

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique, Ecole Normale Supérieure de Lyon
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Internship location: **ENS de Lyon**
Thesis possibility after internship: YES
Funding: Very likely Yes Type of funding: **QuantEdu or Google**

A superconducting qubit with built-in protection against errors

Quantum processors correct their errors in software, at a cost of roughly a thousand physical qubits per useful logical one. A protected qubit works differently. Its two logical states are placed so far apart in phase space that no local noise can connect them. Errors are suppressed by the geometry of the circuit rather than corrected after the fact.

How it is done

The building block is a Josephson element that lets Cooper pairs tunnel only in pairs, with an energy $U(\varphi) = -E_J \cos(2\varphi)$. This potential repeats every π and has two degenerate minima, which encode the qubit. Rhombi chains, the 0- π qubit and the KITE all realize it [1–4], and chaining such elements turns the circuit Hamiltonian itself into a stabilizer of a repetition code [5].

Where it stands

No such circuit has yet produced a long-lived qubit. The scheme needs two identical interferometer arms, and real junctions differ by a few percent. A mismatch $\varepsilon = \delta E_J / E_J$ restores an unwanted first harmonic $U(\varphi) \simeq -\varepsilon E_J \cos(\varphi - \varphi_0) - E_J \cos(2\varphi)$ that splits the two degeneracy and brings back sensitivity to offset charge and to flux noise. Even with ideal junctions a deeper obstacle remains, since charge protection and flux protection pull the circuit parameters in opposite directions. Lifetimes T_1 above a millisecond are reachable, while the coherence time T_φ stays near a few microseconds [6].

The project

In a collaboration with Lev Ioffe, Lara Faoro and Michel Devoret (Google Quantum AI), we identified a new circuit, the xiqubit, that should solve the current bottleneck. During the internship, you will measure and characterize the first version of that circuit. Moreover, we recently experimentally demonstrated [7] that it is possible to remove any charge offset drift, which would greatly improve the coherence time of our qubit. You will also contribute to the development of a new fabrication recipe that stabilizes the charge offset deterministically.

The team

You will work on quantum control with multiparametric measurement-based feedback, microwave design, nanofabrication, low-noise cryogenic setups, pulsed microwave measurements, data processing and analysis and dissemination of scientific research. The experiments will be performed at ENS de Lyon in the Quantum Circuits Group. Fabrication will be performed at ENS de Lyon and in Santa Barbara by our collaborators from Google. Theory and simulations will be performed with them as well. You will work with our finishing PhD student, Adria Rospars.

1. S. Gladchenko et al., Nat. Phys. 5, 48 (2009) — <https://arxiv.org/abs/0802.2295>
2. M. T. Bell et al., Phys. Rev. Lett. 112, 167001 (2014) — <https://doi.org/10.1103/PhysRevLett.112.167001>
3. A. Gyenis et al., PRX Quantum 2, 010339 (2021) — <https://doi.org/10.1103/PRXQuantum.2.010339>
4. W. C. Smith et al., Phys. Rev. X 12, 021002 (2022) — <https://arxiv.org/abs/2010.15488>
5. K. Dodge, Y. Liu et al., Phys. Rev. Lett. 131, 150602 (2023) — <https://doi.org/10.1103/PhysRevLett.131.150602>
6. S. Messelot et al., arXiv:2601.10209, accepted in Phys. Rev. Applied (2026) — <https://arxiv.org/abs/2601.10209>
7. A. Rospars et al., arXiv:2603.12367 (2026) — <https://arxiv.org/abs/2603.12367>

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	NO