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**Strongly nonlinear displacement measurement in a nano-optomechanical resonator** JUHA MUHONEN, Center for Nanophotonics, FOM Institute AMOLF, RICK LEIJSSEN, GIADA LA GALA, LARS FREISEM, EWOLD VERHAGEN, Center for Nanophotonics, FOM Institute AMOLF, Science Park 104, 1098 XG Amsterdam, The Netherlands — Creation of non-classical states of mechanical motion is a long-standing goal of experimental physics. One promising approach to achieve this is measurement-based state preparation where sufficiently strong interaction with a measurement device is used to project the mechanics into an eigenstate of the measured observable. In order to prepare non-classical states, one needs to move away from linear continuous displacement measurements towards non-linear ($x^2$) and possibly also non-continuous (pulsed) measurements. We present here strongly nonlinear measurement of a mechanical resonator in a novel nanophotonic cavity optomechanical system with a record high optomechanical coupling strength. Although the coupling between displacement and optical cavity frequency is itself linear, the high interaction strength in combination with narrow optical linewidth (resulting in a single-photon cooperativity $C_0 > 1000$) allows us to use the second order working point of a homodyne interferometer to perform a sensitive $x^2$ measurement, with noise floor at $\sim 100\ x_{zpf}^2/\sqrt{Hz}$. We discuss future potential to reach the quantum regime with such non-linear measurements, as well as the possibilities for pulsed, backaction-evading, measurements.

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