Ultralow dissipation mechanical resonators for sensing and optomechanics

The reduction of mechanical dissipation increases force sensitivity of mechanical oscillators and decreases the thermal decoherence rate of mechanical quantum states. Concomitantly, reduced size allows stronger coupling to other degrees of freedom such as electromagnetic fields. These two demands are conflicting: due to surface losses, smaller size typically leads to increased dissipation. However, the phenomenon ‘dissipation dilution’, where mechanical losses are diluted by stress, breaks the trend. Over the last decade, dissipation dilution has been exploited to reduce the dissipation of nanomechanical resonators by three orders of magnitude; thereby allowing nanomechanical oscillators to surpass the quality factors of the best macroscopic oscillators. In this talk, I will show how dissipation dilution is greatly enhanced by engineering the resonator geometry. Our best devices show mechanical quality factors exceeding 3 billion at room temperature, giving decoherence rates approaching those of optically levitated nanoparticles. Finally, I will present a new material platform for nanomechanics: single-crystal strained silicon—a material developed for implementing high mobility transistors. The strained silicon nanostrings support MHz mechanical modes with Q exceeding 10^9 at room temperature and 10^{10} at 6 K, surpassing state-of-the-art implementations in Si_3N_4. Finally, I will show a feedback-assisted force detection scheme with attonewton force sensitivity at room temperature and discuss prospects for using mechanical resonators for dark matter searches.