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Spin tunneling in optically excited quantum dot molecules: Controlling g-factors with electric field

MATTHEW DOTY, Materials Science and Engineering, University of Delaware

We have recently demonstrated coherent tunneling of electron and hole spin between two quantum dots using optical spectroscopy [1,2]. In the case of a hole spin, a very large and resonant enhancement or reduction of g-factor is controlled with an applied electric field [3]. This effect arises because of the corresponding enhancement or suppression of the hole wavefunction in the tunnel barrier for the bonding (symmetric) and anti-bonding (anti-symmetric) states, respectively. This effect was discovered for single holes, but also occurs for two-particle states (two holes or 1 hole and 1 electron). Using this effect to identify the symmetry of the wavefunction, we have now found that the energetic order of the bonding and anti-bonding molecular states goes through a reversal as a function of tunnel barrier thickness. That is, the bonding state is the low energy state for a 2nm barrier thickness (as expected in the simple particle-in-a-box model, or the one-band effective mass theory). But for thicknesses larger than 3nm, a transition occurs such that the anti-bonding state becomes the low energy state. This dramatic and non-intuitive effect arises from the spin-orbit interaction.

[1] "Optical Signatures of Coupled Quantum Dots," E. A. Stinaff *et al*, *Science* **311**, 636 (2006).
[2] "Spin Exchange in Optically Excited Quantum Dot Molecules," M. Scheibner, M. F. Doty, I. V. Ponomarev, *et al.*, *PRB* **75**, 245318 (2007).
[3] "Electrically Tuneable g Factors in Quantum dot Molecular Spin States" M.F. Doty *et al., Phys. Rev. Lett.* **97**, 197202 (2006).