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Enhanced nonlinear interactions in quantum optomechanics via mechanical amplification NICOLAS DIDIER, Quantic team, INRIA Paris, MARC-ANTOINE LEMONDE, Atominstitut, Vienna University of Technology, AASHISH A. CLERK, Department of Physics, McGill University — A key challenge limiting truly quantum behaviour in optomechanical systems is the typically small value of the optomechanical coupling at the single-photon, single-phonon level. We present an approach for exponentially enhancing the single-photon coupling strength in an optomechanical system using only additional linear resources. It allows one to reach the quantum nonlinear regime of optomechanics, where nonlinear effects are observed at the single photon level, even if the bare coupling strength is much smaller than the mechanical frequency and cavity damping rate. Our method is based on using a large amplitude, strongly detuned mechanical parametric drive to amplify mechanical zero-point fluctuations and hence enhance the radiation pressure interaction. It has the further benefit of allowing time-dependent control, enabling pulsed schemes. For a two-cavity optomechanical setup, we show that our scheme generates photon blockade for experimentally accessible parameters, and even makes the production of photonic states with negative Wigner functions possible. We discuss how our method is an example of a more general strategy for enhancing boson-mediated two-particle interactions and nonlinearities. Preprint: arXiv:1509.09238.

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