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## Enhanced Optomechanical Cooling In Brillouin Waveguides Using Squeezed Light

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Over the past two decades, the field of cavity optomechanics has succeeded in cooling resonant mechanical oscillators down to their quantum ground state. The success of cavity optomechanics has led to various proposals which aim to harness the quantum properties of cooled mechanical systems, including in tests of fundamental physics [1], quantum state preparation [2] and quantum metrology [3]. More recently, analogous cooling without optical cavities has been explored using Brillouin-Mandelstam scattering in waveguides. These systems host a continuum of acoustic modes, making them a potential platform for quasi-broadband cooling. However, ground state cooling in waveguides has yet to be demonstrated, with recent experiments achieving cooling of 219 K, but still with a minimum phonon population in excess of  $\langle n \rangle = 200$  [4].

In this work we propose a method to enhance the optomechanical cooling in waveguides using squeezed light. We demonstrate how non-classical driving may selectively boost Brillouin scattering from high-frequency phonons. These improvements are analysed from the perspective of the quantum spectral noise. Squeezing the optical field modifies the spectral noise of the nonlinear Brillouin interaction, leading to increased photon-phonon scattering. These results indicate that squeezed light may modify the phononic density of states beyond the standard optomechanical interaction. We find expressions for the strength of these enhancements and find that in certain regimes phononic decay rates can be increased compared to typical laser driving. This work offers a potential avenue for further reducing phonon populations bringing these systems closer to the quantum regime. Additionally, this proposal introduces only minor additional complexity to typical Brillouin cooling experiments and should be readily implementable.

[1] C. Whittle et al., *Science* **372**, 1333 (2021).

[2] M. D. LaHaye, et al., *Science* **304**, 74 (2004).

[3] M. R. Vanner, et al., *Phys. Rev. Lett.* **110**, 010504 (2013).

[4] L. Blázquez Martínez, et al. *Phys. Rev. Lett.* **132**, 023603 (2024).

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