Towards a platform for many-body spin emulation: Acoustically coupled transmon qubits patterned on a piezoelectric material

B. A. Moores, L. R. Sletten[a,b], J. Viennot[a,b], and K. W. Lehnert[a,b]

[a]JILA, National Institute of Standards and Technology and the University of Colorado, Boulder, Colorado 80309, USA
[b]Department of Physics, University of Colorado, Boulder, Colorado 80309, USA

Man-made systems of interacting qubits are a promising way of building model systems that emulate many interacting spins. Although the circuit quantum electrodynamics architecture comprising of transmon qubits coupled to microwave cavities is perhaps the most advanced quantum computing technology, building a large system of many cavity modes coupled to many qubits is hindered by the mismatch of scales between the transmons and the electromagnetic modes. In this talk we consider a strategy to overcome this mismatch of scales by replacing the electrical cavities with acoustical resonators. In particular, we couple a single tunable transmon qubit to a surface acoustic wave (SAW) resonator. We show that this 300 micron long resonator supports a dense spectrum of microwave-frequency high-Q modes that couple to the transmon qubit piezoelectrically through an interdigited SAW transducer. A simple model of the acoustical mode overlap with the qubit's SAW transducer accounts for the variable coupling that we observe. Notably, the coupling strength in some cases exceeds the SAW cavity's free-spectral range, indicating that the device operates deeply in the multi-mode regime.