



Mechanical qubits made of nanotubes and quantum dots

An international team of researchers describes a new concept for a mechanical qubit, using a carbon nanotube mechanical resonator and a double quantum dot.

August 03, 2021

Quantum information (QI) processing, including computation, communication and sensing, may deliver the next technological revolution, through the promise of unprecedented computational capabilities, security and detection sensitivities.

A significant outstanding challenge is determining the best way to encode and manipulate information in quantum systems. The basic hardware element for quantum information is the qubit, similar to the bit used for classical information, which provides the building block for quantum computers and quantum information processing.

So far, only a handful of qubit platforms have been demonstrated to have the potential for use in a quantum computer, in particular simultaneously achieving high-fidelity controlled

gates, easy qubit-qubit coupling, and good isolation from the environment, thus yielding sufficiently long-lived coherence. Several studies have shown that mechanical resonators might serve as qubits, as these can have large quality factors and long coherence times, a must for scaling up in quantum computing. A remaining puzzle is how to make a qubit out of a mechanical resonator.

In a recent study published in *Physics Review X*, researchers Prof Fabio Pistolesi from the CNRS and the University of Bordeaux, Prof Andrew N. Cleland from the University of Chicago and Prof Adrian Bachtold from ICFO develop a theoretical proposal for quantum information processing an innovative electromechanical system, using a mechanical qubit composed of a nanotube resonator coupled to a double-quantum dot formed in the suspended nanotube.

The researchers use the quantum dots to introduce a very strong $\frac{1}{2}$ anharmonicity $\frac{1}{2}$ to the mechanical system, such that quantum information can be controllably encoded in just two quantum levels, a key requirement for manipulating and storing quantum information. This thus provides a simple and practical approach to a mechanically-based qubit, that further should display very long coherence times as well as easy qubit-qubit coupling, satisfying the major requirements for a quantum computer.

In addition to the potential for long coherence times, mechanical qubits based on nanotubes and other systems may facilitate the coupling to other quantum systems, such as photons, spins, and superconducting qubits, something that has not yet been explored in other qubit systems but that shows to have a tremendous potential.