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Cavity optomechanics - Manipulating mechanical motion at the quantum level

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Cavity optomechanics is a rapidly-growing field in which mechanical degrees of freedom are coupled to modes of the electromagnetic field inside optical or microwave resonators. These devices may lead to ultra-sensitive mass and force sensors, provide long-range interaction between distant qubits, and serve as probes of quantum mechanics at increasingly large mass and length scales [for a review see e.g. Physics Today 65, 29 (2012)]. Adapting laser-cooling techniques from atomic physics several experiments have recently observed mechanical motion close to the quantum ground-state. This paves the way for exploiting mechanical systems in the quantum regime. In this talk I will address three problems. First, I will demonstrate that signatures of the intrinsically nonlinear interaction between light and mechanical motion in cavity optomechanical systems can be observed even when the cavity line width exceeds the optomechanical coupling [PRL 111, 053603 (2013)]. Second, I will discuss optomechanical systems in which the position of a mechanical oscillator modulates the line width of the cavity [NJP 15, 045017 (2013) and PRA 88, 023850 (2013)]. Finally, I will present a recent study on synchronization in a self-sustained oscillator coupled to an external harmonic drive [arXiv:1307.7044]. Work done in collaboration with Kjetil Børkje, Christoph Bruder, Steven M. Girvin, John D. Teufel, Stefan Walter, and Talitha Weiss.