Measurement of Dispersive Coupling Between a Nanoresonator and Cooper-Pair Box Qubit

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The integration of superconducting qubit technology in nanoelectromechanical systems (NEMS) is expected to provide a viable route toward studying fundamental issues of quantum mechanics with mechanical systems. Devices like the Cooper-pair box (CPB) qubit have been posited as central elements in measurement proposals ranging from quantum non-demolition (QND) read-out of nanomechanical Fock states to the generation of nanomechanical ”squeezed states”. As a first step toward this end, we have recently measured the interaction between a MHz-range flexural nanoresonator and CPB. We find the interaction strength and low-frequency response of the system to be consistent with predictions from a model that treats the system as a simple harmonic oscillator and qubit in the far-detuned, weakly-coupled limit. Analogous to the dispersive limit for photons and real or artificial atoms in cavity and circuit QED experiments, the dispersive regime here is characterized by a virtual exchange of energy between the flexural mode and the CPB. From the perspective of the nanoresonator, this is manifest as a CPB-state-dependent shift in its natural resonant frequency, which we detect via a technique combining capacitive displacement transduction and RF reflectometry. In my talk, I will present data demonstrating detection of the dispersive shift and discuss recent spectroscopic measurements of the CPB utilizing this technique. I will then address the prospects for realizing more advanced measurement proposals, including cooling of the NEMS to its quantum ground state and the preparation of nanomechanical ”laser” states.