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Appearance and disappearance of motional sideband asymmetry in measurement-based control of a mechanical oscillator VIVISHEK SUDHIR, DALZIEL WILSON, RYAN SCHILLING, HENDRIK SCHUETZ, Ecole Polytechnique Federale de Lausanne, ANDREAS NUNNENKAMP, University of Cambridge, TOBIAS KIPPENBERG, Ecole Polytechnique Federale de Lausanne
— Measurement-based feedback provides an avenue to study the delicate interplay between the quantum correlations established during the process of measurement, and their progressive obfuscation when exposed to uncorrelated noise in the form of fundamental quantum fluctuations in the feedback path. Here we demonstrate this tradeoff using a feedback strategy whose objective is to cool a nano-mechanical oscillator close to its ground state. The correlations established due to the measurement are revealed in the appearance of motional sideband asymmetry. The latter, faithfully measured using an optical heterodyne interferometer with an imprecision ˜17 dB below that at the standard quantum limit, increases to 6% as the oscillator is feedback cooled to an occupation of 15 phonons. Further increase in the gain of the feedback loop leads to a decrease in the asymmetry. This is due to the addition of unavoidable quantum fluctuations in a feedback amplifier – photon shot-noise amplified by a homodyne detector in our case.

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