Quadratic optomechanics at 500 mK

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We present measurements of the optical spring and optical damping that arise when a cavity's detuning is proportional to the square of the displacement of a mechanical element. In our experiment this quadratic coupling is realized by placing a dielectric membrane inside an optical cavity in such a way that it produces an avoided crossing between the cavity modes. This quadratic spring has a qualitatively different dependance on laser detuning and membrane position than the "usual" linear optical spring, and we find good agreement between theory and our measurements. These measurements were made in a cryostat at temperature ~ 500 mK. Although this device is still in the classical regime, these results appear promising for exploiting the quadratic coupling in the quantum regime. We will also describe a separate experiment that is underway in which we plan to magnetically levitate a drop of liquid helium in vacuum, and realize an ultralow-loss optomechanical system via coupling between the drop's optical whispering gallery modes and its vibrational and rotational motion.