Pauli spin blockade and spin-dependent shell filling in heavy hole quantum dots: going down to the last hole

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The spin states of heavy holes in semiconductor quantum dots are attracting significant attention for quantum information applications, with rapid progress being made by a number of groups over the past few years. The interest arises because the weak hyperfine coupling to nuclear spins allows long coherence times, while the strong spin-orbit interaction enables fast spin manipulation. In this talk I will discuss our recent progress studying spin properties of holes in silicon and gallium arsenide quantum dots [1,2,3]. In silicon single quantum dots we are able to study the spin shell filling sequence for the first 8 holes, which is consistent with the Fock-Darwin states of a circular 2D quantum dot. However while the spin filling obeys Hund's first rule, the hole-hole interaction energy is 90% of the orbital energy, so that the two-hole system to be on the verge of having a ferromagnetic ground state. In few hole GaAs and Si double quantum dots we observe Pauli spin blockade, and find that the lifting of the spin blockade by an external magnetic field is highly anisotropic. These results highlight the promise, and challenges, of using holes for spin qubits.

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3. S.D. Liles, R. Li, C.H. Yang, F.E. Hudson, M.E. Veldhorst, A.S. Dzurak and A.R. Hamilton, Spin filling and orbital structure of the first eight holes in a silicon metal-oxide-semiconductor quantum dot, unpublished (2017).