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Multi-mode Experiments with Superconducting Qubits and Metamaterial Resonators. SAGAR INDRAJEET, MATTHEW HUTCHINGS, HAOZHI WANG, BRITTON PLOURDE, Syracuse University, BRUNO TAKETANI, FRANK WILHELM, Saarland University — Metamaterial resonant structures made from arrays of lumped circuit elements can exhibit significantly different mode spectra compared to resonators made from conventional distributed transmission lines. In particular, left-handed resonators can be used to produce a high density of modes in the same frequency range where superconducting qubits are typically operated. We present a series of low-temperature measurements of such a superconducting metamaterial resonator coupled to a flux-tunable transmon qubit. Using a separate conventional resonator to read out the qubit state, we are able to track the qubit as we tune it through many of the metamaterial resonances. We present measurements of the qubit coherence as a function of frequency in this multi-mode system as well as measurements of Stark shifts of the qubit transition while driving a separate microwave tone in the vicinity of the various metamaterial modes.

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