Ion-carrier exchange interaction in II-VI quantum dots containing individual magnetic ions

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Semiconductor quantum dot (QD) containing an individual transition metal ion offers a unique opportunity to explore the spin properties of a magnetic impurity interacting with the semiconductor lattice and confined carriers, but being well-isolated from any other magnetic dopants located in a macroscopic sample. Owing to a strong *s,p–d* exchange coupling between the ion and the exciton, such a system provides an all-optical interface to the ion spin, allowing for its readout, orientation [1-3], and tracing of its coherent precession [4]. In parallel, the variety of magnetic dopants that can be incorporated in different semiconductors brings up a wide range of combinations, which can be chosen to tailor the properties of a magnetic-ion-QD system in a desired way, e.g., to prolong the ion spin relaxation time [5], or to engineer the energy spectrum of the ion states using a local strain [6,7].

In this talk, I will review the results of our recent magneto-spectroscopic experiments performed on CdTe and CdSe QDs doped with individual Mn^{2+} and Fe^{2+} ions [5-8]. Particular attention will be paid to the factors governing the character and strength of the ion-carrier exchange interaction in the studied dots. In the first part of the lecture, I will focus on the dependence of the ion-carrier exchange integral on the orbital state occupied by the carrier. In particular, I will compare the strengths of the *s–d* exchange determined for the electron residing in its ground and first excited orbital states based on the magneto-photoluminescence measurements of the neutral and doubly negatively charged excitons [8]. The ratio of these integrals will be shown to sensitively depend on the position of the ion inside the QD, thus providing an experimental tool allowing for a direct evaluation of this quantity. The second part of the talk will be devoted to a discussion of the impact of the Coulomb attraction between the electrons and the hole on the *p–d* exchange. Based on the results of systematic experiments carried out on a large number of randomly selected QDs, the strength of this exchange will be demonstrated to significantly and monotonically vary with increasing number of electrons confined in the dot. Interestingly, the direction of these changes is found to be opposite for Te- and Se-based QDs, suggesting existence of a difference in ion-induced localization of the hole wave function in the two QD systems.

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