NÉEL INSTITUTE Grenoble

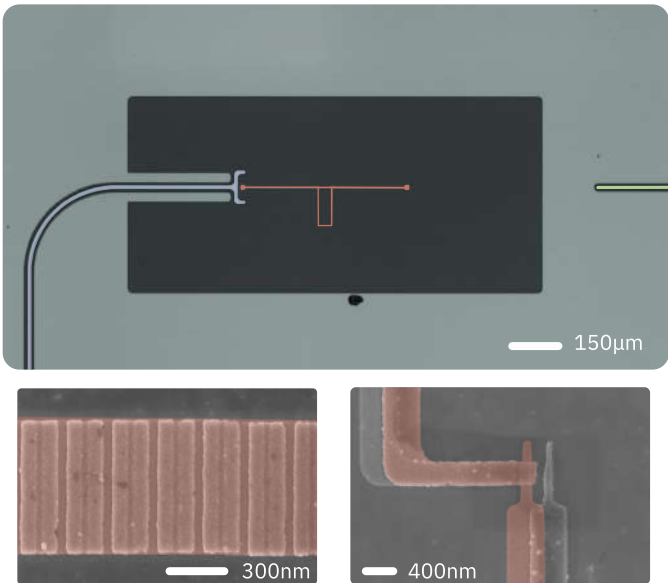
Topic for Master 2 internship – Academic year 2024-2025

Protected superconducting qubits

General Scope: In recent years, it has been demonstrated that superconducting Josephson circuits can serve as quantum bits. They are ideal for conducting advanced quantum mechanical experiments and can be utilized to construct advanced quantum processors. These circuits imitate artificial atoms, and their characteristics are defined by their electronic properties such as capacitance, inductance, and tunnel barrier.

Furthermore, because of their small size, these quantum bits strongly interact with electromagnetic radiation in the microwave range. This allows for the performance of quantum optics experiments using microwave photons and the exploration of light-matter interactions using circuits. This field of study is referred to as circuit-QED (Quantum Electro-Dynamics).

Research topic and facilities available: The goal of this project is to use new fabrication methods and advanced circuit design to create improved superconducting qubits with better quantum coherence and built-in protected gates. We have recently shown a new form of protection for fluxonium qubits [1], which has promising implications for this endeavor.



False colored optical image of a protected superconducted qubit [1]. Insets show scanning electron microscope (SEM) images of the Josephson junction of the qubit (right) and the superinductor (left). The combination of Josephson junctions and superinductors allows new protection mechanisms for superconducting qubits.

Our team specializes in the coherent control and manipulation of superconducting quantum circuits. You will benefit from a dedicated, state-of-the-art setup combining very low temperatures (around 10 mK), fast electronics and quantum-limited microwave detection chains. The devices are fabricated in the clean room of the Neel Institute (Nanofab), offering state-of-the-art equipment (100 keV e-beam writer, dedicated Plassys evaporator, ALD and PE-CVD machines…).

[1] Using bi-fluxon tunneling to protect the Fluxonium qubit, W. Ardati, S. Léger, S. Kumar, V. N. Suresh, D. Nicolas, C. Mori, F. D'Esposito, T. Vakhtel, O. Buisson, Q. Ficheux, and N. Roch, arXiv:2402.04495 (To appear in Physical Review X).

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Possible collaboration and networking: Our team is part of several national and international networks (for example https://www.robustsuperq.fr/ or https://opensuperqplus.eu/)

Possible extension as a PhD : Yes since this position is funded within the ERC project SuperProtected (SUPERinductance for hardware-PROTECTED superconducting qubits).

Required skills : Master 2 or Engineering degree. We are seeking motivated students who want to take part to a state-of-the-art experiment and put some efforts in the theoretical understanding of novel superconducting qubits.

Starting date : Flexible

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