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A photonic microscope for observing real-time vibrations of carbon nanotubes ARTHUR W. BARNARD, MIAN ZHANG, School of Applied and Engineering Physics, Cornell University, GUSTAVO WIEDERHECKER, Instituto de Fisica Gleb Wataghin, Universidade Estadual de Campinas, MICHAL LIPSON, School of Electrical and Computer Engineering, Cornell University, PAUL L. MCEUEN, Department of Physics, Cornell University; Kavli Institute at Cornell for Nanoscale Science — Vibrational modes in suspended carbon nanotubes (CNTs) are incredibly responsive to small forces, which makes them a prime candidate as nano-mechanical sensors. However, transducing this mechanical motion into detectable signals is a considerable challenge. Electrical detection, which has been the prevailing method thus far, suffers a significant impedance mismatch to macroscopic electronics and is thus susceptible to noise. We demonstrate an alternative: optical readout of CNT vibrations in real-time. By combining a unique CNT microtweezer platform with a high-finesse optical microdisk resonator, we dramatically enhance the naturally small optical cross-section of CNTs and thereby achieve unprecedented detection sensitivity. With this novel photonic microscope, we directly measure the thermal Brownian motion of CNTs and observe marked spectral diffusion at room temperature, shedding light on CNTs unique thermal physics. By further enhancing the optical coupling, we demonstrate optical amplification of CNT vibrations and directly observe period-doubling in the amplified state.

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