Readout of a dopant spin in the anisotropic quantum dot with a single magnetic ion

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Spin degree of freedom of defect centres in semiconductors is a desirable storage for quantum information thanks to relatively long coherence times caused by weak interaction with the crystal environment[1]. Owing to exchange interaction between the exciton and a dopant, a quantum dot embedding a single magnetic ion is a great platform for optical control of individual spin. In particular, a quantum dot provides strong and sharp optical transitions, which give experimental access to spin states of a specific magnetic ion. (Fig. 1)

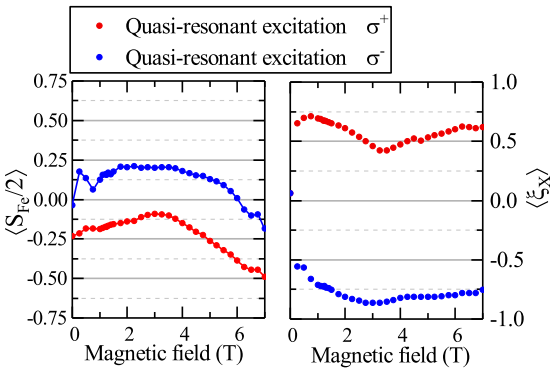

Figure 1: Spin orientations of exciton (a) and Fe^{2+} ion (b) under quasi-resonant excitation as a function of magnetic field, determined using proposed model. (from [2])

We show, however, that physics of quantum dot excitons also complicate spin readout and optical spin manipulation in such a system. This is due to electron-hole exchange interaction in anisotropic quantum dots, which affects the polarization of the emission lines. One of the consequences is that the intensities of spectral lines in a single spectrum are not simply proportional to the population of various spin states of magnetic ion.

In order to provide a solution of the above problem, we present a method of extracting both the spin polarisation degree of a neutral exciton and magnetic dopant inside a semiconductor quantum dot in an external magnetic field. Our approach is experimentally verified on a system of CdSe/ZnSe quantum dot containing a single Fe^{2+} ion. Both the resonant and non-resonant excitation regimes are explored resulting in a record high optical orientation efficiency of dopant spin in the former case. The proposed solutions can be easily expanded to any other system of quantum dots containing magnetic dopants.

[1] M. Goryca et al. *Phys. Rev. Lett.* 113, 227202 (2014).
[2] A. Rodek et al. *arXiv:1903.02969*(2019)