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**Nonlinear phonon interferometry at the Heisenberg limit**[1] HIL F. H. CHEUNG, YOGESH SHARAD PATIL, LAURA CHANG, SRIVATSAN CHAKRAM, MUKUND VENGALATTORE, Cornell University — Interferometers operating at or close to quantum limits of precision have found wide application in tabletop searches for physics beyond the standard model, the study of fundamental forces and symmetries of nature and foundational tests of quantum mechanics. The limits imposed by quantum fluctuations and measurement backaction on conventional interferometers ($\delta\phi \sim 1/\sqrt{N}$) have spurred the development of schemes to circumvent these limits through quantum interference, multiparticle interactions and entanglement. Here, we realize a prominent example of such schemes, the so-called SU(1,1) interferometer, in a fundamentally new platform in which the interfering arms are distinct flexural modes of a millimeter-scale mechanical resonator [1]. We realize up to 15.4(3) dB of noise squeezing and demonstrate the Heisenberg scaling of interferometric sensitivity ($\delta\phi \sim 1/N$), corresponding to a 6-fold improvement in measurement precision over a conventional interferometer. We describe how our work extends the optomechanical toolbox and how it presents new avenues for studies of optomechanical sensing and studies of nonequilibrium dynamics of multimode optomechanical systems.

[1] H. F. H. Cheung *et al.* arXiv:1601.02324 (2016)

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Yogesh Sharad Patil
Cornell University

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