NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Quantum microwave-to-optics interface

General Scope: This project aims at developing a microwave-optical quantum interface to be used as a key element in future quantum technologies. Such an interface will for example permit long-distance transfer of microwave quantum information, which is not possible without conversion in the optical domain. The realization of this project will also make possible the optically-mediated entanglement of distant microwave qubits (superconducting qubits or spin qubits). This will support the scalability and the connectivity of quantum-computing architectures by opening an interface between microwave qubits and silicon photonics.

Research topic and facilities available: We aim to realize a device capable to convert signals between microwave and optical domains, but also to generate entanglement between microwave and optical fields. This device consists of three main elements: a microwave superconducting circuit, a GHz-frequency mechanical mode (see Figure 1) and a near-infrared optical cavity on a single chip. The interactions between these elements (optomechanical and electromechanical) will be designed and optimized to provide the best performances for the full device.

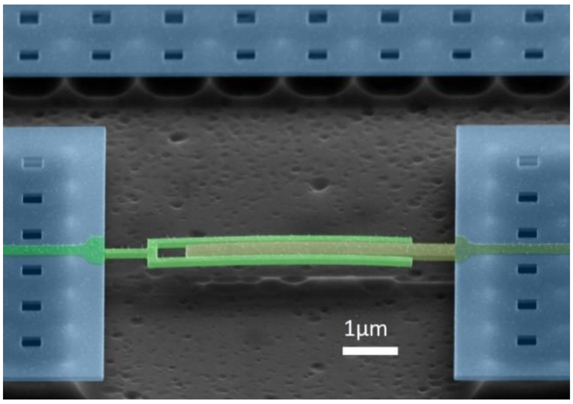

Figure 1: electron micrograph of a suspended mechanical resonator integrated with a superconducting circuit (green)

The student will start with learning how to design, fabricate and operate microwave superconducting electromechanical devices (several GHz) and optomechanical devices (hundreds of THz) at cryogenic temperatures (tens of mK). We will then combine these techniques to develop the full microwave-to-optics converter and characterize it, in terms of quantum efficiency and added noise.

The fabrication will take place in the clean room of the Néel institute using state-of-the-art techniques such as electron beam lithography. The cryogenic microwave measurements will be performed in a dedicated dilution refrigerator.

Possible collaboration and networking: This project is part of the french Quantum plan and we will work in close collaboration with partners with an expertise that complements ours: Matériaux et Phénomènes Quantiques (MPQ) in Paris is recognized for breakthroughs in quantum optomechanics and CEA Leti is a major Research Technological Organization in Europe.

Possible extension as a PhD: Yes

Required skills: We are looking for a student motivated to learn a wide variety of skills in experimental physics, willing to be part of a project involving both fundamental and technical challenges.

Starting date: Flexible

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