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Ultrafast optical control of interacting hole spins in coupled quantum dots SAMUEL CARTER, Naval Research Laboratory, Washington, DC 20375, ALEX GREILICH, Naval Research Laboratory, Washington, DC 20375; University of Maryland, College Park, Maryland 20742, DANNY KIM, Naval Research Laboratory, Washington, DC 20375; University of Michigan, Ann Arbor, Michigan 48109, ALLAN BRACKER, DANIEL GAMMON, Naval Research Laboratory, Washington, DC 20375 — Recently, hole spins in quantum dots (QDs) have shown great promise as quantum bits due to a reduced hyperfine interaction with nuclear spins, the primary source of decoherence for electron spins. We have developed a system of two vertically stacked InAs QDs that can be charged with a number of holes. In this way, an isolated hole in one QD or two interacting holes in separate dots can be studied. We demonstrate ultrafast optical control of both systems and find a number of differences compared to electron spins. Complete control of the single hole qubit is obtained through optical initialization and single qubit rotations. These control measurements give a hole spin T_2^* of 20ns, an order of magnitude longer than electrons in similar QDs. Spin echo experiments extend the coherence time but are complicated by oscillations in the echo amplitude. For the case of two hole spins, we can observe and tune the coherent exchange interaction that acts as a two qubit gate. We also initialize and perform gates on an entangled spin state, taking a significant step toward a scalable platform for quantum information processing. [1] "Optical control of one and two hole spins in interacting quantum dots," A. Greilich, S. G. Carter, D. Kim, A. S. Bracker and D. Gammon. *Nature Photon.***5**, 702 (2011).

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