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Carbon nanotube mechanical resonators

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Nano-electromechanical systems (NEMS) make use of electrically induced mechanical motion and vice versa. Carbon nanotubes are ideal building blocks of NEMS because of their unique (mechanical) properties and their low mass. This puts them in an unexplored regime of motion which approaches the fundamental detection limit set by quantum mechanics. At room temperature, we use mixing techniques to probe the bending-mode vibration of a suspended carbon nanotube; the gate voltage strains the carbon nanotube and thereby tunes the frequency. At low temperatures, mechanical vibrations are actuated by a nearby antenna and a record high Q-value of 150000 at a resonance frequency of 300 MHz is achieved. Electron tunneling and mechanical motion are strongly coupled resulting in single- electron tuning oscillations of the mechanical frequency and in energy transfer to the electrons causing mechanical damping. Strikingly, we also observe that a d.c. current through the nanotube spontaneously drives the mechanical resonator, exerting a force that is synchronized with the high-frequency vibrations.