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Controlling hole spin in quantum dots GARNETT BRYANT, NIST - Natl Inst of Stds & Tech, XIANGYU MA, MATTHEW DOTY, University of Delaware — Hole spins in semiconductor quantum dots (QD) are promising qubits. The Zeeman-split states form two-level systems with splitting determined by the physical spin of the state. We show that application of a magnetic field B in Voigt configuration, in the plane of the QD, combined with a lateral electric field parallel or antiparallel to B provides exquisite control of the hole's physical spin and Zeeman splitting. We use tight-binding theory to study strained InAs/GaAs and strain-free GaAs/AlAs QDs. As a result of strong spin-orbit coupling, the hole spin is strongly polarized and locked to the QD axis for B away from the Voigt configuration. The spin polarization is nearly complete for thin QDs but is reduced for taller dots. In Voigt configuration, the hole spin is nearly fully depolarized. When an electric field is applied to push the hole to one side of the QD, strong spin polarization is recovered. The z-component of the spin can be parallel or antiparallel to the QD axis, depending on the direction of B relative to the atomic lattice and whether the electric field is parallel or antiparallel to B. The direction of the spin z-component is reversed by flipping the direction of the electric field. We provide several examples to explain the origin of this exquisite control.

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