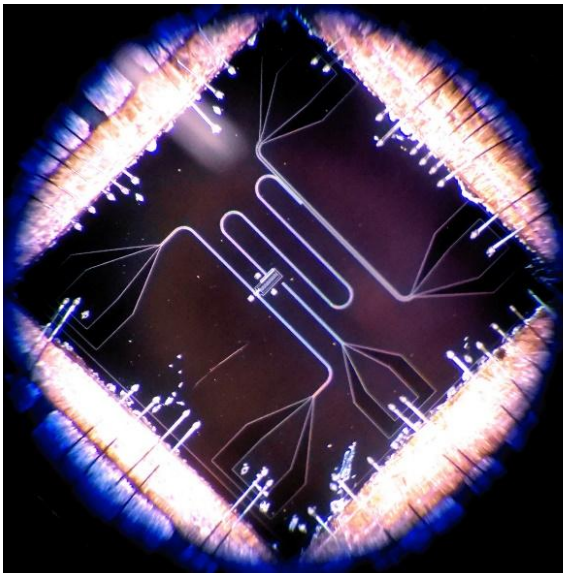
Kvantti group –

summer students projects 2026



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Superconducting circuits are one of the most promising experimental platforms for the realization of quantum computers and simulators. A superconducting qubit behaves as an artificial two-level system, with transitions between the ground state and the first excited state being driven by resonant microwave fields. In the Kvantti group we design, fabricate and measure these amazing devices. We offer two main research projects for the summer of 2026. Note that they might look "advanced" (and they are!) but they can be tailored to adjust your level (B.Sc. thesis, M.Sc. thesis, etc.) and your interests. If you are looking forward to making an impact in quantum technologies, maybe this is your place to be.

1. Optimization of qudit readout for transmon qudits

Reading out a qudit implies sending a microwave signal through a resonator and finding out how the quantum state modifies it, typically through measuring the in-phase (I) and quadrature (Q) components. This project targets two key bottlenecks in that process: how the readout signal is shaped and how the measured signal is demodulated and integrated. While pulse shaping and multi-tone readout already outperform simple approaches [1,2], they are not guaranteed to be optimal.

The aim of this project is to use reinforcement learning to design optimal readout protocols by training an agent on a realistic digital twin of a superconducting qudit, and then refining the solution on real data [3]. In parallel, the time-domain demodulation filter used to extract I and Q will be optimized, extending known two-state solutions to true multi-state discrimination. Early results show potential for fidelity gains and shorter optimal readout times and combining drive-shape and filter optimization promises further improvements. This is a hands-on project at the intersection of quantum hardware, signal processing, and machine learning, with results directly relevant to cutting-edge quantum computing experiments.

[1] "Fast Accurate State Measurement with Superconducting Qubits"
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.112.190504
[2] "Transmon qubit readout fidelity at the threshold for quantum error correction without a quantum-limited amplifier" https://www.nature.com/articles/s41534-023-00689-6
[3] "Enhanced qubit readout via reinforcement learning"
https://journals.aps.org/prapplied/abstract/10.1103/PhysRevApplied.23.054057

2. Fast qutrit gates on a transmon circuit

Transmons, the most widely used superconducting qubit, suffer from low anharmonicity: the spectrum of transition frequencies is "crowded", and one can inadvertently drive transitions to higher excited states. This is even more-so pronounced if the drive pulses used for controlling the qubits are short, as the pulse bandwidth scales like $\propto 1/T_{pulse}$. The use of short pulses is generally beneficial, as one can then manage to implement more operations within the finite lifetime of the qubit. This can be achieved by using DRAG [1] pulses, or other similar techniques, which aim to minimize the leakage associated with the presence of higher states even with short-duration pulses.

However, these techniques do not leave the second excited state undisturbed, as it typically acquires an additional phase. The aim of the research project is to experimentally characterize these effects and to mitigate them by a higher order DRAG-like method [2], or by an alternative parametrization of the drive pulses. This would enable fast and high fidelity qutrit operations on transmon circuits.

[1] "Simple pulses for elimination of leakage in weakly nonlinear qubits"
https://arxiv.org/abs/0901.0534
[2] "Universal pulses for superconducting qudit ladder gates"
https://arxiv.org/abs/2412.18339