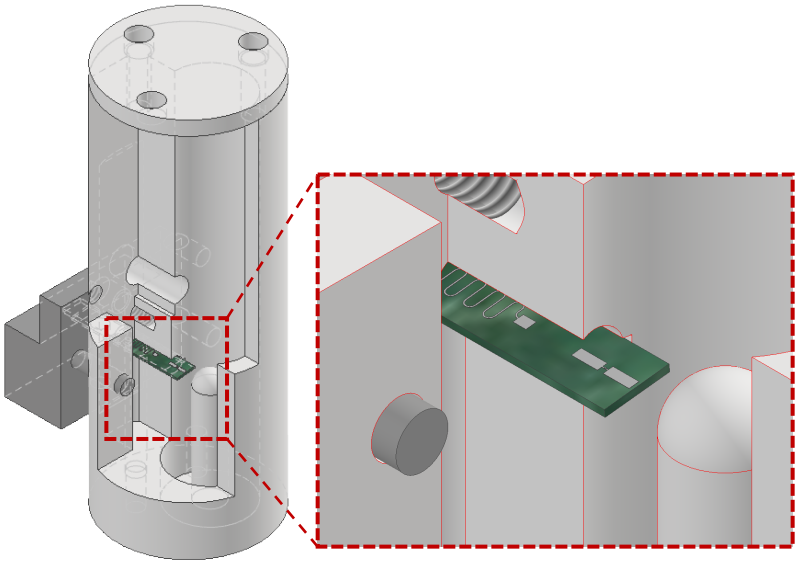
MSc thesis in experimental continuous-variable quantum computing

202Q-lab, Quantum Technology Laboratory

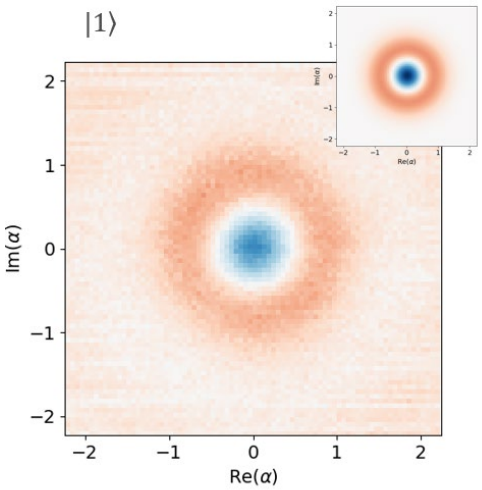
The 202Q-lab is looking for a MSc student who is interested in superconducting qubits and microwave cavities.

Background – An alternative approach to discrete quantum bits is to use a harmonic oscillator to encode the values 0 and 1 of a logical qubit into complex superpositions of harmonic states. This approach is referred to as continuous-variable quantum computing. We explore continuous variable quantum computing in three-dimensional (3D) microwave cavities [1,2]. Our superconducting 3D cavities [3] provide state-of-the-art quality factors and long-lived photon states. This makes it possible to implement hardware-efficient quantum error correction while keeping the noise channels limited. However, one form of noise comes from thermal excitation of the cavity modes.



3D rendering of a high-Q coaxial microwave cavity used in our experiments [3]. Close-up: a silicon chip with a superconducting qubit and a readout resonator is inserted into the cavity to prepare, manipulate, and read out nonclassical states in the cavity.

The challenge – It is therefore of great interest to quantify the thermal occupation of cavities fabricated from different materials and measure the thermalization time of the cavities as they are cooled down from room temperature down to a nominal temperature of 10mK. The temperature is measured with a help of a superconducting qubit that is connected to the cavity. The measurement techniques are therefore same as in the field of quantum information processing with superconducting circuits.



Experimentally measured Wigner function of a single-photon Fock state prepared in one of our microwave cavities. Inset: theoretical function.

The project – The successful candidate will measure the thermal occupation of aluminum (Al) and niobium (Nb) cavities. The project will involve learning about superconducting 3D cavities in the context of continuous variable quantum computing, microwave measurements, and data analysis. The candidate will plan the measurements and execute them with the help of senior members of the group.

About us – We are part of the Quantum Technology Laboratory, a division of the Department of Microtechnology and Nanoscience (MC2) at Chalmers University of Technology. We are also part of the Wallenberg Centre for Quantum Technology (WACQT).

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References

[1] Ma *et al.*, *Quantum Control of Bosonic Modes with Superconducting Circuits*, Science Bulletin **66**, 1789 (2021).[2] Joshi, Noh, and Gao, *Quantum Information Processing with Bosonic Qubits in Circuit QED*, Quantum Sci. Technol. **6**, 033001 (2021). [3] Kudra *et al.*, *High Quality Three-Dimensional Aluminum Microwave Cavities*, Applied Physics Letters 117, (2020).