NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Superconducting qubits: from fundamental to applications

General Scope:
During the last decade, it has been demonstrated that superconducting Josephson quantum circuits constitute ideal blocks to realize quantum mechanical experiments and to build promising quantum bits for quantum information processing. These circuits appear as artificial atoms whose properties are fixed by electronics compounds (capacitance, inductance, tunnel barrier).
Recently we demonstrated a new quantum measurement [1] which overcomes the usual limitations (see Fig). We propose to study its physical properties of this open quantum system such as quantum-non-demolition measurement, quantum trajectories, simultaneous measurements and to build a superconducting four-qubits plateform based on this new readout and on our recent achievement on quantum limited amplifiers [2].

We are also studying new superconducting materials (Tantalum and Rhenium) in order to increase the qubit coherence times.

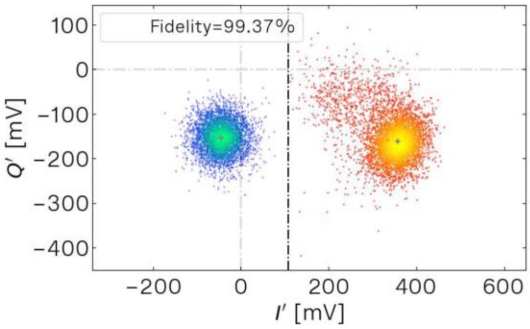

Figure: Histograms of ten thousand single shot QND measurements of the microwave transmitted signal when the qubit is prepared in its ground state |g> (blue points) and excited state |e> (orange points). The two states are very well separated by the measurements leading to a very high readout fidelity.

[1] *"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) and Phys. Rev. Applied 20, 044050 (2023).
[2] *"A photonic crystal Josephson traveling wave parametric amplifier"*, L. Planat, et al, Phys. Rev. X 10, 021021 (2020).

Research topic and facilities available:
Our team has a strong experience in superconducting quantum circuit modelization, nanofabrication, microwave electronics, cryogenic equipment and superconducting qubit experiments. The student will carry out experiments at very low temperature to study original quantum properties. She/he will participate to the development of the superconducting four qubits plateform and to the understanding and improvement of the quantum non-demolition measurements.

Possible collaboration and networking: Our "Quantum Electronics Circuits Alps" team is part of several national networks. This project on superconducting qubits is financially supported by the National French Funding Agency (ANR) and the French Quantum Plan and benefits from collaborations with theoretical groups in Madrid (Spain) and Sao Carlos (Brazil).

PhD grants: available funding through Grenoble PhD calls.

Required skills: Master 2 or Engineering degree. We are seeking highly motivated students on quantum mechanics who want to develop experiments on quantum bits.

Starting date: February/ April 2025.

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