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Researchers uncover a novel mechanical bistability in carbon nanotubes

A study published in Nano Letters demonstrates the existence o two stable states in carbon nanotubes-tiny tubes of carbon just few nanometers in diameter-and reveals that the system switche between these mechanical states due to intrinsic fluctuations.

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Scientists from the Polytechnic University of Marche, Michigan State University, TU Delft, and **Dr. Wei Yang** and **Prof. Adrian Bachtold** from ICFO have discovered a previousl unobserved form of bistability in a mechanical resonator based on a carbon nanotube. Thi bistability, reported onNano Letters, manifests as two distinct stable states: a quiet state where the nanotube remains nearly motionless, and a second state characterized by large, sustained oscillations. Unlike typical bistability observed in mechanical resonators, this new type was not triggered by sweeping an external control parameter.

Switching between the two states was achieved simply by applying a constant voltage across the nanotube's ends. What makes this bistability unique is that the large oscillatory state emerges spontaneously through the system's intrinsic fluctuations, causing transitions between states without external modulation. In fact, without noise, the bistability would disappear, and the oscillatory state would remain hidden.

The team precisely measured how long the nanotube stayed in each state, confirming that both states are equally stable. They also developed a minimal theoretical model to explain the origin of this bistability and the mechanisms driving it.

This work advances our understanding of complex nonlinear dynamics in nanomechanical oscillators and could have important implications for nanotechnology applications that rely on precise control of mechanical vibrations, such as ultra-sensitive sensors and nanoscale actuators.

Reference:

P. Belardinelli, W. Yang, A. Bachtold, M. I. Dykman, F. Alijani, Hidden Vibrational Bistability Revealed by Intrinsic Fluctuations of a Carbon Nanotube, Nano Lett. (2025).

DOI: https://doi.org/10.1021/acs.nanolett.4c06618

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Carbon nanotube-based electromechanical oscillator and measurement schematic. Scanning electron microscope image in the bottom left panel. Source: Nano Letters.