Abstract: Recent advances in the understanding of mechanical dissipation have led to nanomechanical oscillators with greatly increased quality factors, now reaching above 1 billion. This entails extremely good isolation of a single motional degree of freedom from any fluctuating environment, thereby providing an ideal setting for manipulation at the quantum level.

 Here I will on report a series of quantum experiments with nanomechanical oscillators made from thin silicon nitride membranes, into which we pattern phononic crystals1 to achieve quantum coherence times of up to 100 ms.2 Efficient optical measurement allows us to reach the Standard Quantum Limit (SQL) of position detection, in which the imprecision of the measurement and its quantum mechanically required backaction are ideally balanced – much like in the famous “Heisenberg microscope” thought experiment.3 A feedback force based on this measurement allows freezing all thermal motion of the mechanical mode, preparing it very close to its quantum ground state.4 Furthermore, we have exploited the strong correlations between the optical and mechanical quantum fluctuations to realize the first measurement of a mechanical displacement below the SQL.5 Later we used the same underlying correlations to mediate entanglement between two electromagnetic fields.6

 One of the great promises of mechanical systems in quantum science and technology is their possible application to mediate interactions between otherwise incompatible systems.7 Along these lines, I will also report on our recent progress in realizing mechanical interfaces to superconducting microwave devices2 and spins8.

**References**

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