Manipulating nanotube mechanical resonators with single-electron tunneling

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Mechanics has historically played a pivotal role in science by providing the basis for classical physics. Today, with the advent of nanoscale mechanical devices combined with quantum electronic devices, we are witnessing a renaissance in the field of mechanics. Here, I will discuss our recent advances on resonators based on carbon nanotubes. In particular, single-electron tunneling enables coupling mechanical vibrations to electrons by a large amount in these systems. I will show how to use this coupling to create a nonlinear mechanical oscillator approaching the quantum regime, where the resulting quantum energy levels of the mechanical oscillator are no longer evenly spaced. Using mechanical nanotubes hosting multiple quantum dots, we expect that our approach may enable the realization of a mechanical qubit [1] and a quantum simulator of quantum matters featuring strong electron-phonon correlations [2,3].

References

[1] F. Pistolesi, A. N. Cleland, and A. Bachtold, Phys. Rev. X 11, 031027 (2021)
[2] U Bhattacharya, T Grass, A Bachtold, M Lewenstein, F Pistolesi, Nano Lett. 21, 9661 (2021)
[3] Lin Zhang, Utso Bhattacharya, Adrian Bachtold, Stefan Forstner, Maciej Lewenstein, Fabio Pistolesi, Tobias Grass, npj Quantum Information 9, 7 (2023)

Figures

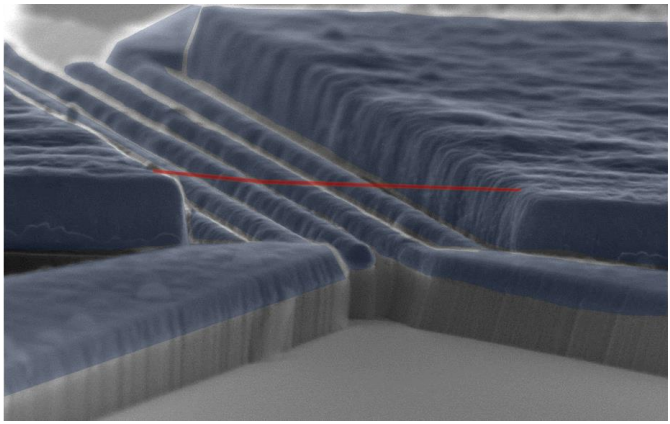

Figure 1: Vibrating nanotube in red hosting a double-quantum dot