinctive feature of this system is an unexpected change in the character of the iron dopant, which is non-magnetic in bulk but almost doubly degenerate in the nanostructure [5]. This change in the character of the ground state opened the way to examine ion spin orientation dynamics by optical means. Such attempts are, unfortunately, burdened by a number of technical challenges the most important one being an absence of a commercially available automatically tunable lasers in the required spectral ranges with a satisfying resolution.

In our work we study the CdSe/ZnSe quantum dot with a single Fe^2 ion in a quasi-resonant excitation regime. Tunable CW excitation in the range 510-520nm is realized by combination of commercially available diode laser and the high-resolution wavemeter. The automated routine allowed us to find excitation resonances for a given quantum dot, including dots with single Fe2+ ions. In order to gain information about the spin polarisation degree of a single dopant in this regime we perform the magnetoluminescence studies up to B = 7 T with polarisation resolution. The results of our experiment reveal a subtle interplay between two distinct phenomena: optical orientation of the Fe^{2+} ion spin and optical orientation of the exciton spin, which together govern intensities of the emission lines in the PL spectrum.

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