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Summary

The studies presented in this thesis offer a comprehensive picture of the behaviour of the exciton states in quantum dot molecules. The formation of 'bonding' and 'antibonding' exciton states has been demonstrated by a systematic dependence on the quantum dot separation. The coupling can be well understood on the basis of quantum mechanical tunnelling of the carriers through the molecule barrier, although we cannot exclude that also other mechanisms such as radiative coupling or dipole-dipole interaction contribute as well.

Tunnel coupling has been demonstrated by a variety of experimental tests using single molecule spectroscopy. As a major experimental tool, the exciton fine structure gives access to the underlying physical processes. The obtained fine structure patterns depend sensitively on the details of the molecule geometry and thus vary from molecule to molecule. In the case of wide barrier molecules, from avoided crossings observed in the magnetic field dispersion of the exciton fine structure for the 'bonding' state a quantum-mechanical coupling of the two dots has been established. Theoretically, this can be attributed to a lateral displacement of the quantum dots that leads to a symmetry breaking and allows mixings of bright and dark states. For both wide barrier molecules of high symmetry and narrow barrier molecules an enhanced diamagnetic shift in Voigt-configuration strongly indicates a coupling of the quantum dots. Within the developed statistics, the systematic dependence of spin splittings and diamagnetic shifts in Faraday-configuration on the barrier width confirm the consistent picture of tunnel coupling. Moreover, whenever the 'bonding' state shows a doublet splitting indicating high symmetry, also for the 'antibonding' state a doublet splitting appears. Whenever the 'bonding' state exhibits a more complicated splitting pattern due to reduced symmetry, it is reflected by the 'antibonding' state. For quantum mechanical coupling the two quantum dots forming the molecule do not have to be identical on an atomistic level. A final conclusion might be that from the entirety of indications we can safely conclude a coupling of the quantum dots.

Finally, further investigations have focused on the demonstration of the control of tunnel coupling in such molecule structures by electric fields. A simple electrical gate allows for a controlled bandstructure tilting of the molecule system. As a basic result, transitions between a 'coupled' and an 'uncoupled' situation can be achieved which depends systematically on the coupling strength. In view of an optically driven quantum gate, this has the potential to serve as a controllable physical interaction between potential molecule qu-bits. To conclude, the presented investigations add to the understanding of manipulating tunnel coupled exciton states in quantum dot molecules and demonstrate a promising step towards applications in quantum information processing.