PhD Proposal 2020: Quantum error correction with superconducting circuits

Keywords: `quantum computing`, `quantum error correction`, `Josephson junctions`, `circuit quantum electrodynamics`, `high-impedance circuits`

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Quantum systems can occupy peculiar states, such as superpositions or entangled states. These states are intrinsically fragile and eventually get wiped out by inevitable interactions with the environment. Protecting quantum states against decoherence is a formidable and fundamental problem in physics, and it is pivotal for the future of quantum computing. Quantum error correction provides a potential solution, but its current envisioned implementations require daunting resources: a single bit of information is protected by encoding it across tens of thousands of physical qubits.

Our team in Paris proposes to protect quantum information in an entirely new type of qubit with two key specificities. First, it will be encoded in a single superconducting circuit resonator whose infinite dimensional Hilbert space can replace large registers of physical qubits. Second, this qubit will be rf-powered, continuously exchanging photons with a reservoir. This approach challenges the intuition that a qubit must be isolated from its environment. Instead, the reservoir acts as a feedback loop which continuously and autonomously corrects against errors. This correction takes place at the level of the quantum hardware, and reduces the need for error syndrome measurements which are resource intensive.

We are looking for two experimental PhD students or post-docs. The work will cover all aspects of the project, from quantum feedback protocol design to circuit nanofabrication, cryogenic measurements and circuit characterization. Applicants can send a CV including references to our email addresses above.

1. Leghtas, Z. *et al.* Confining the state of light to a quantum manifold by engineered two-photon loss. Science 347, 853-857 (2015).

2. Lescanne, R. *et al.* Exponential suppression of bit-flips in a qubit encoded in an oscillator (under review in Nature Physics, arXiv:1907.11729).

3. Campagne-Ibarcq, P *et al.* A stabilized logical quantum bit encoded in grid states of a superconducting cavity (under review in Nature, arXiv:1907.12487)