Abstract Submitted for the MAR14 Meeting of The American Physical Society

Feedback Cooling in Hybrid Atom–Optomechanical Systems JAMES BENNETT, LARS MADSEN, MARK BAKER, HALINA RUBINSZTEIN-DUNLOP, WARWICK BOWEN, Centre for Engineered Quantum Systems (EQuS), University of Queensland, St Lucia, Queensland 4072 — Hybrid atomoptomechanical devices may be engineered such that a mesoscopic mechanical oscillator is sympathetically cooled by optically-mediated coupling to an atomic cloud, potentially to the motional ground state. Alternatively, one can cool the oscillator by measuring its position and applying a feedback force. Our modelling shows that an optimised classical derivative feedback scheme outperforms atomic sympathetic cooling over a wide range of experimental conditions. In the limit that all optical fields may be adiabatically eliminated from the description of the system we find an analytical power spectrum: integration of which indicates that both cooling strategies are capable of reaching temperatures near to the ground state, though in different parameter regimes. From this we obtain criteria which specify the optimum cooling strategy as a function of experimental specifications. Interestingly, it is never beneficial to combine the two cooling mechanisms. This finding implies that systems with sufficient optomechanical cooperativity are best cooled by feedback, with coupling to the atoms being reserved for later manipulations of the mechanical state. Conversely, sympathetic cooling is necessary if the optomechanical coupling rate is small.

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Date submitted: 08 Jan 2014

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