Nonlinear phonon interferometry at the Heisenberg limit\(^1\) HIL
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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 fundamen-
tal forces and symmetries of nature and foundational tests of quantum mechanics.
The limits imposed by quantum fluctuations and measurement backaction on con-
tventional 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 stud-
ies of optomechanical sensing and studies of nonequilibrium dynamics of multimode
optomechanical systems.


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