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Electron-phonon coupling in suspended carbon nanotube quantum dots

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Abstract

Single wall carbon nanotubes (SW-CNTs) excel in many ways as a nano-electromechanical system. With their high Young's modulus, extreme flexibility, smoothness on a molecular level, small cross-section, and low mass, they promise possibilities of directly observing the quantization of mechanical motion.

With this in mind, low-temperature transport measurements targetting both the longitudinal (stretching) and the transversal (bending) vibration mode of suspended SW-CNTs are presented. At cryogenic temperatures, a quantum dot forms within a nanotube device; due to the Franck-Condon effect, vibrational modes then become visible as harmonic excitation spectra in single electron tunneling. The many issues that need to be experimentally addressed here include, e.g., mechanisms of the electron-vibron coupling, the mechanical relaxation, or the mechanical behaviour of ultra-short (< 100 nm) nanotube segments.

While being work in progress, our data shows several interesting new phenomena, including the observation of mechanical modes in higher-order tunneling in Coulomb blockade. Our results may point towards electronical pumping of vibration states. Further mechanisms such as "distortion blockade of current" are discussed, as are more complicated sample geometries defining suspended double quantum dots.

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