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Cavity optomechanics – beyond the ground state

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The coupling of coherent optical systems to micromechanical devices, combined with breakthroughs in nanofabrication and in ultracold science, has opened up the exciting new field of cavity optomechanics. Cooling of the vibrational motion of a broad range on oscillating cantilevers and mirrors near their ground state has been demonstrated, and the ground state of at least one such system has now been reached. Cavity optomechanics offers much promise in addressing fundamental physics questions and in applications such as the detection of feeble forces and fields, or the coherent control of AMO systems and of nanoscale electromechanical devices. However, these applications require taking cavity optomechanics "beyond the ground state." This includes the generation and detection of squeezed and other non-classical states, the transfer of squeezing between electromagnetic fields and motional quadratures, and the development of measurement schemes for the characterization of nanomechanical structures. The talk will present recent "beyond ground state" developments in cavity optomechanics. We will show how the magnetic coupling between a mechanical membrane and a BEC – or between a mechanical tuning fork and a nanoscale cantilever – permits to control and monitor the center-of-mass position of the mechanical system, and will comment on the measurement back-action on the membrane motion. We will also discuss of state transfer between optical and microwave fields and micromechanical devices. Work done in collaboration with Dan Goldbaum, Greg Phelps, Keith Schwab, Swati Singh, Steve Steinke, Mehmet Tesgin, and Mukund Vengallatore and supported by ARO, DARPA, NSF, and ONR.