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Quantum nano-electromechanics: non-equilibrium cooling and strong feedback effects

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A nano-electromechanical system consists of a micron-scale mechanical resonator coupled to a mesoscopic electronic conductor (e.g. a single-electron transistor, an atomic quantum point contact, etc.). The dissipative quantum mechanics of these systems are particularly interesting. How do the tunneling excitations in the conductor heat and damp the oscillator? To what extent do they act as an effective thermal bath? I will review recent theoretical work which demonstrates how a generic out-of-equilibrium mesoscopic conductor can act as an effective thermal bath. I will also discuss the interesting case where this bath is formed by out-of-equilibrium, incoherently-tunneling Cooper pairs. This is system is remarkable in that significant cooling of the oscillator is possible, as well as a negative-damping instability which leads to a regime of strong-feedback between the oscillator and the Cooper pairs. Both these effects are analogous to ponderomotive effects occurring in a driven optical Fabry-Perot cavity having a moveable mirror; in our case, tunneling Cooper pairs play the role of the cavity photons.

[1] A. Clerk, Phys. Rev. B, 70, 245306, 2004.
[2] A. Clerk and S. Bennett, New J. Phys. 7 238, 2005.