The Nonlinear Sound of Tiny Guitars Approaching the Quantum Regime

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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 mechanical resonators based on carbon nanotubes. The nanotube in these devices vibrates as a guitar string. Single-electron tunneling enables coupling the mechanical vibrations to electrons by a large amount. 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 [1]. I will also discuss our effort towards the first realization of a mechanical qubit using a double quantum dot embedded along a suspended nanotube, following the proposal in [2].

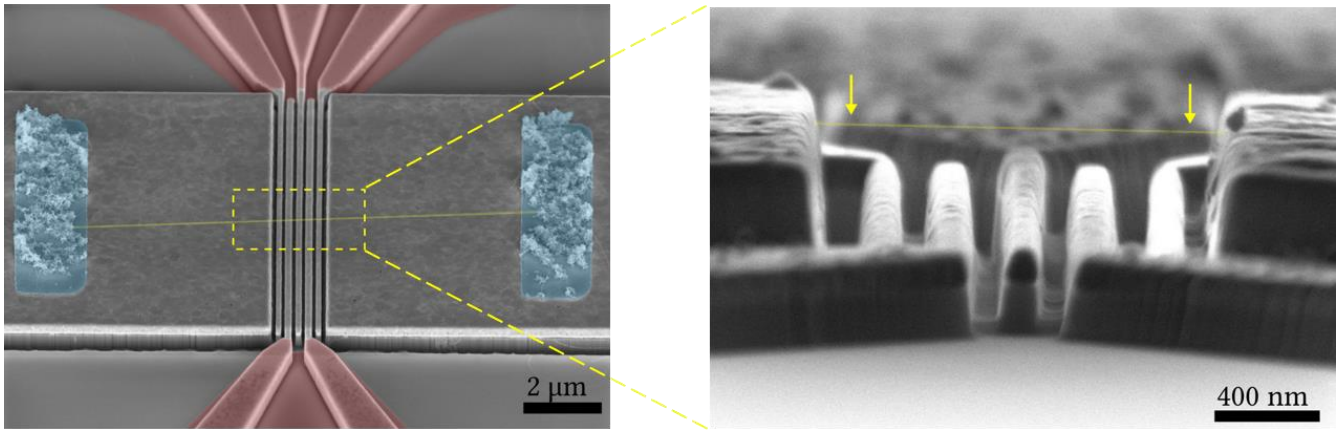

Fig.1. A nanotube electromechanical system employed to create a mechanical qubit. The image on the right side shows a suspended nanotube highlighted in yellow. It hosts a double quantum dot qubit formed by electrostatic means using the five gates at the bottom of the trench.

References

[1] C Samanta, SL De Bonis, CB Møller, R Tormo-Queralt, W Yang, C Urgell, B Stamenic, B Thibeault, Y Jin, DA Czaplewski, F Pistolesi, A Bachtold, Nature Physics 19, 1340 (2023).
[2] F. Pistolesi, A. N. Cleland, and A. Bachtold, Phys. Rev. X 11, 031027 (2021)