Quantum Measurement and Characterization

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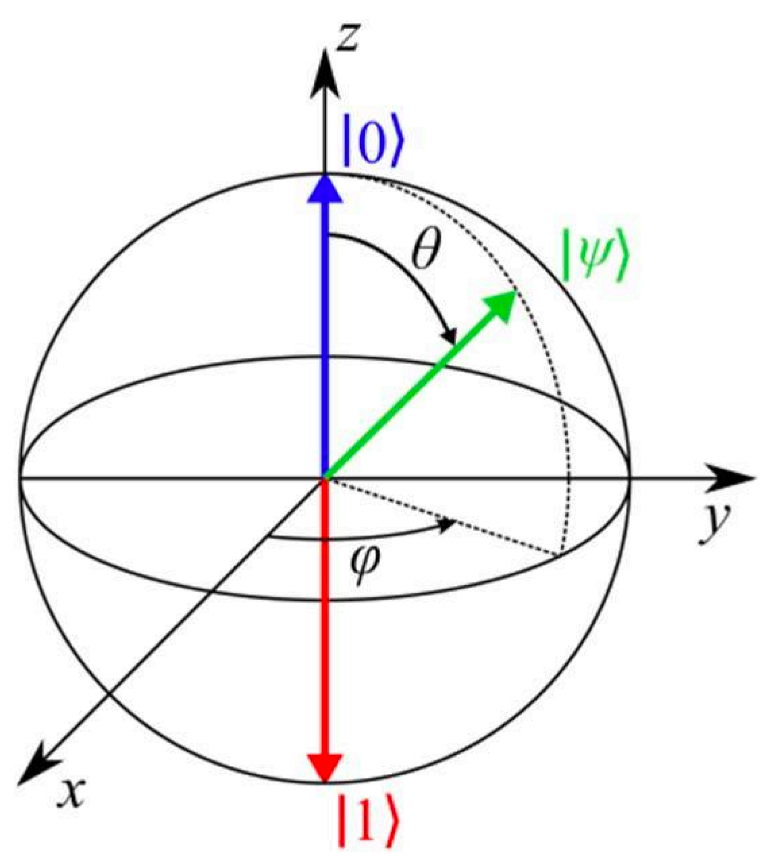
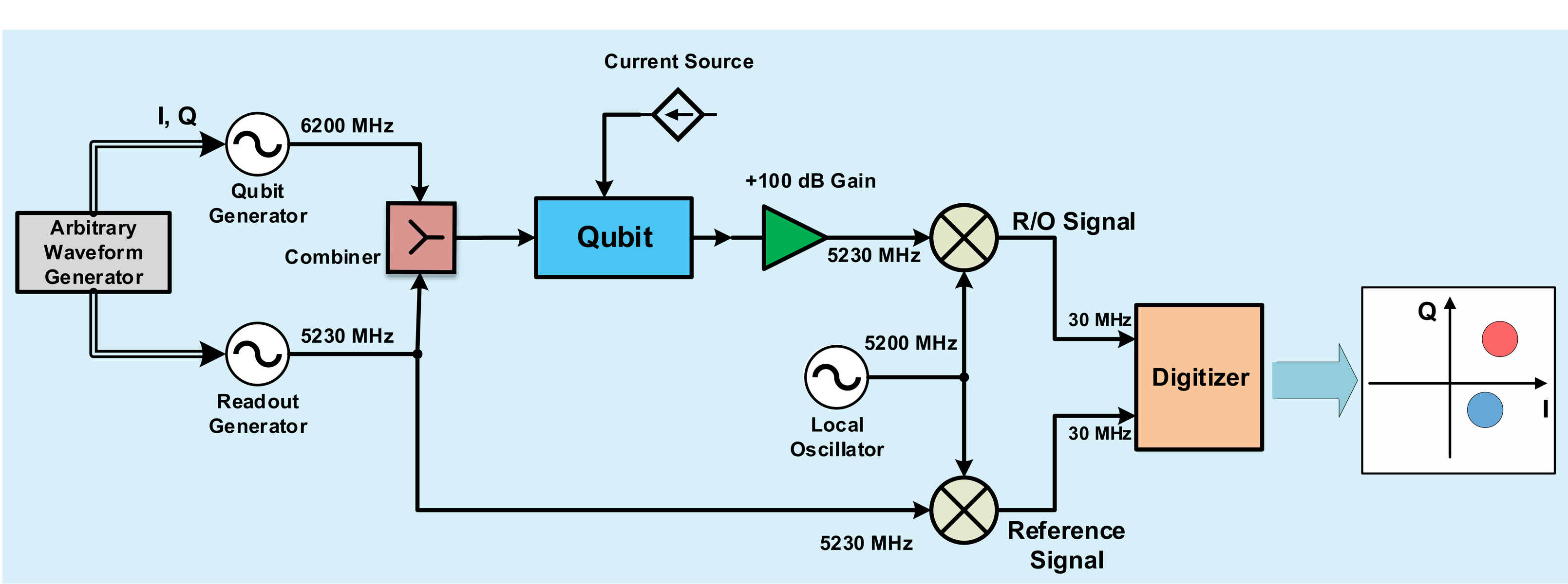
FERMILAB-POSTER-20-018-TD

