Towards Quantum Control of a Room Temperature Mechanical Resonator

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It is now possible to engineer the quantum state of macroscopic mechanical resonators. This opens up the possibility for new quantum technologies, such as quantum-enhanced sensors and quantum memories/interfaces for quantum computers. However, ultrahigh vacuum or cryogenic environments are currently required, limiting the breadth of applications.

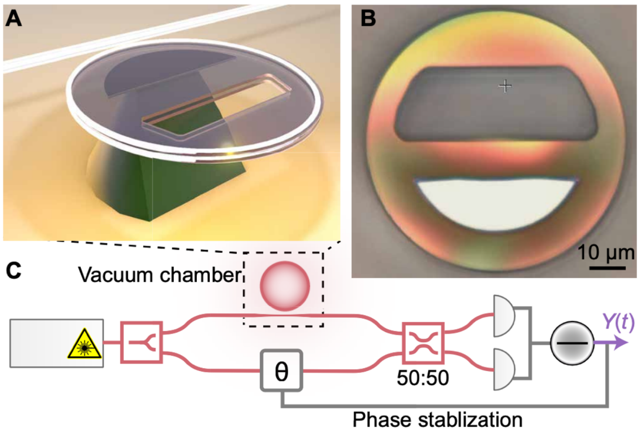

Figure 1: Schematic of experiment. A: Illustration of double-disk. B: Photograph of fabricated device. C: Experiment

In this presentation I will introduce a new approach to control the quantum state of a macroscopic mechanical resonator via measurement and conditioning [1]. This approach is based on continuous position measurement, but – unlike other schemes – operates with a measurement that is faster than the mechanical oscillation. By operating in this regime, beyond the usual rotating wave regime, it is possible to prepare quantum squeezed states of motion. Remarkably, our theory predicts that the experimental requirements are greatly relaxed, even compared to mechanical ground-state cooling, to the point that quantum state preparation is feasible at room temperature with existing technology.

I will present experiments showing a classical version of the predicted squeezing effect in a new engineered double-disk optomechanical device fabricated on a silicon chip [2]. These experiments take advantage of both structural damping – which we show that, compared to the usual viscous damping, can improve quantum state preparation – and arrays of mechanical modes. Specifically, I will present experiments demonstrating that continuous position measurement can prepare thermomechanical squeezed states of motion, and to this for ensembles of structurally damped mechanical resonances.

Together, our results provide a new way to generate nonclassical states of macroscopic mechanical oscillators and open the door to quantum sensing and tests of quantum macroscopicity at room temperature.

References

[1] C Meng, G A Brawley, J S Bennett, M R Vanner and W P Bowen, Phys. Rev. Lett. **125**, 043604 (2020)

[2] C Meng, G A Brawley, S Khademi, E M Bridge, J S Bennett and W P Bowen, Sci. Adv. **8**, eabm7585 (2022)