Erasing the exciton fine structure splitting in semiconductor quantum dots

R. Trotta [1,2], C. Ortix [3], E. Zallo [2], O. G. Schmidt [2] and A. Rastelli [1,2]

[1] *Institute of Semiconductor and Solid State Physic, Johannes Kepler University Linz, Altenbergerstr. 69, A-4040 Linz*
[2] *Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany*
[2] *Institute for Theoretical Solid State Physics, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany*

Despite the remarkable progress achieved in the growth and fabrication of semiconductor nanostructures, real semiconductor quantum dots (QDs) usually do not show any structural symmetry. This induces a coherent coupling of the two bright excitonic states and leads to an energetic separation between them, the well-known fine structure splitting (*FSS*). When the *FSS* is larger than the radiative linewidth of the transitions (~ 1 µeV) the fidelity of the entangled photons emitted during the cascade biexciton-exciton-ground state is strongly reduced and the possibility to use QDs in advanced quantum optics experiments is severely hampered. For more than a decade researchers have struggled to find a reproducible way to suppress the FSS and the idea to use external perturbations (such as magnetic, electric, and strain fields) has been explored [1, 2]. However, recent results [3] have raised fundamental doubts about the success of these attempts in QDs with low structural symmetry.

In this presentation [4], we will show that the coupling between the bright excitons, and hence the *FSS*, can be always erased by the simultaneous application of large strain (up to 0.4%) and electric fields (up to 250 kV/cm) provided by a novel device where diode-like nanomembranes are integrated on top of piezoelectric substrates [5]. In particular, we will show that the energetic degeneracy between the bright excitons can be restored when one of the external perturbations is used to align the polarization of the exciton emission along the axes of application of the second perturbation, which is then able to suppress completely the energetic splitting between the states. The experimental results are supported by a theoretical model valid for every QD, regardless of its properties of symmetry. Our findings highlight the importance of having at hand two independent and broad-band tuning knobs for creating artificial atoms meeting the stringent requirements imposed by advanced quantum optics experiments. Finally, new concepts enabling the demonstration of tunable sources of entangled photons will be discussed.

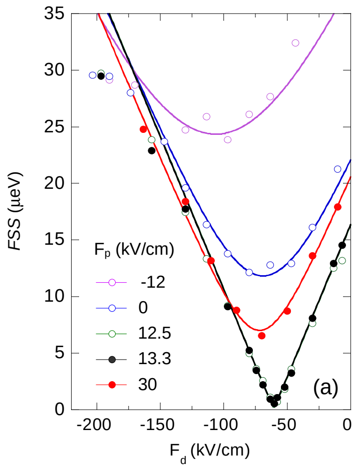

Figure. Exciton fine structure splitting (symbols) as a function of the electric field across the diode (F_d) and the piezoelectric substrate (F_p). The lines are the result of a theoretical analysis of the experimental data.

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