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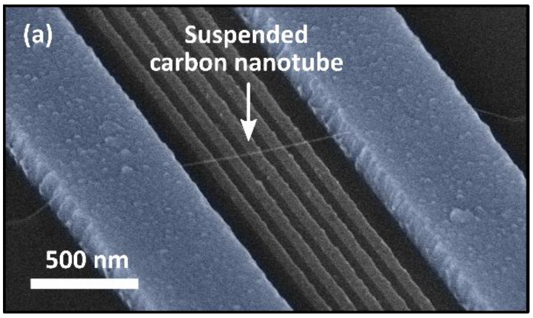
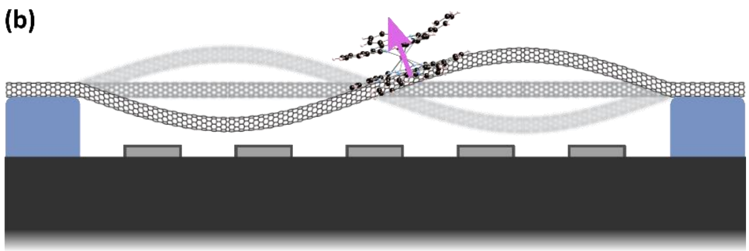
PhD job offer

Spin-phonon coupling between a single molecular magnet and a carbon nanotube in a quantum circuit

Context: The last two decades have seen fast progresses in the research field of nano-mechanical resonators **[1]**, enabling to use these systems to study quantum mechanic at the scale of a single quanta. Among the various physical implementations of nano-mechanical resonators, carbon nanotubes are very attractive candidates. Thanks to their small dimensions (diameter of 1-4nm) they possess very high resonance frequency (from 50MHz to few GHz), and very large **quality factor (up to few millions) [2]**. In our group we recently developed a **unique nano-assembly technique [3]** allowing to fabricate state of the art quantum circuits based on suspended carbon nanotubes. Besides, it is also possible to graft a single molecular magnet (SMM) on a carbon nanotube, allowing to explore the interaction between a single spin and a phononic mode at the quantum level. This system already led to the observation of the **quantum Einstein de-Haas effect [4].**

PhD subject: The goal of the project is to study the spin-phonon coupling between a single molecular magnet and the bending modes of a suspended carbon nanotube. A suspended nanotube is a near ideal environment for the spin of the molecule, and it allows to control its phononic environment, which is expected to result in very long coherence time of the molecular spin. This project relies on the realization of a double quantum dot circuit within the carbon nanotube enhancing the scope of experimental exploration, one example being the ground state cooling of the carbon nanotube vibration.





(a) Double quantum dot circuit built out of a suspended carbon nanotube using our home-made nano-assembly technique. (b) Schematic of a vibrating carbon nanotube with a single molecular magnet grafted onto it.

Work plan and Skills: The core of the project will be the low temperature measurement of the circuit thanks to our **cryogenic setup.** It involves advanced quantum measurement techniques such as **low-noise transport** (RLC tank circuits, lock-in measurements), as well as **microwave electronic** techniques necessary for the control of quantum systems. The project will also comprise the fabrication of the circuit devices. This includes clean-room nanofabrication steps as wells as more specific techniques, crucial to the experiment, such as the nano-assembly of a carbon nanotube within the circuit, or the grafting of a molecular magnet on a nanotube. Simulations of the experiment can also be part o the project according to the applicant.

References:

[1] Mesoscopic physics of nanomechanical systems A. Bachtold, et al. RMP (2022).
[2] Nanotube mechanical resonators with quality factors of up to 5 million J. Moser, et al. Nature Nano (2014)
[3] Nano-assembled open quantum dot nanotube devices T. Althuon et al. submitted (2023)
[4] Quantum Einstein-de Haas effect M. Ganzhorn, et al. Nature Communication (2016)