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Passive Cooling of a Micromechanical Oscillator with a Resonant Electric Circuit K.R. BROWN, J. BRITTON, R.J. EPSTEIN, J. CHIAVERINI, D. LEIBFRIED, D.J. WINELAND, NIST Boulder — Currently there is considerable interest in the cooling of macroscopic mechanical oscillators, as strong cooling may allow one to reach the quantum regime of such oscillators. Recent advances in fabrication and cooling techniques have brought this regime much closer. Here we present theoretical and experimental results for cooling of the fundamental mode of a miniature cantilever by capacitively coupling it to a driven rf resonant circuit. Cooling results from the rf capacitive force, which is phase shifted relative to the cantilever motion due to the finite decay time of the resonant circuit. If this force varies with an appropriate phase shift relative to the motion of the cantilever, it can oppose the velocity of the cantilever, leading to cooling. We demonstrate this technique by cooling a 7 kHz cantilever from room temperature to 45 K, obtaining reasonable agreement with a model for the cooling, damping, and frequency shift. Extending the method to higher frequencies in a cryogenic system could enable ground state cooling and may prove simpler than related optical experiments in a low temperature apparatus.

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