Symmetry-properties of hole wave function in CdTe/ZnTe quantum dot

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Anisotropy properties of semiconductor quantum dots (QDs) determine the main obstacle of their applications as a source of entangled photon pairs. The symmetry breakdown is usually caused by an in-plane elongation of the dot and the local strain. Both of these effects lead to a valence band mixing, which yields the anisotropic coupling between the hole states and magnetic field in a Voigt configuration [1]. On the other hand, the presence of J^3 term in the Luttinger Hamiltonian [1,2] leads to an isotropic part of the coupling. Therefore, the in-plane hole g-factor anisotropy is governed by strength of these two mechanisms. However, up to now the ratio of both contributions (isotropic and anisotropic) has not been determined experimentally for a single quantum dot.
Here we analyze the in-plane hole g-factor anisotropy of CdTe/ZnTe self-assembled QDs, which are known for their anisotropic properties [3]. Linear polarization resolved measurements of a dark exciton photoluminescence (PL) for various directions of the in-plane magnetic field (Fig 1a) enables independent determination of both isotropic and anisotropic contributions to the hole g-factor.

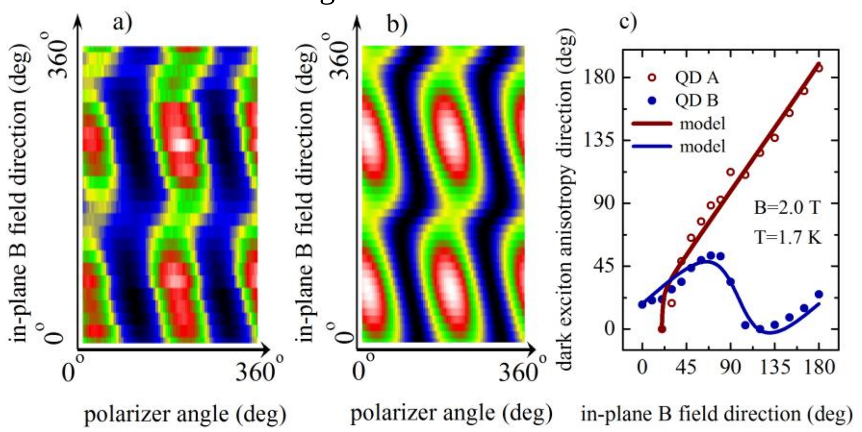

Fig.1 Linear polarization resolved dark exciton PL map (a) compared with analytical model (b). c) The dark exciton anisotropy angle as a function of in-plane magnetic field direction (symbols) for two extreme cases: isotropic QD A and anisotropic QD B. Solid lines represent our analytical solution of the spin Hamiltonian model based on [4].

The simplicity of the experiment allowed us to study significant number of QDs. In contrast to the previous studies [1,2], we observe QDs with different contributions of both mechanisms. Such an observation is based on detailed calculations in the frame of spin Hamiltonian model. In Fig. 1c we present results obtained for two QDs representing extreme cases: highly isotropic character of in-plane hole g-factor (QD A), and much more anisotropic one (QD B). Additionally, we present an analytical solution of the model (Fig. 1c) obtained with a very few assumptions. Our model perfectly fits to the experimental data. Moreover, the simplicity of obtained formula speeds up analysis of the data and makes proposed method extremely efficient.

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