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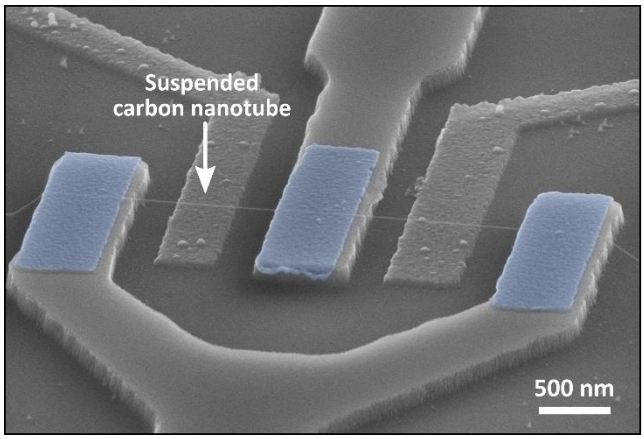
PhD job offer

Superconducting carbon nanotube quantum circuits for nanomechanical experiments

Context: The last two decades have seen fast progress 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. The recent advances in this field such as **Schrödinger cat mechanical states [2]** or **entanglement between distinct resonators [3,4]**, offer great promise in the context of **quantum computing**. Among the various physical implementations of nano-mechanical resonators, a carbon nanotube is a very attractive candidate. Thanks to their small dimensions (diameter of 1-4nm) they possess very high resonance frequencies (from 50MHz to few GHz), and very large quality factors (up to few millions). In our group we recently developed a **unique nano-assembly technique [5]** allowing to fabricate state of the art quantum circuit based on suspended carbon nanotubes.

PhD subject: We propose to study the interaction between mechanical and electronic degrees of freedom using a Superconducting Quantum Interference Device (SQUID) based on a single suspended carbon nanotube. The project can evolve toward two main directions. The first one aims at observing and **generating mechanical quantum states** of the carbon nanotube such as Schrödinger cat. The other direction focuses on the study of the dynamics of a **single molecular magnet [6]** using the nanotube-SQUID as an ultra-sensitive magnetometer.



SQUID-circuit built out of a suspended carbon nanotube using our custom nano-assembly technique.

Work plan/Skills: A large part of the project is the measurement of the circuit. It will begin with the quantum transport characterization of the SQUID circuit using **low-noise measurement techniques.** The nanomechanics will also be probed with our **microwave measurements setup**. At a lower degree, the project will also contain the nano-fabrication of the circuit (cleanroom techniques, carbon nanotube nano-assembling). According to the taste of the applicant, the project can also include some nanofabrication developments or simulations of the experiment.

References:

[1] Mesoscopic physics of nanomechanical systems A. Bachtold, et al., RMP (2022).
[2] Schrödinger cat states of a 16-microgram mechanical oscillator. M. Bild, et al., Science (2023)
[3] Quantum mechanics–free subsystem with mechanical oscillators. L. Mercier de Lépinay et al., Science (2021)
[4] Direct observation of deterministic macroscopic entanglement. S. Kotler et al., Science (2021)
[5] Nano-assembled open quantum dot nanotube devices. T. Althuon et. al, submitted (2023)
[6] Quantum Einstein-de Haas effect. M. Ganzhorn, et al., Nature Communication (2016)