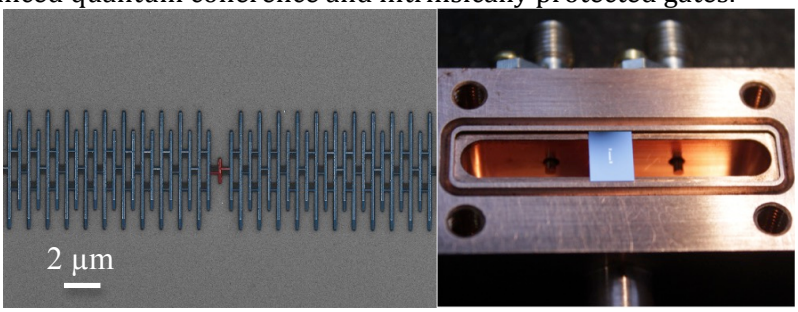
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Protected superconducting qubits

General Scope : During the last decade, it has been demonstrated that superconducting Josephson circuits behave as quantum bits and are very well suited to realize advanced quantum mechanical experiments. These circuits appear as artificial atoms whose properties are defined by their electronic characteristics (capacitance, inductance and tunnel barrier).
Moreover, given their mesoscopic size, these quantum bits couple very strongly to electromagnetic radiations in the microwave range. Thus, it is now possible to perform quantum optics experiments using microwave photons and to unravel light-matter interactions using circuits. This field is dubbed circuit-QED (Quantum Electro-Dynamics).

Research topic and facilities available : The aim of this project is to combine superinductances and innovative circuit geometry to build the next generation superconducting qubits with enhanced quantum coherence and intrinsically protected gates.



Left: example of a Josephson meta-material we engineer in our lab [1]. It is made of thousands of Josephson junctions and behaves as a "superinductance", which is several orders of magnitude larger than what is usually found in standard electronic circuits. Right: superconducting qubit embedding a superinductance (black rectangle) sitting in its copper microwave cavity. In this specific case, the addition of a superinductance enabled a novel readout mechanism.

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] Observation of quantum many-body effects due to zero point fluctuations in superconducting circuits, S. Leger, et al. Nature Communications 10, 5259 (2019). [2] Fast high fidelity quantum non-demolition qubit readout via a non-perturbative cross-Kerr coupling, R. Dassonneville, et al. Phys. Rev. X 10, 011045 (2020).

Possible collaboration and networking : Our team is part of several national and international networks.

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 quantum effects in Josephson parametric amplifiers.

Starting date : Flexible

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