Coherent Control Required to Manipulate Quantum States



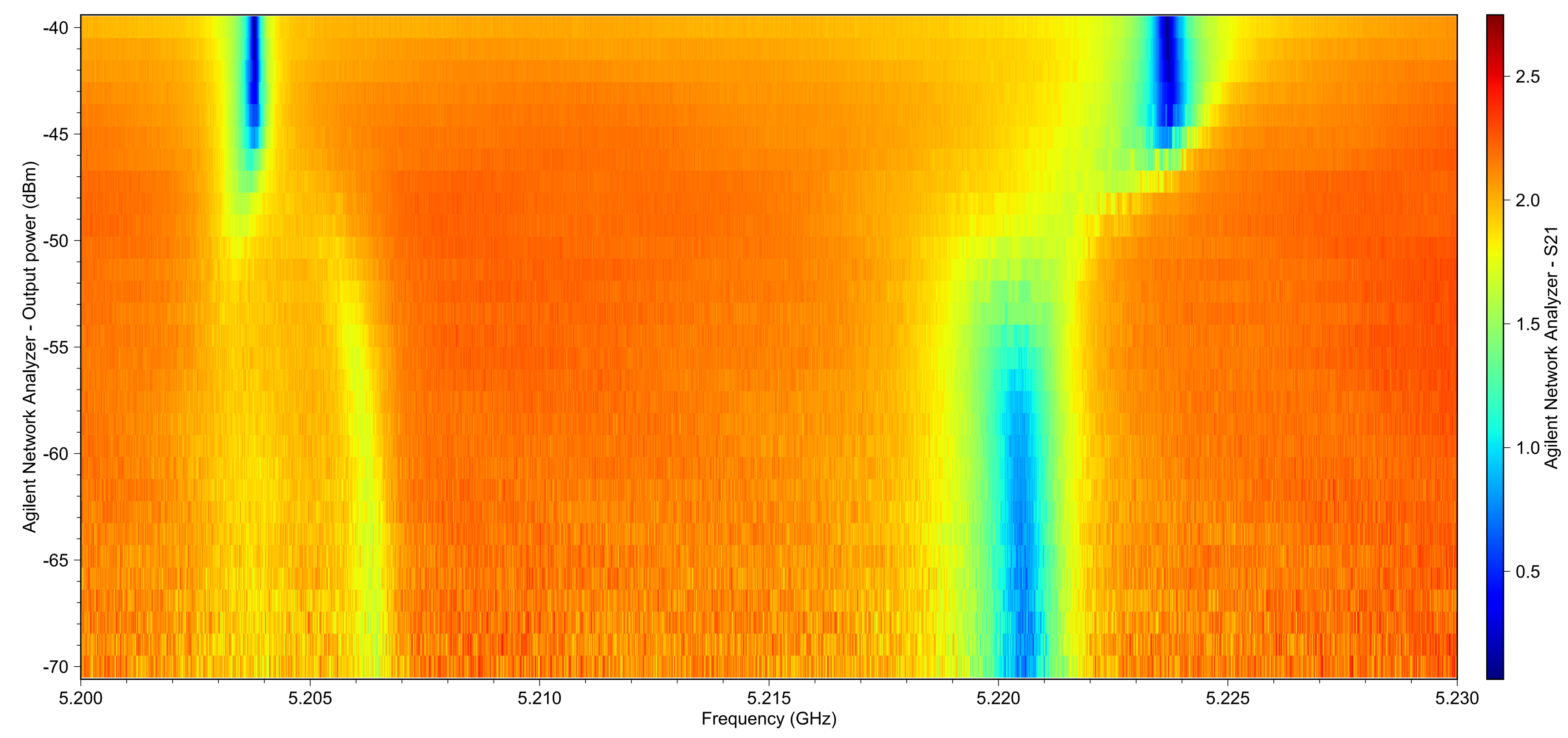
Depicted above is the Bloch sphere of a quantum bit (qubit). Creating any arbitrary superposition of the two orthogonal quantum states requires coherent evolution along the surface of the Bloch sphere. Coherent evolution is enacted in our superconducting radio frequency quantum system through an external microwave drive.

