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Hole spins as qubits in gated lateral devices opportunities and challenges

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In semiconductor materials, the wave functions of holes are built from p-type atomistic orbitals. This leads to a weaker hyperfine interactions of the hole spin with nuclear lattice spins and thus promises longer coherence times compared to those of electron spins [1,2]. However, holes are also subject to much stronger spin-orbit (SO) interactions. This talk explores the new physics brought about by the SO interaction for few carrier systems and discusses how it influences the magneto-transport spectra of GaAs lateral double quantum dots (DQD) populated by one or two holes [3,4]. In contrast with DQDs fabricated in Si, where the SO interaction is much weaker [5], in GaAs two-hole DQD the Pauli spin blockade is found to be absent except for the regime of very small magnetic fields. A simple theoretical model, accounting for both the usual spin-conserving and the spin-flipping tunneling (SFT) processes, is introduced. The magnitudes of both elements, extracted from single-hole photon-assisted tunneling, are shown to be similar and strongly dependent on the magnetic field. While the SFT process complicates the usual spin-to-charge conversion process, it enables fast hole spin rotations by electrostatic means. [1] J. Fisher, W. A. Coish, D. V. Bulaev, and D. Loss, Phys. Rev. B 78, 155329 (2008). [2] B. D. Gerardot et al., Nature 451, 441 (2008). [3] L. A. Tracy, T. W. Hargett, and J. L. Reno, Appl. Phys. Lett. 104, 123101 (2014). [4] A. Bogan, S. Studenikin, M. Korkusinski G. Aers, L. Gaudreau, P. Zawadzki, A. Sachrajda, L. Tracy, J. Reno, and T. Hargett, Phys. Rev. Lett. (submitted). [5] R. Li, F. E. Hudson, A. S. Dzurak, and A. R. Hamilton, Nano Lett. 15, 7314 (2015). Collaborating Authors: A. Bogan, S. Studenikin, G. Aers, L. Gaudreau, P. Zawadzki, A. Sachrajda (NRC, Canada), L. Tracy, J. Reno, and T. Hargett (Sandia National Laboratories, USA)