MAR10-2009-003013

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Optically controlled spins in semiconductor quantum dots

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Spins in charged semiconductor quantum dots are currently generating much interest, both from a fundamental physics standpoint, as well as for their potential technological relevance. Being naturally a two-level quantum system, each of these spins can encode a bit of quantum information. Optically controlled spins in quantum dots possess several desirable properties: their spin coherence times are long, they allow for all-optical manipulation—which translates into fast logic gates—and their coupling to photons offers a straightforward route to exchange of quantum information between spatially separated sites. Designing the laser fields to achieve the unprecedented amount of control required for quantum information tasks is a challenging goal, towards which there has been recent progress. Special properties of hyperbolic secant optical pulses enabled the design of single qubit rotations, initially developed about the growth axis z [1], and later about an arbitrary direction [2]. Recently we demonstrated our theoretical proposal [1] in an ensemble of InAs/GaAs quantum dots by implementing ultrafast rotations about the z axis by an arbitrary angle [3], with the angle of rotation as a function of the optical detuning in excellent agreement with the theoretical prediction. We also developed two-qubit conditional control in a quantum dot 'molecule' using the electron-hole exchange interaction [4]. In addition to its importance in quantum dot-based quantum computation, our two-qubit gate can also play an important role in photonic cluster state generation for measurement-based quantum computing [5]. [1] S. E. Economou, L. J. Sham, Y. Wu, D. S. Steel, Phys. Rev. **74**, 205415 (2006) [2] S. E. Economou and T. L. Reinecke, Phys. Rev. Lett., **99**, 217401 (2007) [3] A. Greilich, S. E. Economou *et al*, Nature Phys. **5**, 262 (2009) [4] S. E. Economou and T. L. Reinecke, Phys. Rev. B, **78**, 115306 (2008) [5] S. E. Economou, N. H. Lindner, and T. Rudolph, in preparation