MAR13-2012-020419

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Circuit quantum electrodynamics with a spin qubit[1]

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Electron spins in quantum dots have been proposed as the building blocks of a quantum information processor. While both fast one and two qubit operations have been demonstrated, coupling distant spins remains a daunting challenge. In contrast, circuit quantum electrodynamics (cQED) has enabled superconducting qubits to be readily coupled over large distances via a superconducting microwave cavity. I will present our recent work aimed at integrating spin qubits with the cQED architecture.[2] Our approach is to use spin qubits formed in strong spin-orbit materials such as InAs nanowires to enable a large effective coupling of the spin to the microwave cavity field. For an InAs nanowire double quantum dot coupled to the superconducting microwave cavity we achieve a charge-cavity coupling rate of ~ 30 MHz. Combining this large charge-cavity coupling rate with electrically driven spin qubit rotations we demonstrate that the cQED architecture can be used a sensitive probe of single spin dynamics. In another experiment, we can apply a source-drain bias to drive current through the double quantum dot and observe gain in the cavity transmission. We additionally measure photon emission from the cavity without any input field applied. Our results suggest that long-range spin coupling via superconducting microwave cavities is feasible and present new avenues for exploring quantum optics on a chip.

[1]Research was performed in collaboration with Will McFaul, Michael Schroer, Minkyung Jung, Jake Taylor, Andrew Houck and Jason Petta. We acknowledge support from the Sloan and Packard Foundations, Army Research Office, and DARPA QuEST.

[2]K.D. Petersson et al., Nature 490, 380 (2012).