DAMOP11-2011-000811

Abstract for an Invited Paper
for the DAMOP11 Meeting of
the American Physical Society

Ultrahigh-Q mechanical oscillators through optical trapping[1]

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Rapid advances are being made toward optically cooling a single mode of a micro-mechanical system to its quantum ground state and observing quantum behavior at macroscopic scales. Reaching this regime in room-temperature environments requires a stringent condition on the mechanical quality factor Q_m and frequency f_m, $Q_m f_m \gtrsim k_B T_{\mathrm{bath}}/h$, which so far has been marginally satisfied only in a small number of systems. Here we propose and analyze a new class of systems that should enable unprecedented $Q_m f_m$ values [1-3]. The technique is based upon using optical forces to "trap" and stiffen the motion of a tethered mechanical structure [3], thereby freeing the resultant mechanical frequencies and decoherence rates from underlying material properties. We have lithographically fabricated a diverse set of planar structures in Silicon Nitride, made measurements of their optical and mechanical properties, and compared these results to numerical models by finite element analysis.

This work has been carried out in collaboration with D. E. Chang, K.-K. Ni, R. Norte, O. J. Painter, and D. J. Wilson.

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[1] Work supported by DARPA ORCHID program, NSF, and NSSEFF.