Coherent Coupling of a Single Spin to a Single Photon

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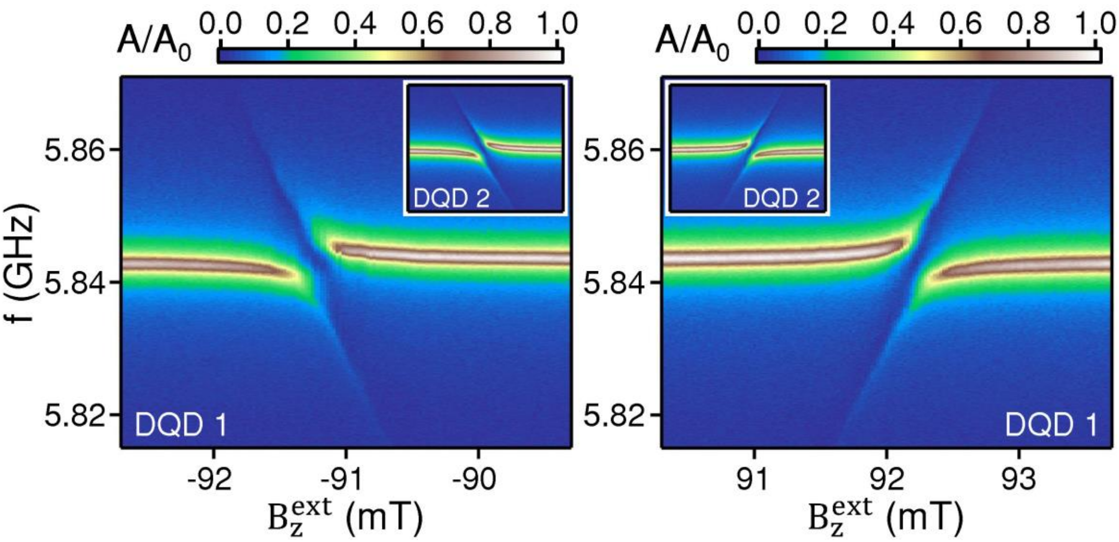
Pioneering experiments in the field of atomic physics demonstrated "strong coupling" between light and matter [1]. In the strong coupling regime, the coherent coupling rate between light and matter exceeds all of the relevant loss rates in the system. A little over a decade ago, it was shown that a superconducting circuit can be coherently coupled to a single microwave frequency photon in the circuit quantum electrodynamics (cQED) architecture [2]. Coupling to microwaves provides elegant routes to coherent control, quantum state readout, and long distance coupling. In this presentation, I will describe how we have completed a decade-long quest to coherently couple a single spin to a single microwave frequency photon.

Electron spins are often hailed as excellent candidates for solid state quantum computing due to their exceptionally long quantum coherence times, which is a result of weak coupling to environmental degrees of freedom. However, this isolation comes with a cost, as it is difficult to coherently couple two spins in the solid state, especially when they are separated by a large distance. Here we combine a large electric-dipole interaction with spin-orbit coupling to achieve spin-photon coupling [3]. Vacuum Rabi splitting is observed in the cavity transmission as the Zeeman splitting of a single spin is tuned into resonance with the cavity photon. We achieve a spin-photon coupling rate as large as g_s/2□ = 10 MHz, which exceeds both the cavity decay rate □/2□ = 1.8 MHz and spin dephasing rate □/2□□= 2.4 MHz, firmly anchoring our system in the strong-coupling regime [4]. Moreover, the spin-photon coupling mechanism can be turned off by localizing the spin in one side of the double quantum dot. These developments in quantum dot cQED, combined with recent demonstrations of high-fidelity two-qubit gates in Si, firmly anchor Si as a leading material system in the worldwide race to develop a scalable quantum computer [5].



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3. Mi *et al*., Science **355**, 156 (2017).
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5. Zajac *et al*., Science **359**, 439 (2018).