NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

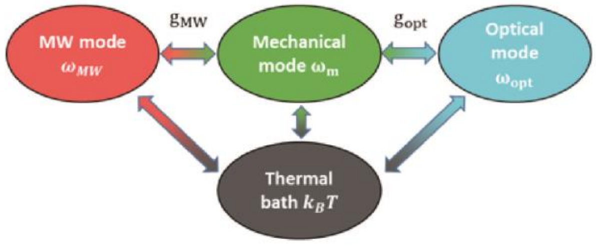
Microwave to optical conversion for quantum networks

General Scope :

The most promising solid-state implementations of qubits today, *i.e.* superconducting or spin qubits, have typical energy scales corresponding to microwave frequencies of order 10GHz. However, microwave frequency photons are difficult to transmit over long distances without large losses. Typical attenuation in low-loss microwave cables at 10GHz is more than 1 $dB.m^{-1}$, which compares very poorly with optical fibres with losses below 0.2 $dB.km^{-1}$ at telecom wavelengths ($\lambda \approx 1550$ nm, f $\approx$ 193 THz). In today's classical communication technologies too, the information is processed electronically at MW frequencies and distributed over long distances via optical fibers. In both cases, converters from one frequency range to the other are then required. For classical electronics, the efficiency of the converter is not a limiting issue but for quantum signals, it would destroy any superposition of states. This is why an optical to microwave converter able to conserve quantum signals would be very useful for future quantum networks.

Research topic and facilities available:

In this project, we will develop such a converter using a nanoelectromechanical system (NEMS) as the intermediate between microwaves and optics (see figure). The idea is that it is possible to have a very strong interaction between microwaves/optics and a NEMS and it thus appears as the ideal mediating system for the conversion. The samples are produced by our colleagues at CEA-LETI on a semi-industrial platform. In Néel, we will perform experiments at very low temperatures (20mK). Initially, and this will be the goal of the internship, we will focus on the microwave-NEMS part and demonstrate the cooldown of the NEMS in its ground state using superconducting microwave circuits.



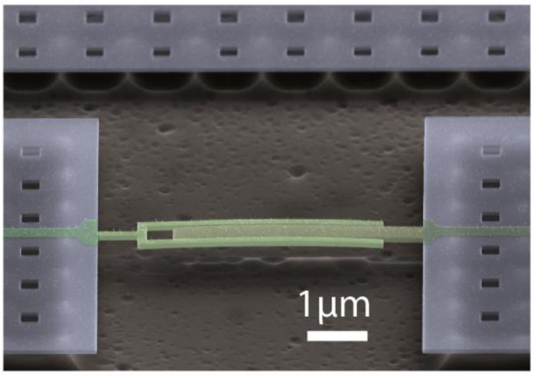


Figure 1: Scheme of the conversion process. A mechanical mode (NEMS) couples the optical and microwaves (MW) modes (coupling terms g_{MW} and g_{opt}). All modes are coupled to a common thermal bath. On the right, a scanning electron microscope image of a fabricated device with a suspended NEMS integrated with a superconducting microwave circuit (green).

Possible collaboration and networking : The student will interact with the other partners of the project: CEA Leti and the LMPQ lab in Paris.

Possible extension as a PhD : Yes

Required skills: The internship (and the PhD thesis) will require a solid background in solid state/condensed matter physics. The work will be mainly experimental. The candidate is expected to be strongly motivated to learn the associated techniques (radiofrequency electronics, optics, cryogenics...) and engage in a hands-on experimental work.

Starting date : March 2022 (flexible)

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