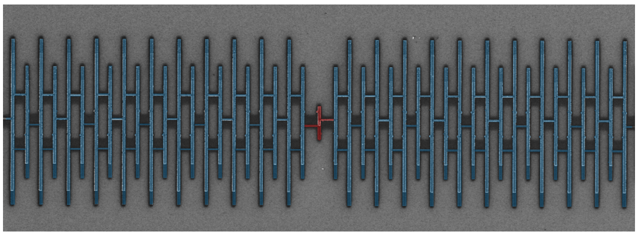
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Coherent manipulation of a many-body superconducting quantum circuits

General Scope: One of the present leading technologies for the realization of a universal quantum computer is based on *superconducting quantum circuits* (SQCs). It exploits superconducting circuits based on Josephson junctions, which are characterized by quantized energy levels and for this reason can be adopted as quantum bits (qubits), the basic units of quantum information. While high quantum coherence has been demonstrated for systems containing a few number of qubits, a full-fledge quantum computer will require the interconnection and manipulation of hundreds of highly coherent qubits. This obviously imposes very challenging engineering issues but also raises interesting points regarding our current understanding of quantum mechanics. For example, questions such as "how coherent can a large quantum system be?" or "what is the quantum to classical transition when many quantum systems are interacting?" remain open.



Quantum simulator we recently developed [1]. A quantum bit (in red) couples to a superconducting metamaterial (in blue). This metamaterial hosts as many as 30 propagating electromagnetic modes, which are all strongly coupled to the qubit. This forms a complex many-body system, which simulates a class of problems called "quantum impurities".

Our team focuses on the fabrication and characterization of machines called quantum simulators [1,2], which are dedicated to a given class of physical problems (e.g. quantum impurities, Hubbard models...). The required building blocks (quantum bits) as well as the control electronics are similar to the one of the universal quantum computer but since universality is not required, the overhead developments are less stringent. As such, these simulators should allow us to address the above-mentioned questions with an experimental platform much simpler than a universal quantum computer. This Master project aims at setting-up an experiment to perform time-resolved manipulation of the quantum simulator we recently demonstrated. In particular, the student will develop quantum information protocols to reveal the coherence properties of this many-body system.

[1] A tunable Josephson platform to explore many-body quantum optics in circuit-QED, J. Puertas-Martinez, et al. npj Quant. Info. 5, 19 (2019).
[2] Superconducting quantum bits with artificial damping tackle the many body problem, A. Cottet, npj Quant. Info. 5, 21 (2019).

Research topic and facilities available: The quanteca team specializes in the coherent control and manipulation of superconducting quantum circuits. The student will use state-of-the-art setups 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). This project is funded by the European Union via the QuantERA Network.

Possible collaboration and networking: Our team is part of several national and international networks. For this specific project we are collaborating closely with Serge Florens at the Néel Institute and with Izak Snyman at the University of Witwatersrand in Johannesburg, South Africa.

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 many-body physics using superconducting quantum circuit. This internship can be pursued toward a PhD.

Starting date: Flexible

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