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Cooling in the single-photon regime of optomechanics ANDREAS NUNNENKAMP, Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland, KJETIL BORKJE, STEVEN GIRVIN, Departments of Physics and Applied Physics, Yale University, New Haven, Connecticut 06520, USA — Optomechanics experiments are rapidly approaching the regime where the radiation pressure of a single photon displaces the mechanical oscillator by more than its zero-point uncertainty. We show that in this limit the power spectrum has multiple sidebands and that the cavity response has several resonances in the resolved-sideband limit [Phys. Rev. Lett. **107**, 063602 (2011)]. We then discuss how red-sideband cooling is modified in this nonlinear regime. Using Fermi's Golden rule we calculate the transition rates induced by the optical drive. In the resolved-sideband limit we find multiple cooling resonances for strong single-photon coupling. They lead to non-thermal steady states and are accompanied by multiple mechanical sidebands in the optical output spectrum. Our study provides the tools to detect and take advantage of this novel regime of optomechanics.

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