The nonlinear sound of tiny guitars approaching the quantum ground state

Adrian Bachtold, ICFO
Barcelona, Spain

An open question in mechanics is whether mechanical resonators can be made nonlinear with vibrations approaching the quantum ground state. This requires engineering a mechanical nonlinearity far beyond what has been realized thus far. In this talk, after an introduction on the mesoscopic physics of nanomechanical resonators, I will discuss our recent advances on mechanical resonators based on carbon nanotubes. I will present a mechanism to boost the Duffing (also called Kerr) nonlinearity by coupling the vibrations of a nanotube resonator to single-electron tunneling in a quantum dot and by operating the system in the ultrastrong coupling regime[1]. In a second series of experiments, we couple the nanotube vibrations and a double quantum dot qubit, which is readout with a superconducting resonator using circuit QED techniques. It enables us to observe nonlinear vibrations at the zero-point motion level. Our work paves the way for realizing mechanical qubits[2], quantum simulators emulating the electron-phonon coupling, and macroscopic quantum superposition states[3].

After his PhD work in Basel, Bachtold went to Berkeley and Delft for two postdocs. Bachtold became a permanent researcher of the CNRS at the Ecole Normale Supérieure in Paris in 2001. He moved to Barcelona in 2005 in the Catalan Institute of Nanoscience and Nanotechnology (ICN2) as a CSIC researcher/professor and ICN2 professor, and then to the Institute of Photonic Sciences (ICFO) as ICFO professor. He is recipient of the IBM award of the Swiss Physical Society, the medal of the CNRS, and the EURYI award of the European Commission. He is APS fellow, received three ERC grants (including starting and advanced), and is the coordinator of the physics project awarded within the Programa Fundamentos de la Fundación BBVA.

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