Phonon thermometry below 1 K temperatures

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The study of genuine quantum effects in the motion of a mechanical object requires in the first place to cool it down to its quantum ground state. For structures resonating up to 100 MHz, this requires sub-milliKelvin temperatures to be reached.

In order to measure on-chip the phonon temperature of a nano electromechanical systems (NEMS), we have used a circuit based on an optomechanical scheme where a long mechanical resonator is coupled to a microwave cavity. We demonstrate the ability of our device to be actively cooled or amplified. Focusing on this second phenomenon we resolved the parametric instability in order to extrapolate the mode temperature of our nanoscale beam at zero optical antidamping effect. This essentially realizes an in-built parametric amplifier.

The experimental cell is installed in a nuclear demagnetization cryostat able to reach temperatures below 1 mK. Even if active amplification is performed, the main goal is to exhibit the limits of brute force cooling of nanosized objects within a standard microwave setup.