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Spin Interactions in Optically Excited Quantum Dot Molecules[1]

MICHAEL SCHEIBNER, Naval Research Laboratory Washington DC 20375 USA

Recently we have demonstrated controlled interaction between QDs [1] – a key requirement for the use of QDs as basic building blocks in novel information processing technologies, as e.g. in quantum computation or spintronics. Here we delineate for the first time the origin of the exchange coupling between spins [2] in optically excited QD molecules, and we trace its atomic to molecular evolution. We have performed photoluminescence spectroscopy on single InAs/GaAs QDMs. The QD molecules were formed by the subsequent growth of two closely spaced layers of self-assembled QDs. The two QD layers were embedded in a diode structure in order to controllably tune different excitonic charge states through molecular resonances. The resulting optical spectra of double QDs exhibit a rich variety of fascinating features. Distinct patterns of anticrossings formed by the various excitonic and biexcitonic charge states allow us to determine the rules governing the state energies and quantum mechanical coupling between two QDs. Prominent spin fine structure in the molecular spectra is understood in terms of the interplay between h-h, e-h, and e-e exchange interactions. This work sets the stage for using laser fields to execute two-qubit operations in quantum dots.

[1] E. A. Stinaff, et al., Science **311**, 636 (2006)
[2] M. Scheibner, et al., cond-mat/0607241

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