Pulse Radiofrequency Electronics Required for Quantum Measurement and Characterization



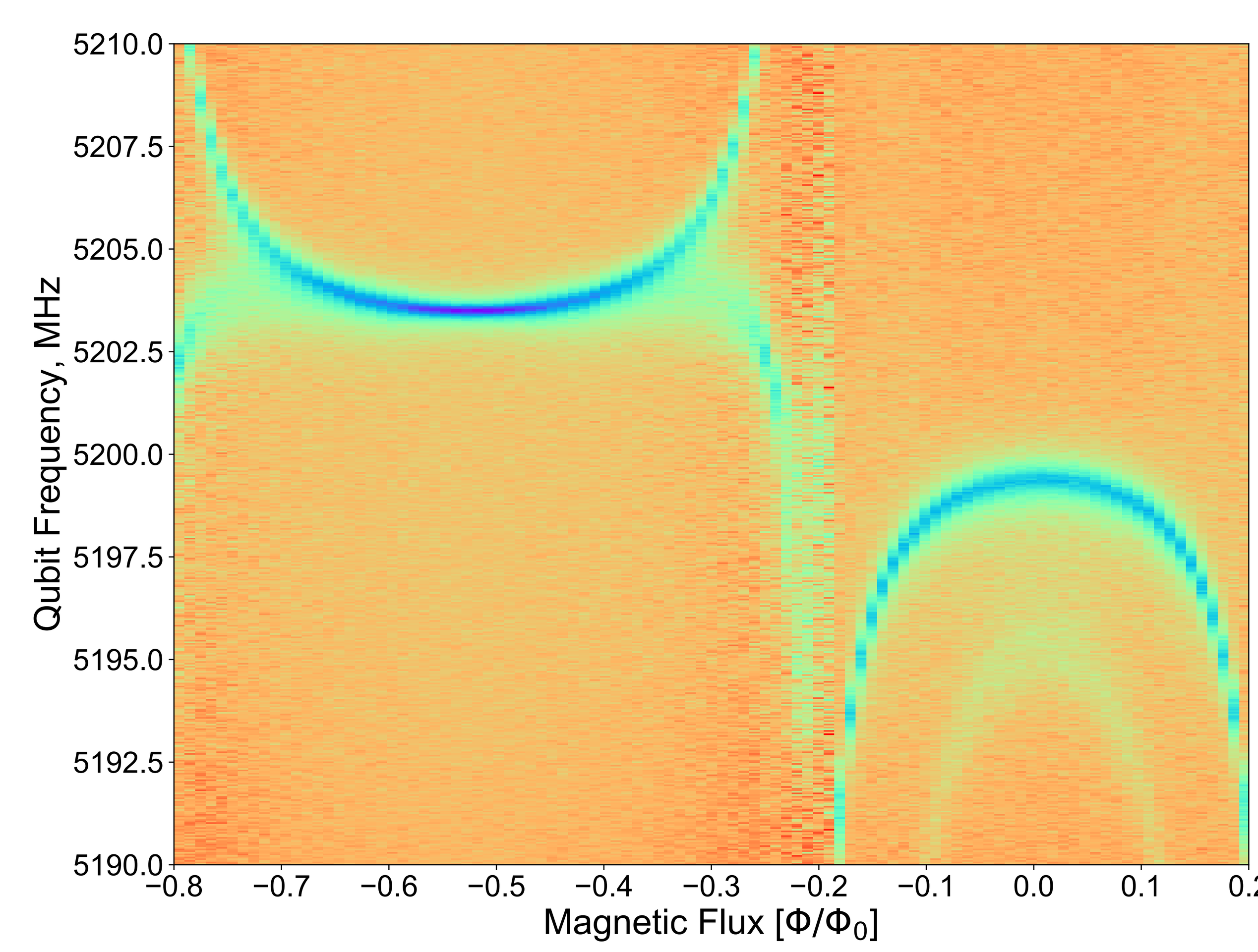
To create, control, and measure quantum states in a superconducting radio frequency quantum system requires synchronized, pulsed readout and control electronics. Above is a diagram of a single qubit radio frequency readout and control electronics setup. Qubit state control is determined by an arbitrary waveform generator applied at the qubit frequency. The qubit state is measured by applying a tone at a readout cavity. The resulting readout pulse is demodulated with the qubit states creating two distinct gaussian distributions in I/Q space.

Qubit Mediated Cavity Self-Interaction



The quantum mechanical coupling between a qubit and a cavity causes the cavity to inherent a self-interaction term. There are three distinct regimes in the above plot. Low power where there is a distinct cavity response. A regime where the cavity frequency depends on the average photon number in the cavity (intra cavity power) caused by the inherited self-interaction. The cavity self-interaction continues until there are so many photons within the cavity that its self-interaction causes it to no longer be coupled to the qubit resulting in a third regime (high-power). In the high-power regime, the cavity's frequency no longer depends on its average photon number.

Quantum Vacuum Rabi Splitting



In the above, we change the qubit frequency by adjusting the local magnetic field and observe power transmission through the cavity. As the qubit is brought into resonance with the cavity, we observe the energy level repulsion characteristic of an avoided crossing. Furthermore, we observe an avoided crossing when there is an excitation in the qubit (faint line). This photon number dependent avoided crossing is a purely quantum mechanical effect.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

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