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Strong "position squared" optical readout of a micromechanical oscillator JACK SANKEY, ANDREW JAYICH, BENJAMIN ZWICKL, CHENG YANG, JACK HARRIS, Yale University — Optomechanical devices with a flexible SiN membrane inside an optical cavity allow for very high optical finesse and high mechanical quality factor in a single device. They also provide fundamentally new functionality: the cavity detuning can have a quadratic dependence on the membrane position. This enables a measurement of "position squared" (x^2) and in principle a QND phonon number readout of the membrane. However, the readout achieved using a single cavity mode is not sensitive enough to observe quantum jumps between phonon Fock states. Here we demonstrate an x^2-sensitivity that is orders of magnitude stronger using two nearly-degenerate transverse cavity modes, and that we can tune this sensitivity somewhat by tilting the membrane. We derive a perturbatve treatment that describes the interactions between the transverse optical modes and achieve good agreement with observation using realistic parameters. We also show that the x^2-coupling should be easily tunable over a wide range via mm-scale membrane displacements along the cavity axis.

Jack Sankey
Yale

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