ZOOM-Kolloquium

physikalisches Kolloquium

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A macroscopic object passively cooled into its quantum ground state of motion

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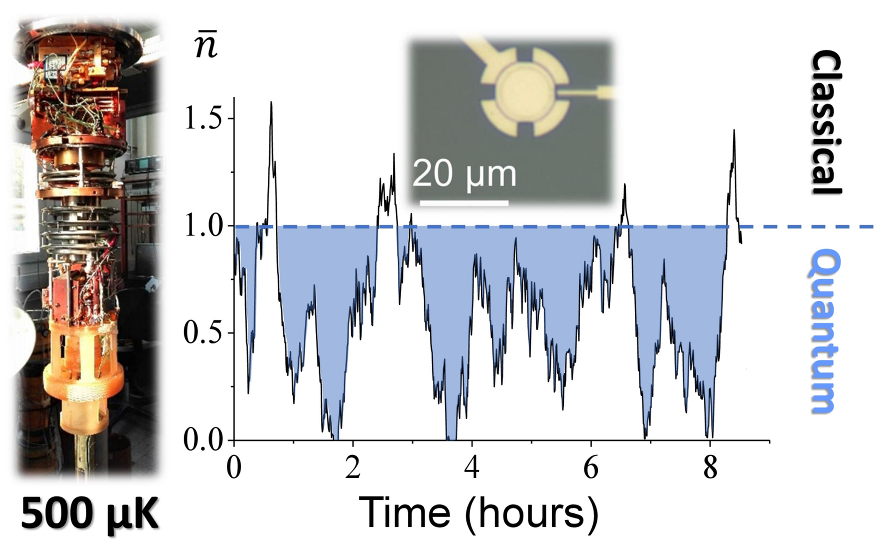
Recent advances in observing and exploiting macroscopic mechanical motion at the quantum limit brought opto-mechanical experiments down to always lower temperatures and smaller sizes, boosting a new research area where (more compatible) low energy photons are employed: microwave opto-mechanics.

Microwave opto-mechanical platforms provide unique capabilities for testing quantum mechanics at the most basic level: if one thinks about these devices in terms of quantum-limited detectors, the focus is on the thermodynamic baths that continuously interact with the mechanical degrees of freedom. The fundamental questions that are addressed are then quantum thermodynamics, the boundary between classical and quantum mechanics defined by wavefunction collapse, and ultra-low temperature materials properties.

In order to perform such experiments at the frontier of modern physics, we created a unique micro-wave/micro-Kelvin opto-mechanical platform, which is part of the European Microkelvin Platform (https://emplatform.eu/). We demonstrate passive cooling of a whole aluminium drumhead mechanical device down to 500 µK [1], reaching its quantum ground state of motion.

Using microwave opto-mechanics as a non-invasive detector, we report on the in-equilibrium thermal properties of this lowest frequency mode, in particular the fluctuations of the population number. These reveal a surprisingly complex interplay with the local environment.

[1] D. Cattiaux et al., Nat. Comm. Vol. 12, Art. 6182 (2021).



Nuclear demagnetization cryostat (left), and drumhead device (centre). The trace is the thermal population measured at 650 µK, demonstrating huge fluctuations [1].

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