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Sensing nanomechanical motion with a microwave cavity interferometer

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Optomechanical and electromechanical systems utilizing micro and nanomechanical oscillators offer a promising route towards manipulation of macroscopic objects at the quantum level. In this talk I present experiments that use principles of popular optomechanical systems yet employ light at microwave frequencies. Operating at microwave frequencies allows us to also harness technology associated with electromechanical systems, such as very light nanoscale mechanical objects and on- chip circuit elements compatible with a dilution refrigerator environment. Specifically, in our work we embed a nanomechanical flexural resonator inside a superconducting transmission-line microwave cavity, where the mechanical resonator's position couples to the cavity capacitance and thus to the resonant frequency of the cavity. With our device we realize near state-of-the-art force sensitivity (3 $\mathrm{aN}/\sqrt{\mathrm{Hz}}$) and thus add to only a handful of techniques able to measure thermomechanical motion at 10's of milliKelvin temperatures. Our current measurements achieve a promising total displacement uncertainty at 140 times the quantum limit and a measurement imprecision as low as 30 times the quantum limit, as well as elucidate the important steps that will be required to progress towards the full quantum limit of displacement detection with this new system.